America's Future in Energy
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Source: *Current History*, Vol. 69, No. 407, ENERGY AND SCARCE WORLD RESOURCES (JULY/AUGUST, 1975), pp. 1-5, 43-46
Published by: University of California Press
Stable URL: https://www.jstor.org/stable/45313333
Accessed: 31-01-2022 02:02 UTC

Current History

JULY/AUGUST, 1975 VOL. 69, NO. 407

In the second of a two-part symposium on world resources, nine articles examine the world's energy needs and resources and evaluate the prospects for meeting world energy requirements in the late twentieth century. Our introductory article analyzes America's real energy needs, the false logic of special interest groups, and the need to stop wasting energy resources. The author concludes that: "An increase in net energy from coal should be regarded as a transitional stage . . . toward a new energy system . . ."; he urges changes in patterns of energy consumption "to produce a healthier and happier society. . . ."

America's Future in Energy

By Carroll Quigley

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In 1973, President Richard M. Nixon announced Project Independence, his hope that the United States could achieve self-sufficiency in energy by 1980. This project is now almost dead, rejected or ignored by many government agencies and nongovernment opinions. Nonetheless, the project remains as a point of departure for any examination of this country's prospects in energy resources.

Project Independence pervades every aspect of our lives. Many vested special interests (including the richest and most influential corporations and individuals) are opposed to the very idea of self-sufficiency in energy resources. The owners of supertankers, which bring in oil from the Persian Gulf, and the railroad, which sends out one thousand shiploads of coal a year from Norfolk, Virginia, to Japan and other countries, object to Project Independence. In fact, powerful interests will work to prevent any real solutions to the "energy crisis"; and financial resources for such solutions will be meager unless we free ourselves from the interest groups and "experts" who created the crisis.

Most important, the goals and methods of Project Independence cannot be established by those methods of thinking and acting that have made the United States what it is today. The methods that made the United States the most powerful and most affluent state that ever existed by 1968 were the methods of reductionism. Such methods operate as follows: they isolate the problem as narrowly as possible; break down the problem into the factors that determine what happens; quantify each factor; and vary these factors quantitatively to reach a specific desired material goal.

Energy self-sufficiency must be considered by holistic and not by reductionist methods. This does not mean that the United States must sacrifice either its affluence or its power. In fact, a shift from the reductionist methods of the past to the holistic methods of the future would probably increase American affluence and power by increasing the happiness, mental health, stability, and security of the American people.

The chief weakness of reductionist methods is that each problem is dealt with in isolation and the costs of solving problems are cumulative. But a holistic approach makes it possible to solve several problems at once by putting them together into a single system in which the problems provide solutions for one another; the different costs often cancel each other out. For example, consider three problems: the potential shortage of gasoline; atmospheric pollution from using gasoline (including lead poisoning from antiknock compounds put into motor fuel); and the enormous costs of dumping or disposing of trash. Today we pay these costs separately. But in December, 1973, *Science* published plans for a retort that would convert municipal refuse or other waste into methanol (wood alcohol) and would recover metals and molten glass.[1]

About a year later, the state of Maine, which is

[1] *Science*, December 28, 1973.

very short of fuel, announced that it was going to use a similar scheme to convert the great tracts of dead trees there into methanol to be used as heating fuel. Methanol costs much less than gasoline (below 20¢ a gallon). It is 108 octane and can be used in automobiles in a ratio up to one-seventh of each tankful without modifying any parts of the engine, or in greater proportions up to 100 percent methanol, with slight engine changes. In addition, it has superior antiknock characteristics (far superior to lead). Any methanol fuel mixture, according to scientists at MIT's Lincoln Laboratory, "results in improved economy, lower exhaust temperature, low emissions pollutants, and improved performance, compared to the use of gasoline alone." These scientists add that methanol "is safe clean fuel for home heating and can be burned in power plants to generate electricity without polluting." Methanol does not have to be made from trash but can be made from many other substances, including coal (cost about 8¢ a gallon); it can be delivered or transported using current delivery systems for petroleum.[2]

A similar holistic approach may solve the following problems: the shortages and high costs of fertilizer (now largely made from natural gas); the shortage of natural gas; the pollution of streams, lakes and oceans by sewage; and the high costs of disposing of sewage. If sewage and other organic wastes were processed into fertilizer, at least in cities (as it is in Milwaukee), these four problems would help solve one another, with great savings in money and energy and a large decrease in environmental pollution. In fact, a Swedish toilet now available has no connections outside the house and converts sewage into dry powder fertilizer within the house without odors or the use of water.[3]

An example of the sharp contrast between reductionist and holistic views appears when we realize that although it is illegal for corporations to pay dividends out of capital, the American economy as a whole has been paying dividends (wealth) out of capital (our natural resource base) increasingly since 1840. In 1840, our resources included energy from the sun locked up in our reserves of fossil fuels (coal, gas and petroleum) millions of years ago, as well as in great forests that had captured energy from the sun in the centuries before 1840. Since 1840, and especially since 1940, we have used up those capital reserves of solar energy with increasingly reckless waste. Because we have been living off resource capital but treating it as income, our energy costs have been very low. These low costs encouraged Americans to build up a wasteful "energy intensive" society, in which manpower was reduced by so-called "labor-saving" methods; later, land was also eliminated from the productive processes, and energy-wasting activities on a smaller percentage of our land ("high-rise urbanization") became the core of our economic and business activities. Since 1973, the rising costs of energy, really a blessing in disguise, are forcing us toward a reallocation of resources, which will ultimately bring manpower and land back into the productive system in a more decentralized, more diversified, more flexible, sounder, and more satisfying structure.

The vested interest groups in our society who profit from the destructive course we have been following insist that we must solve the energy crisis by increasing our speed upon that same course, using gross production figures to support their arguments. They ask us to exhaust our resources of fossil fuels even faster, to increase the pollution of our environment by abandoning our puny environmental protection measures, and to ignore the rising tide of social and emotional problems in urban and suburban life. These misguided "experts" insist that the cure for destructive technology is more destructive technology, and that the only way to solve one problem is to ignore or increase other problems. The truth is that the only permanent solution for any one of these problems lies in finding a solution for all these problems together.

Any extensive reallocation of resources must function as a kind of long-range master plan within which we must seek two other shorter-range goals. These are: to reduce the present waste of energy, which now amounts to over half the energy we use; and to increase the supply of energy, especially from the natural sources of energy income rather than from our remaining deposits of energy capital. Energy conservation, especially the elimination of energy waste, must be tackled before we seek new sources of energy.

There are only four sources of energy: the rotation of the earth, which can be harnessed through the tides: the internal heat of the earth, which can be tapped through geothermal wells; the sun; and atomic power, which can be obtained by fission or fusion. Today, atomic fission is achieved either in plants using moderated uranium or in "fast-breeder" reactors. Our only fusion power source is the sun itself, although considerable money and energy have been spent on research on fusion.

Tidal power has been harnessed in some other countries, notably in France. But the only promising location for its use in the United States is at Passamaquoddy Bay in Maine. This site has a potential of over two billion kilowatt-hours a year, but has been a subject of controversy since the New Deal

[2] T. B. Reed and R. M. Lerner, "Methanol: A Versatile Fuel for Immediate Use," *Science,* December 28, 1973, pp. 1325–1332.

[3] R. Wolf, "Is There a Flushless Toilet in Your Future?" *Organic Gardening and Farming,* April, 1975, pp. 108–112. Per year per person, this toilet delivers about 60 lbs. of 20:12:14 fertilizer.

over 40 years ago. The quarrel is not yet dead, but the severe power shortage in northern New England makes it a more attractive project.

The internal heat of the earth is used in a few places in the United States, notably to produce a small fraction of the electricity of San Francisco, at a cost far below that of the rest of the city's power. But this is not likely to contribute much to our energy crisis in this century.

The energy of the sun can be captured either by physical processes, like focusing its rays to boil water, or by chemical processes, like raising carbohydrate crops to burn in living people, who can then utilize the solar energy released in digestion. The physical processes are of four kinds: from winds; from falling water; from the differential heat in the geosphere, either in the atmosphere through a heat pump or in the oceans through more complex and largely undeveloped techniques; and from the direct use of the sun's heat or light in various ways. The chemical processes are largely biological, of which the best known is through vegetation, either natural or agricultural. In these chemical processes, solar energy is locked up in more complex compounds made by plants out of carbon dioxide and water; this energy is released when these complex compounds, like sugar, are burned and reduced to the original carbon dioxide and water again. All fossil fuels are compounds that were created in the remote past by plants and animals by chemical capture of solar energy.

The energy income from the sun is practically limitless, whether we view it in terms of winds, vegetation, atmospheric, or oceanic heat, or direct radiation; but it cannot be used until we know how to collect it, store it, transform it, and transport it. All of these steps involve energy losses, and we know little about required techniques, especially storage. We must also remember money costs, environmental changes and social impacts. If we had a choice between large energy losses at low money cost and very efficient energy use with little loss, our choice might be based on the fact that the inefficient use of energy, by releasing heat into nature, may have very damaging long-range effects.

The real problems are not so much the capture or collection of energy (these are often done for us by nature as in winds or rainfall), but storage or transformation. Since fossil fuels are a natural method of storing energy, which can then be transformed or converted into heat, work, electricity or food, we have never given much attention to methods of storing energy, except for the familiar (and expensive) dam reservoirs and storage batteries. We could capture enormous amounts of energy from the wind, but we have developed no effective methods of storage.

It has been suggested that wind energy, converted into electricity, could be used to separate hydrogen and oxygen in water; the hydrogen could then be transported by pipeline to plants far away where it could be burned to release again the energy that had separated it. This method is attractive because pipeline transportation is the most efficient method of transportation; we already have a network of pipelines; and hydrogen-burning is the least polluting kind of combustion, since it produces water vapor. For this last reason, hydrogen is the most desirable form of residential heating, for it needs no flue or chimney (a great heat-waster) and houses will not suffer from low humidity.

Another kind of energy storage that has been neglected is flywheels. Wind or electric energy could be stored in the momentum of vacuum-contained fiber flywheels, while smaller flywheels could be used as silent, totally nonpolluting, engines for vehicles. We are told by R. F. Post of Lawrence Livermore Laboratory that such a flywheel in an automobile body could be "revved up" in five minutes on any house electric outlet to 30 kilowatt-hours of momentum energy, enough to drive for 250 miles at 60 mph. Or the car could be left up to six months without running down.[4] Travel in such a car would have an energy cost about one-fifth that of gasoline, with all the mechanical problems much simplified. The car could be braked by putting its kinetic energy back into the flywheel. And coin-operated electric outlet booths along the highway instead of filling stations would save those thousands of lives a year now lost in gasoline fires.

New methods of converting energy must be developed along with new methods of storage. Two that appear promising are heat pumps and fuel cells. A heat pump is like any refrigerator, except that it pumps heat into an enclosed space, like a house, from outside the enclosure, while a refrigerator pumps heat from the enclosure to the outside. A heat pump has two surprising characteristics that make it attractive. It works at more than 100 percent efficiency, since it can bring into the hosue from outside more than the heat equivalent of the energy it uses. And it can pump heat in even when the outside is very much colder, in effect pumping heat uphill. Moreover, the same heat pump can be used in reverse to cool the house in summer by pumping the heat outward instead of inward. If used in this way, a heat pump is cheaper to install and to operate than the usual separate heating and air conditioning systems.

Fuel cells need more development than heat pumps before they will be financially competitive with most methods for making electricity from fuel. They were very successful on the Apollo space missions, and prices are falling as technical improvements continue. They are silent, nonpolluting, and operate with almost equal efficiency at all parts of their operating

[4] See R. F. Post, *Scientific American,* December, 1973.

range (compared to conventional electric generators that operate with low efficiency below 40 percent) at full speed and have very much lower efficiency at lower speeds. Such fuel cells oxydize any fuel, but work best on hydrogen, joining the two gases together, with the released energy appearing as electric current.

Much of the energy waste and pollution of our present energy system (based on the generation of electricity from fossil fuels at central power systems and carried long distances over wires) come from intrinsic weaknesses in this system. Less than 40 percent of the fuel energy is taken from the fuel even under the best conditions, with much pollution and great loss of heat to the environment, and considerable energy loss in carrying electricity over wires to the consumer. Moreover, since the plant runs at full power for only a few hours a day, with less demand for current during much of the day, it operates at low efficiency during non-peak hours. Since electricity, like wind power, cannot be stored, electric utilities have tried to store current by pumping water into high reservoirs during slack hours and using the power of the falling water to generate current again at the peak hours. This is wasteful; it requires very expensive, large reservoirs, and takes years to build, especially if the project arouses controversy.

To encourage our energy system to develop better methods, we must allow energy costs to rise, especially the cost of fossil fuels. Fossil fuel costs are bound to increase anyway, as they become scarcer and as extraction costs increase. Not only must the price of petroleum products be allowed to rise, but electricity rate structures must be reformed to reduce waste. At present, utility rates reward waste by reducing the prices of successive increments of electricity as more is used by a customer.

Because the efficiency of most utility systems averages about 31 percent, a revised rate structure with higher fuel costs would encourage the more efficient practice of generating electricity locally and using the incidental heat, which is lost in a central power station, for heating and cooling the buildings which receive the electricity. If the fuel was nonpolluting, like natural gas, methanol or hydrogen, we could increase the output of current while reducing electric generators' waste and pollution. This decentralization of electricity generation is supported by the United States Department of Housing and Urban Development, but it is violently opposed by the profit-seeking energy establishment, although it would waste as little as 15 percent of the fuel it used, compared to the over 60 percent now wasted in coal-fired central utility plants and the more than 70 percent wasted in uranium nuclear generating plants, both types causing great environmental pollution.

At present, almost all the plans for increased energy supply deal with individual installations, estimating costs in money terms instead of in real terms, and omitting costs that can be "externalized," that is, excluded from the corporation's accounting methods by being charged to the community. Recently, feeble efforts have been made to require environmental impact evaluations, but in all private installations, decisions are still made in terms of money costs, not energy costs. It must be evident that what is profitable to an enterprise in money terms may be disastrous to the country in real terms. The Arab oil embargo was profitable to petroleum corporations, but, in the short run at least, it was damaging to the country and to millions of individuals. The significant decisions in the energy crisis must be made in real terms, not money terms, on the basis of the general welfare and not for a few favored business firms, and must be made within a total energy budget for the country.

For example, it is claimed that the only solution to the energy crisis is a crash program to build nuclear power plants, especially "fast-breeder" reactors. We are told that a projected nuclear generator will produce one million kilowatt hours of electricity, but we are not told how much energy outside the reactor is needed to build, maintain, and protect the plant, nor are the costs of the reactor to the community discussed. The whole story is too complex to explain here, but, briefly stated, the energy input costs of nuclear power are greater than the forseeable energy output, so that there is little or no net increase in our energy supply. Even in money terms, there is no gain. In 1973, electricity from nuclear plants comprised less than 1.5 percent of our total supply, about the same amount as the energy supplied from burning wood. Yet private industry and the Atomic Energy Commission (which insisted that nuclear energy would provide us with almost limitless supplies of "cheap, clean power") together spent over $40 billion to create a nuclear power business between 1947 and 1970. The internal costs of producing nuclear energy increased from $135 a kilowatt hour in 1960 to $555 in 1972; they have increased much more since. This compares with a few cents per kilowatt hour for electricity from fossil fuels.

The nuclear generators used until 1972 were moderated uranium reactors, which can be used only a few years more; our domestic supplies of uranium will be exhausted by 1990, according to a United States Geological Survey report of May, 1973. This is long before our domestic resources of fossil fuels will be used up. Yet, according to Wilson Clark,[5]

[5] Wilson Clark, *Energy for Survival: The Alternative to Extinction* (New York: Anchor-Doubleday, 1974), p. 652. A good guide to technical details is Hans Thirring, *Energy for Man: Windmills to Nuclear Power* (Westport, Conn.: Greenwood Press, 1968), p. 409ff.

"virtually all government funds spent for research into all energy technologies since World War II have been devoted to the development of nuclear reactors." This is a result of propaganda and the suppression of evidence by those interested in the project, including the AEC itself.

Interested parties have tried to conceal the dangers of nuclear power plants and the fact that such plants are unreliable and dangerous. The plants are always behind schedule in construction, sometimes years behind; they suffer constant breakdowns, and all nuclear breakdowns are expensive and of long duration because of the dangers of radioactivity. These dangers are so great that even the overly optimistic estimates of the AEC showed that it would be financially impossible for private industry to build nuclear reactors because of the high costs of liability insurance. AEC figures showed that a major nuclear accident might kill 3,400 persons, contaminate up to 150,000 square miles more or less permanently, and cause $7 billion in property damages.

To persuade private industry to invest in nuclear power under these conditions, the Price-Anderson Act of 1957 arbitrarily limited the aggregate liability for each nuclear reactor accident to $500 million, only one-fourteenth of the AEC damage estimate; since that time, most private insurance policies for individuals have been rewritten to exclude any protection against nuclear radiation damage. Nuclear energy costs continue to skyrocket, and plant breakdowns are increasing in frequency. The *Wall Street Journal* of May 3, 1973, summed up the situation on nuclear generators: "Their unreliability is becoming one of their most dependable features."

If this is true of the already obsolete moderated uranium plants, it is even truer of the newer "fast breeders," despite the fact that on June 4, 1971, President Nixon declared that: "our best hope today for meeting the nation's growing demand for economical clean energy lies with the fast breeder reactor." Two-thirds of the earliest fast breeders broke down on their trials from fuel-core melting, the most dangerous type of reactor accident. But without fast breeders there is no future for nuclear power, because of the enormous cost and short supply of the U235 used in moderated uranium reactors. The fast breeder can be started on natural uranium, but it continues running on plutonium, which it creates itself in increasing amounts, so that it must be removed. The production of plutonium creates insoluble problems of security, accelerating to astronomical levels the financial, social and security costs of nuclear proliferation and waste disposal.

Plutonium, a radioactive element not found in nature but produced by both types of nuclear generators, is an incredibly deadly poison, far more poisonous than botulism and 35,000 times as poisonous as the cyanide used by the German Nazis for instant suicide. Worse than that, plutonium explodes spontaneously in any mass over about 15 pounds, and a fast-breeder reactor needs almost two thousand pounds to operate. Plutonium is the explosive force in our nuclear weapons. Today any gang of determined persons who have access to the wastes of a fast breeder can obtain by stealth or by violence a few small cans of plutonium to use as poison or to make a nuclear bomb.

AEC rules excluded any consideration of the costs to the community of projected nuclear generators, and the agency's rules have not been changed to fit the Environmental Protection laws of 1970. As a result, it has been necessary to ask the courts to force private nuclear plants to conform to environmental protection rules. The waste products of atomic energy are radioactive, poisonous, and corrosive. Uranium wastes have a half-life of 4.5 billion years, while plutonium wastes have a half-life of 24,000 years; both are also mixed with other radioactive materials. Each waste remains dangerously radioactive for about ten times its half-life. This means that nuclear wastes must be guarded in containers that corrode and must be replaced, for liquid wastes, at least every 20 years. Thus for thousands of generations wastes must be kept out of the environment, like underground waters, and out of the hands of desperate men. This is physically impossible, and the costs of trying to protect the environment against such wastes will soon be unbearable. In fact, at Hanford, Washington, at the original plant for making plutonium for weapons, in the course of only 30 years, the corroded stainless steel tanks were not replaced within the maximum period of 20 years; thus up to half a million gallons of bubbling uranium wastes have leaked into the earth from 108 over-age tanks.[6]

Threats from the increased use of fossil fuels are more remote, and arise from thermal pollution in the atmosphere rather than in the water. All estimates about the size of United States petroleum reserves

(Continued on page 43)

[6] R. Gillette, "Radiation Spill at Hanford," *Science*, August 24, 1973, pp. 728–730. It has been suggested that nuclear energy could be handled safely if the whole process, including all wastes, were sealed off from the environment and if the heat were used to split water to obtain hydrogen for use in a hydrogen economy. See W. Häfele, "A European View of Energy," *Science*, reprinted in Philip H. Abelson, ed., *Energy: Use, Conservation, and Supply* (Washington, D.C.: American Association for the Advancement of Science, 1974).

Carroll Quigley, a contributing editor of *Current History*, is the author of *Tragedy and Hope: A History of the World in our Time* (New York: Macmillan, 1966) and *The World Since 1939: A History* (New York: Collier Books, 1968).

AMERICA'S FUTURE IN ENERGY

(Continued from page 5)

are simply educated guesses and are juggled and manipulated to suit the interests of those who make or use them. Moreover, even if the estimates were accurate, they do not reveal how much energy it will cost to obtain each additional unit of energy recovered. On a world basis, there is still no shortage of either oil or natural gas, but the United States is clearly on the downward slope with regard to both of these. It should be the chief aim of Project Independence to make that slope as gradual as possible by eliminating waste and by allocating the reserves to less damaging end uses. We can reduce waste or poor allocation by using a holistic approach to the problem.

Our most important natural resource is topsoil, with water a close second; both are essential to life and to our ability to obtain energy from our only continuous source of energy, the sun. The greatest resource in our topsoil is the worm who makes new topsoil very slowly, yet our energy intensive agriculture steadily destroys both topsoil and worms. The National Academy of Science says that one-third of our topsoil is already gone. Much of this was lost by erosion even before 1940, when our wasteful use of energy in agriculture began to destroy the texture and the vital organisms of topsoil.

Agriculture is a key to the energy crisis. Even before the New Deal, American agriculture sought high output per man-hour of work by labor-saving machinery that was destructive of the land and gave a low output per acre. During the New Deal, the federal government paid farmers to withdraw land from cultivation, turning agriculture toward high-energy patterns which meant less labor and less acreage, but more capital per acre to get high yields. This required so much capital that many families could not afford it, so food production was taken over by corporations and agribusiness, owned by conglomerates and energy companies. Organic manures were replaced by artificial fertilizers made from fossil fuels, chiefly natural gas. Mixed farming was replaced by hybrid monoculture that required enormous inputs of fertilizers, pesticides, herbicides, and drugs, mostly made from fossil fuels that polluted the environment with great damage to the natural organisms in the soil. As a result, farming today uses more petroleum than any other single industry in the United States; the input of energy must increase every year to maintain the same high yields. In Illinois, in 1949, 20,000 tons of fertilizer produced 50 bushels of corn per acre, but in 1968, it required thirty times as much fertilizer (600,000 tons) to get 93 bushels per acre. Because of rising costs, the farmer had to produce 80 bushels per acre just to break even.

Agriculture used to capture energy from the sun so that men and animals could work. Today, more than ten calories of energy must be put into farming for every calorie that comes out. Now one man can care for up to 75,000 chickens, or 5,000 feed-lot cattle, or 50 milk cows, on farms run as specialized plants. At the same time, the children of former farmers are on relief without work, decent food or even heat, and are destructively unhappy, in northern cities (more than one million persons were on relief in New York City in April, 1975). As one consequence, crime and violence are making our cities uninhabitable. This must be regarded as a cost of our high-energy agricultural system. We must also include as costs the government agricultural subsidies and the farm corporation tax benefits that propel our whole food system along this destructive road.

Between 1945 and 1970, corn yields increased 240 percent, from 34 to 81 bushels per acre, while labor used decreased 60 percent, from 23 hours per acre each year to only 9 hours. At the same time, fertilizer input increased from 19 pounds per acre to 203 pounds, and drying energy (because hybrid corn is too moist) went up from 4,000 to 120,000 kilocalories per acre. The total energy input per acre of corn in 1970 reached 2.9 million kilocalories, equal to 80 gallons of gasoline, up from 0.9 million kilocalories in 1945.

For biological reasons, the excess use of hybrid seed is self-defeating and dangerous over the long run (say 25 years) because hybrid seed is bred for an increasingly artificial environment, including soil oversaturated with nitrogen and other pollutants. It is also incapable of performing well in the natural environment, because its genetic strain is too narrowly specialized. As a result, natural pests can adapt to it so well, by natural selection, that they can wipe out a major part of the crop after a few years.

At present, the American public, including Secretary of Agriculture Earl Butz and most scientists, does not recognize the dangers inherent in our high-energy agribusiness system, but the situation is increasingly ominous. Disaster can be avoided only if the rising costs of energy force us back toward an organic, more labor-intensive farming system, replacing monoculture with a more diversified system. More than a million kilocalories per acre could be saved and soil conditions could be improved with a great reduction of pollution if we replaced artificial fertilizer by manure and decentralized feedlots. If we could restore crop rotation with winter legumes (used as fodder), we could save 1.5 million kilocalories per acre more in energy and would improve both the soil and human diets. Replacing herbicides with a rotary hoe could save 10 percent energy in weed control, and the use of biological pest controls instead of chemicals would save more. If pesticides were applied only as needed, rather than routinely, energy costs would be reduced 35 percent, while doing this by hand rather than by machine would reduce energy for this from 18,000 to 300 kilocalories per acre. Almost total abandonment of chemical farming would reduce food output 5 percent, would increase farm prices 16 percent (the same amount they fell in the year March, 1974, to March, 1975), and would increase farm income about 25 percent, would bring much unused farm land back into cultivation, and would save vast sums in government subsidies. It would also encourage unemployed city dwellers, or at least their children, to return to rural areas, with some savings in welfare costs.

Just as government subsidies and special-interest tax benefits have made agriculture wasteful of energy, so they have also given us a wasteful transportation system. If, for example, tax rules required depreciation over the life of the equipment, and if energy costs rose, producers would turn from wasteful to energy-efficient methods. Similarly, our transportation system would have been much more careful about wasting energy if the government did not subsidize wasteful modes of transportation, like airlines, keeping their fares down, while refusing to help energy-efficient modes of transportation and allowing their fares to rise. Forty-one percent of all our energy in 1972 went to transportation. The most efficient way to move goods is by pipeline, at 450 Btu. a ton-mile, and the least efficient is airfreight, at 4,200 Btu. a ton-mile. Railroads move freight for 670 Btu. a ton mile; competing trucks use 2,800 Btu. a ton-mile. Over 20 years, from 1950 to 1970, railroad efficiency increased from 3,045 to 670 Btu. while in the same years truck efficiency decreased from 2,400 Btu. to 2,800 Btu. Yet railroads were hampered by public policy; trucking and airlines were encouraged and subsidized.

Moving people has been just as wasteful. Auto travel in general moves people at an energy cost of 5,400 Btu. per passenger-mile, exceeded only by autos in cities, at 8,100 Btu. and airlines, at 8,400 Btu. Between cities, railroads move people for 2,900 Btu. a passenger-mile; buses use 1,600; and private automobiles use 3,400 Btu. a passenger-mile. In cities, mass transit moves people at 3,800 Btu. a mile each, less than half the automobile cost of 8,100 Btu. Yet government subsidies have consistently gone to the most wasteful; an annual subsidy estimated at $38,000 a year goes to each private business turbojet plane. More than 80 percent of the federal transportation budget has gone to highways and airports, while only 5 percent has gone to mass transit and railways. At the same time, regulatory agencies, chiefly the Interstate Commerce Commission, have allowed railroads to destroy their passenger service and to neglect their tracks and equipment so that these have now dangerously deteriorated, and have driven passengers from buses and railroads to private autos and airplanes by allowing air fares to increase only 8 percent during 1950–1970 compared to increases of 90 percent in buses and 40 percent in rail fares.

The drive toward private profit is also apparent in the search for new oil reserves. Petroleum corporations say that if they are allowed to make outrageous profits and freed from any concern about the environment, they will increase their exploration for new petroleum reserves and will find enough to meet our most wasteful desires. This is sheer propaganda. For more than 50 years, oil companies have enjoyed profits and freedom from environmental restraints equalled by few other corporations, yet their discoveries of new reserves and new pools of oil have been decreasing. Instead of using profits for the domestic exploration for new reserves, petroleum firms have sent their profits overseas or have used them in this country to take over other businesses like our largest circus, our chief motel chains, our largest coal mines, and much agribusiness.

But even if all oil company profits were devoted to seeking new petroleum resources, the rate of discovery of new reserves is not likely to grow. The consensus among serious students of the subject, like the National Petroleum Council, the American Association of Petroleum Geologists, and a recent committee of the National Academy of Sciences, is that we used more than half our total recoverable supply of oil in the period from 1856 to 1974 (100 billion barrels), and have a smaller total remaining, which can be extracted only at constantly increasing costs in both energy and money. Off-shore oil exploration is too expensive when both immediate and holistic costs are considered.

The solution is to devote less money to seeking new oil pools and to devote more money to achieving a higher rate of extraction from known oil pools, since the rate of "recovery" is now only about 30 percent. If we could secure a larger part of the oil we know is in the ground, by raising the recovery rate to 35 percent or more, and, at the same time, if we could increase the efficiency with which we use petroleum (eliminating waste and needless or damaging uses, as in agriculture), we could help to close the petroleum gap from both ends. At present, 80 percent of the energy in gasoline is wasted.

A recent article in *Science* by R. R. Berg et al. says: "Oil recovery methods capable of recovering a high percentage of the oil remaining in abandoned fields are known."[7] Such fields could be reactivated as the price of oil rises.

[7] R. R. Berg et al., *Science*, April 19, 1974, pp. 331–336.

The other "exciting new source" of oil is the oil shales of the Rocky Mountains (Colorado). Here the technology for extraction of oil is known and could be covered by an oil price of about $6 a barrel from the best shale. But the total costs in money or resources are so large that no extensive exploitation is likely unless the government subsidizes production. It would be far better to use public money for energy conservation, subsidizing mass transportation or providing low-cost loans to insulate homes heated by natural gas. The fuel in oil shale is kerogen, which exists in very small amounts in the rock (usually far less than 30 gallons per ton), so that tons of shale have to be dug out, transported, processed with heat, and disposed of for each barrel of oil recovered. The energy needed to extract the oil is likely to be greater than the energy in the oil recovered.

The costs to the community are also very formidable. The rocky residue that must be disposed of after extraction is full of salts. Present plans are to dump this in nearby canyons, but even if enough canyon capacity is found, the debris would have to be leveled, to prevent sliding, and would have to be covered, to prevent blowing. It would have to be covered with topsoil, which is in short supply in the area, and the topsoil would have to be held down by vegetation. It is very unlikely that local vegetation would grow, because the debris is too salty, and the local rainfall is below 15 inches a year. Such scanty precipitation is not sufficient to establish vegetation, but unfortunately it is enough to leach out the salts, so that the salinity of the Colorado River at Hoover Dam might increase by 50 percent. This would increase the costs of desalinization downstream, where there is already an excessive demand and an insufficient supply of residential and irrigation water. Since the most promising shale area is now only scantily inhabited, although it is within 100 miles of the ski resort at Aspen, homes, roads, stores, schools, hospitals, and other facilities for workers would add to the costs of this enterprise. And local wildlife would be exterminated.[8]

The voting population of Colorado will not accept this development without a struggle. Nonetheless, the corporations concerned hope to obtain government subsidies large enough to make the experiment profitable with little regard for its impact on the area. Even if the environmental problem is ignored, the net yield of energy will be so small, the costs of extracting the shale and dumping the debris are so great, and the water supply is so inadequate that oil shale offers little help in solving the energy crisis, especially in comparison with the coal in the same area, which will be competing for the same inadequate supply of water.

The United States has plenty of coal. The size of its reserves can be judged from the fact that the energy content of our coal is at least 18 times that of the Arab oil reserves. It has been estimated that if West Europe and Japan obtain two-thirds of their energy needs from the Middle East, the Arab oil would last about 23 years, but if United States coal were consumed at the same rate, it would last over 600 years. The real problem is not the supply of coal but how to get it out of the ground with the maximum gain in net energy and with the minimum damage to the land and the people.

Over the last 50 years, coal has not been able to compete with oil in convenience or in price, even with great sacrifice of the land, the coal field environment, and the health and lives of the miners. Strip-mining, even without regard to environmental damage, could not drive the price of coal low enough to compete successfully with oil. The new leaders of the once corrupt United Mine Workers Union are determined to improve the conditions of deep-mine workers. At the same time, it is impossible to continue to destroy the land by strip-mining, because the costs of the damage, including the loss of topsoil and the danger of increasing dust storms in the West, would become too large to bear. In 1970, the cost of deep-mined coal was $7.40 a ton compared to $4.69 for stripped coal, and 44 percent of all American coal was produced by stripping.[9] The costs of reclaiming the land after stripping can run up to $2,700 an acre or more, but if the surface is too sloped, or the climate is too dry, or the underground streams (aquifers) are destroyed by the stripping, it may be impossible to rehabilitate the land at all.

Unfortunately, the best remaining coal reserve in the world, the very thick, low-sulfur deposits of our northern Great Plains, lie where the rains are eight to fifteen inches a year and the aquifers run through the coal. Moreover, this is also our region of high and fairly constant winds, which is why W. E. Heronemus of the University of Massachusetts has suggested the plains as the proper place for windmill power. When the sod of the plains was broken for wheat farming in World War I, the subsequent dust storms darkened the skies at noon as far away as Chicago. This was one of the reasons the New Deal paid farmers to withdraw these lands from planting. In 1971, the United States government secretly opened those lands to enormous strip-mining projects that cover over 250,000 square miles of land, to generate electricity on the sites and send it by wires over thousands of miles of 765,000 volt transmission lines. All environmental damage and all wastes, including enormous ash residues, were ignored. The

[8] W. D. Metz, "Oil Shale," reprinted from an article in *Science*, April 19, 1974 in Abelson, *op. cit.*

[9] Jane Stein, "Coal Is Cheap, Hated, Abundant, Filthy, Needed," *Smithsonian*, February, 1973, pp. 18–27.

first step of the project will produce 50,000 megawatts by 1980, stripping up to 30 square miles a year to obtain 210 million tons of coal by using 855,000 acre-feet of water. The plants are to operate for 35 years, destroying more than 50,000 square miles of surface.

This North Central Power Project is already being constructed, and probably cannot be stopped or substantially modified by judicial action, since the Supreme Court, in March, 1975, refused to stop a similar project, known as the Four Corners Project, on the much drier southern plains where Colorado and Arizona meet. The more northern project will probably have to be forced to cover the external social costs by legislative action. But timely action is unlikely, because the energy-utility interests almost totally control the executive branch of the federal government and are very influential in Congress. The operators would have to be required to operate deep mines or to guarantee the total rehabilitation of strip-mined areas (probably impossible if the aquifers are destroyed, as they may be). Moreover, the wasteful generation and transmission of electricity should be replaced, as far as possible, by methods more economical of coal, energy, and water, like the gasification of the coal, which provides energy at about half the cost in water. The energy losses in moving gas in pipes, further, is only a minute fraction of the energy costs of moving electricity. Moreover, power lines deface the landscape and dangerously affect the atmospheric ozone balance.

If deep-mined coal is used instead of stripped coal, the immediate costs will be greater; if stripped surfaces are rehabilitated, the increased cost of the coal might be 50¢ a ton. Nonetheless, the costs of any energy production must be borne by the American people. It is wiser for society to pay more for coal mined under better conditions than to produce coal at a lower money cost and pay great social costs later.

It is possible that much Great Plains coal could be left in the ground if we use the coal that now pours out of Norfolk, Virginia, to foreign countries. Norfolk's abundant water and coal could be used to make gas, methane, hydrogen, and even electricity, all of which could be distributed more cheaply than Great Plains coal by expanding existing pipelines and electric power lines to energy-short areas.[10] The argument against this, that we need the foreign exchange we get from coal sales abroad, is worthless. Our foreign exchange problems can be resolved more effectively by financial measures. And the political security of the world could be improved if Japan took over our share of the Middle East oil and obtained her coal from other areas, like China.

[10] A. M. Josephy, "Agony of the Northern Plains," *Audubon,* July, 1973, pp. 68–101.

An increase in net energy from coal should be regarded as a transitional stage, perhaps of long duration (up to 60 years or so), toward a new energy system based on cleaner, more economical energy, like hydrogen, methanol, methane, and other gases or liquids, distributed by pipelines or tanks instead of wires. There should also be a substantial shift away from airplanes and private vehicles toward mass transit, railroads, and buses, and the present wasteful cross-traffic of both goods and people should be reduced, to produce a healthier and happier society. There should be more autonomous and decentralized communities, in which people are closer to nature and to each other, and are less concerned with spectator activities, and increasingly involved in community activities, including food production and the essential cycles of nature. Spectator activities and mercenary armies have always been the key symptoms of a society in decay. They can be avoided by wise energy decisions. ■

THE OIL-DEPENDENT DEVELOPING COUNTRIES

(Continued from page 24)

depletable resources will be eased. At the other end of the research scale, attention should be directed to the widespread needs for energy in small scale and diffuse uses. A fourth factor is the global scope of the environmental impact that the energy policies of individual countries, or industrial firms within them, are causing. Oil spills in the oceans and radiation levels in the atmosphere cannot be safely left to decisions at a national—or industrial—level.

Whether there is a possible and practical level at which energy policy can be coordinated internationally is a question that is just beginning to be seriously addressed. Limiting factors and conflicting interests crowd in on all sides when the possibility is raised. But the underlying urgencies remain. Perhaps international coordination could usefully be explored in a framework analogous in some ways to that now being worked out for food. The World Food Conference in Rome, in 1974, brought together all sectors of the world community—the U.S.S.R. and the People's Republic of China included—to approach a worldwide problem in global terms. Goals were set and means were proposed for dealing with them in various time frames. Institutions covering the major facets of the food scene and involving all the key participants were proposed and accepted. Whether this kind of approach could be applied to world energy problems is worth exploring. The shock of the OPEC action may prove to have opened up an awareness of the global energy predicament in a constructive way. ■