World Energy Perspectives

Five members of Caltech's Board of Trustees discuss the current energy situation, how it happened, and some possibilities for the future

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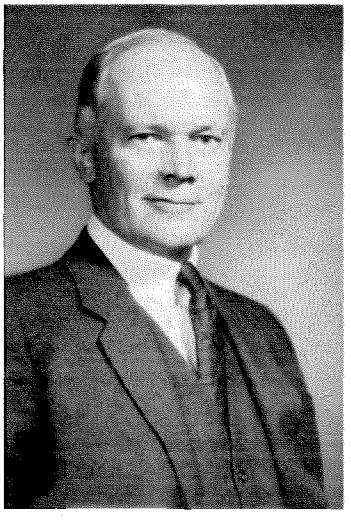


A brief overview of where we are in the energy situation and how we got there is in order because we are in a situation which can only be described as truly grim. We do have an energy problem. We're the only country in the world that does not seem to recognize it, but I can assure you that it is real.

Henry Ford started it. The introduction of the motor car was the beginning of what we know as modern energy use. In 1920 it was a question of which would give out first — dirt roads or gasoline. Gasoline hit 25¢ a gallon — probably its all-time high price on a constant dollar basis. Fortunately, two discoveries of oil in Los Angeles saved Henry Ford and the automobile industry — Kettleman Hills and Midway provided oil to support the eastern seaboard. Oklahoma City came along in the mid-1920s and took care of the growing industry. But the real windfall was the discovery of the east Texas field in 1931-32. This field was so large that it completely dwarfed all known discoveries in the United States or anywhere in the world at that time. It carried the United States and its allies comfortably through World War II.

The east Texas field and subsequent discoveries created the feeling — the myth — that we're living in a world afloat with oil. This feeling of great relaxation was enhanced by the huge discoveries made in the Middle East. There are now some eight to ten oil fields in that part of the world which have come quietly to the forefront and now dominate oil production

The first test of oil production after World War II was in 1957 with the closing of the Suez, but Texas oil production — the mythical power — rose to meet the needs, and we passed that crisis with barely a bobble. In 1967 we had a repeat threat and this time the Texas fields had a little more difficulty meeting the extreme demands on them. Fortunately, the crisis was rather brief and was quickly passed.

At this point, I would like to drive one point home. There are two ways by which you gauge the availability of oil. One is by reserves, and the other is the rate you can extract it. There are absolute physical limits to how fast oil can be taken out of an oil well. The chief problem today is getting to be producibility, not reserves. This is the first time the world has faced that limitation.

Let me give you an example. In 1970 the state of Texas decided to remove all controls on oil production other than those that were absolutely necessary for short-term needs to protect oil and gas ratios. Now, according to popular and conventional wisdom at the time, Texas had a shut-in capacity to produce an additional two to three million barrels a day. But when this producing capacity was released, it turned out to be virtually non-existent. Within a year, Texas production had settled back to roughly where it had been before de-control — some ten million barrels a day.

For many years, OPEC countries had been dominated by the threat that the United States would, if necessary, release this vast quantity of oil in Texas to keep the OPEC

prices under control. It worked, and until 1970 very little oil from the Middle East was sold at a price as high as $1 a barrel. Of course, once this sword was removed from over OPEC's head, OPEC became a viable and a very effective cartel. By early 1972, it had negotiated its first worldwide price increase to $2.50 a barrel, a huge step forward because it proved that these countries could move in concert.

When OPEC realized that the embargo it had imposed in 1973 was failing, its first move was to double the price of petroleum to $5.50 a barrel. That didn't seem to get the world's attention, so between Christmas and New Year's of 1973, it just decided to double the price again — to $11.00 a barrel — and see what would happen. Amazingly enough, that price stuck, and I think OPEC was more surprised than anyone else. What had happened was a quadrupling of world oil prices in a matter of six or seven months.

The reactions were interesting. The rest of the world's consumption of petroleum declined rather significantly in response to the price and the recognition that there were problems with each nation's balance of payments. Developing countries in the extreme and even Europe and Japan significantly reduced their consumption. The only country that did not was the United States, which significantly increased its consumption and its imports.

Now this was the scenario when we moved into 1978. I believe, and I am going to climb out on a limb here, that history will show that world oil production peaked in the last six months of 1978, and in all probability that peak will never be reached again. Figures released in the fall of 1979 by the International Energy Agency in Paris would support this contention.

The collapse of Iran really triggered the start of the decline of world oil production, which this year will probably be down one to two million barrels below the level of the last third or fourth quarter of 1978. This is being driven home very dramatically by something that is not generally known; the present price of world oil is nearly $40 a barrel. The official OPEC price of $22 to $24 ($18 in Saudi Arabia) has practically no relationship to the going price of oil on what has become an open-market economy. We have in the world today a totally free market, and no one knows where the market price will go.

There are indications that price is beginning to have an impact on consumption. Consumption in the United States has gone down for the first time in nearly 50 years. The decline is 6 to 7 percent, which corresponds to 1¼ to 1½ million barrels a day, and so it is significant.

A number of other factors are emerging. First, in the last ten years the production industry has moved to where nearly 3/4 of the world's oil production is in the hands of governments or government-owned oil companies. It is no longer controlled by private industries as it was 20 years ago but is highly nationalized. In the final analysis, you are dealing with governments.

Second, there is a growing tendency for government-to-government negotiations and deals. Two years ago our government intervened for the first time in a negotiation with Mexico for gas. In that case, it was counterproductive and only created hard feelings with Mexico. I would hope this is not the start of a future trend because government-to-government negotiations invariably bring in political considerations. Unless the free-market economy is separated from political decisions, there will be pressures in various parts of the world that will be extremely difficult to deal with.

Another recent happening, one which is very difficult for us to comprehend, is that for the first time the majority of earnings in this industry come from overseas. The rather startling third-quarter earnings of international companies drive this home. Excluding the independent operators, somewhere between 60 and 67 percent of the industry's earnings come from sales and production abroad. The industry is becoming a little like Volvo in Sweden and Sony in Japan. The hue and cry that is now coming out of Washington corresponds to the Japanese complaining that Sony is making too much money selling television sets to the Americans. These earnings from abroad are really a positive benefit to our balance of payments. (I am sorry to say our company is a totally domestic company so we're on the other side of the fence, but I can admire the pasture over there.)

We are moving into an era without any precedent. Production in the United States is declining at the rate of half a million barrels per day per year. The official response to this crisis is what I call a liquidation tax — the government calls it excess profits — but it is a unit liquidation tax on existing domestic reserves which will insure the revenues will go to the federal government rather than to the industry itself. We will still have in no way come to grips with the problem.

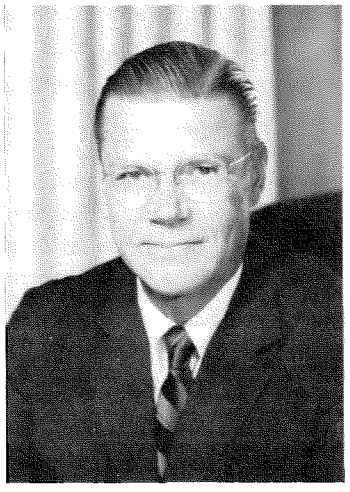
What are our energy options? Solar, of course, in the long range offers remarkable benefits, but it is working on a different time scale than we are. Nuclear and coal still are our only two large viable options.

We have an enormous problem. The biggest part of it is convincing the American public. Washington has conventional wisdom that says the industry has vast quantities of oil still hidden in the ground, that when Texas was turned loose that hidden capacity to produce did not show up so it must still be there. Actually, it was dissipated during a period in which we were importing oil at $1.00 to $1.50 a barrel and enjoying air-conditioning the sidewalks in front of Sears Roebuck stores. Until we can remove the myth that there is unproduced oil — hidden oil — our credibility is lost and the chance of getting our story across near impossible.

There is one thing that I would like to leave with you: that cross-over when demand would exceed supply, which everyone agreed would happen in the mid-1980s or 1990s — it happened last year. We are on a declining curve, and we have a lot of lessons to learn along with it. □

Energy Perspectives

Robert S. McNamara
President
World Bank



I want to start by making two general points that are not accepted by the American people today — and until they are I think the United States is going to be in trouble. Next, I want to make some general comments on the nature of the energy problem, and then shift to a discussion of something that I know a little bit about: the developing countries, and the effect of the problem on them. Finally, I want to draw a conclusion, and that conclusion is this: Although the energy problem does entail a very heavy cost to American society, it is not an insurmountable threat to the economies of either the developed or the developing countries.

The first of my two general points is that it is wrong to think that the current energy problem is a crisis. It is a problem that Americans are going to have to live with, and are going to have to learn to manage, but there aren't any identifiable devils or villains that have caused it. It's not the oil companies' fault, and it's not OPEC's fault. Nor is there any identifiable victory at the end of the line. As a matter of fact, there isn't any end of the line. Rather, it is something that Americans are going to have with them for the rest of their days, their children's days, and their grandchildren's days. They are just going to have to learn to manage energy as they manage many other aspects of their society.

My second general point is that we should thank God for the increase in the oil prices. Where would we be in 1985 or 1990 if we were still consuming $2-a-barrel oil? In fact, imagine where we would be today if we were consuming $2-a-barrel oil or, adjusted for inflation, $3.50 versus whatever it actually is, $22 to $40. We have failed to adjust adequately to this problem, but at least we have begun to adjust in ways that we would not have done had we still been consuming $2-a-barrel oil. In that sense, we are better off because of the price increase.

Actually, the problem isn't so much that the prices have increased; the problem is that the increases have come without anticipation, abruptly, and in lumpy amounts. There was, initially, the quadrupling or quintupling in 1973, and then between September of last year and June of 1979 there was an additional 60 percent increase. What hadn't been generally recognized is that the real price of oil declined rather substantially — perhaps by 10 percent in real terms — between December 1973 and the end of 1978, and then rose by 60 percent in real terms very suddenly. The U. S. wasn't prepared for that. So that's one problem: unanticipated, lumpy increases. And the second problem is that the increment goes to relatively few countries — the OPEC nations — and is diverted from most of the other economies of the world.

The prices, of course, are going to continue to rise, though no one knows by how much. I would guess that the average price is going to double between now and the end of the century, which would mean about a 3½ percent a year increase. We are going to have to anticipate that. We need to plan for it, and I think we can.

Now, let me make some general comments about the nature of the problem. The world is not running out of energy. We have lots of energy, but there is a problem with the cost. That's why I say we're lucky the price rose when it did. If we had waited ten years to have that price increase, we would be less able to mine, if you will, the very large resource of energy that still exists in the world.

In this situation of continuously rising prices, conservation is clearly going to be one of the principal required adjustments. It is going to be at least as important as the expansion of nuclear energy and the expansion of coal, both of which will take time to implement. Conservation is something the U. S. can deal with right now. The society hasn't really begun to conserve energy seriously. When one looks at what the Japanese and the western Europeans have done, one can see tremendous unexplored opportunities for conservation. Nevertheless, the practical realities are that during this next 20-year period the U. S. is going to be dependent on Middle Eastern oil, and that oil is an unreliable source of supply. Perhaps the most important problem the U. S. has today is to adjust to that dependency, and to anticipate interruptions in the Middle Eastern supply of oil.

It certainly can't be very easy being the U. S. Secretary of State under these circumstances. America is in a very awkward position and has given itself almost no bargaining power. As a society, it has been improvident in this matter. The problem affects much of its activities — its relationships between various elements of its own American community, its relationships with other nations, and virtually every aspect of its political, economic, and social life. And the nation as a whole hasn't begun to adjust to all

this. Clearly, one response that it can make — and one particularly relevant to Caltech — is to speed the shift to new energy sources by expanding the research and development effort. Not nearly enough attention has been directed to that.

Now let me turn to something I do know more about, namely, the developing world. What is this developing world? Well, excluding the People's Republic of China and a few other centrally planned economies, there are roughly 100 developing countries that the World Bank deals with. They have a population of 2¼ billion people. One and a quarter billion of those 2¼ billion people live in what we call the poorest countries — India, Bangladesh, Upper Volta, and so on. Their average energy consumption per capita is 166 kilograms of coal equivalent per year. In the United States it is 12,000; in the Federal Republic of Germany, 6,000. The U. S. has a long way to go in conservation — not that it could get its 12,000 down to 6,000. The U. S. is, after all, a much bigger country, it's colder, and there are other reasons why it should consume more than the Federal Republic — but not 100 percent more.

But there are 1¼ billion people in the poorest developing countries consuming 166 kilograms equivalent of energy versus the U. S.'s 12,000. That is going to change. There is a tremendous energy requirement lying ahead if these people are to move upward in the most fundamental human terms. They need more calories, and they cannot get more calories without more energy. I think their per capita consumption of energy will probably quintuple by the end of the century. The United States must understand that and take account of it.

In the short run, the problem of these poorest developing countries isn't energy; their problem is money. Their energy bill has increased tenfold since 1972, from $5 billion to $50 billion a year. There are only two ways to deal with that. Reduce the consumption — and that is pretty difficult when, per capita, you are consuming only 166 kilograms of coal equivalent energy per year — or reduce the rate of economic growth, a terrible penalty for their people.

Another billion individuals live in Brazil, Korea, Mexico, and similar middle-income developing countries, and they consume 900 kilograms compared to the U. S.'s 12,000. They don't have a great deal of room for conservation either. The only way to deal with their problem is for the developed nations and OPEC to help them finance it. I submit that it is in the interest of the developed nations and OPEC to do so and that means, essentially, intermediation. We must take the increment of price, channel it through the world's financial system, and put it to work in the developed countries and in the developing countries as well. That is a primary requirement, and in the short run is much more important than finding new energy sources or anything else as far as the 2¼ billion people in the developing world are concerned.

The second requirement is to help them help themselves. There is a tremendous opportunity to expand the energy production in those countries. The best way to deal with oil prices is to reduce the pressure of supply and demand. It does not matter very much initially whether the additional barrel of oil or energy is produced in the U. S. or someplace else in the world. If the energy demand can be reduced, then the pressure on energy supply will be reduced.

Among those 100 developing countries, we in the World Bank estimate that 78 have the potential to produce oil. Only 23 are producing it, and those only in small quantities. But we think the 78 can expand their production by about 4 million barrels of oil and gas equivalent per day in the next ten years. It will cost some $12 billion per year to do it. And it is in the developed nations' interest to help raise that capital.

The World Bank is trying to assist in this. Within three years we expect to be associated with energy projects worth about $4 billion a year. This will help the developing countries to move towards that 4-million-barrel-a-day increment by the end of ten years.

So I come back to where I began: America is going to have to live with the energy problem for a very long time. The costs are huge. Energy is approximately 5 percent of this country's GNP today. If it doubles in real terms between now and the end of the century, in a sense that means a loss of 5 percent of GNP — 0.4 percent a year reduction in the U. S. growth rate. That is not something one would deliberately seek, but neither is it something one ought to feel overwhelmed by. The American people just need to address it in a determined manner, and so far they haven't. That, I think, is the real issue for the United States. □

Most of the people who talk about energy today unfortunately talk about it in terms of the distant future. They talk about what's going to happen in the year 2000. I would like to try to give you the perspective of the operating utility executive who has the responsibility for delivering the 110-volt current at your outlet today and tomorrow.

I think for most of our energy problems we look toward Washington as a focus. And unfortunately, a coordinated national energy policy has eluded at least three presidential administrations. Perhaps the reasons lie in the basic divisions in our society regarding energy. They include a disagreement about the kind of future people want, the morality of nuclear power, the legitimacy of continued economic growth, the degree of environmental preservation, and also a proper distribution of income. These issues involve more than just energy, but they have been injected on the energy circuit, and they provide what the electronic technician would call "noise" on the circuit.

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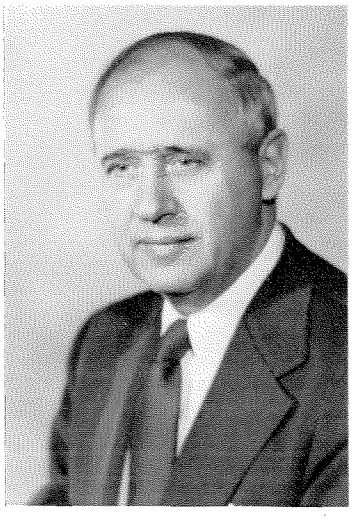
William R. Gould
President
Southern California Edison Company



We have reached the point where the energy debate has become a testing ground, even a place of conflict, over the broader social choices. The process by which we make these choices is completely inadequate. We have to choose between adequate energy and environmental quality, health and safety and national security, and the system by which we do it practically doesn't exist. There has been too much political rhetoric on this subject, too much finger pointing, too much looking for the villain in the piece, and too much knee-jerk reaction. Not enough attention is paid to the factual analysis or the need to balance competing objectives.

Most of the government mechanisms in programs dealing with energy are ineffectual and very expensive. They compound our problems rather than solve them. As one writer has put it, our political circuits have simply become overloaded on the energy issue. The old process of informal compromise and implicit mutual accommodation no longer works. So in addition to needing a workable energy policy, I believe we need a workable decision-making process that will protect the market system and the other institutions that have allowed our country's standard of living to become the highest and the most envied in the world. We must, as a nation, agree on what our energy options are — what environmental trade-offs will be required, what risks we are willing to take. We must acknowledge that our country currently relies too heavily on foreign oil, where we have no control over cost or continuity of supply. A failure to change this fact could hold the horrible specter of another global war.

No single energy source holds the key to our energy future. If our nation is to meet the triple energy objectives of an adequate and dependable supply of energy, environmental protection, and economically feasible conservation, we will require a balanced energy mix that includes nuclear, coal, solar, synthetic fuels and other resources. In short, we are going to need every BTU and every kilowatt from whatever source we can find. Those who would say that any one single source is the answer — such as geothermal, solar, or whatever — are mistaken.

Clearly, the most likely technical alternatives to oil between now and the year 2000 are coal and nuclear. We have in this country a 300- to 400-year supply of coal if government restrictions and regulations are eased to allow this resource to be used with sufficient environmental safety regards. Coal could produce 40 to 50 percent of our electricty by the turn of the century, but unless I have missed a news item, there have been no significant federal coal leases issued in the last ten years.

Our country cannot achieve any energy independence from oil cartels without a substantial reliance on nuclear power. At the present time nuclear power is not generally regarded by the man on the street as being on the side of the angels. Certainly there is increased uncertainty over the future of nuclear power following the Three Mile Island incident. This accident was a serious matter but it must be remembered that no one was injured and radiation releases were well within safe limits. Despite what you may have been led to believe, the safety systems worked. In fact, the margins of safety were greater than what had been anticipated by the designers of the plant.

This is not to excuse what happened at Three Mile Island. Our industry has taken the incident very seriously. We have analyzed what happened, and we have learned a great deal about that particular kind of nuclear plant. We have taken important steps to assure greater responsibility for nuclear safety. The electric business, in concert, has formed the Institute of Nuclear Plant Operations. It has the task of establishing nuclear plant operating standards and setting criteria for operator training. It will conduct on-site audits of the operations — policing if you will — and it will monitor the industry's safety-related goals. This is an attempt on the part of the industry to go beyond what the regulatory agencies did, that is, to properly and intelligently police its own operations. This Institute will have an $11 million budget and a full-time staff of 200 people. It will also have a review board composed of prominent educators, scientists, and engineers from outside of the business.

A Nuclear Safety Analysis Center has also been established. It is currently carrying out a detailed technical analysis of what happened at Three Mile Island. Recordings were taken at three-second intervals at most of the critical system points, so we have a great mass of hard data that is now being evaluated by some of the most experienced technical specialists in the nation. The lessons we learn will be recycled in the operation and design of existing and future nuclear plants, and they will be thoroughly

communicated with the public.

One of the things we found was missing in Three Mile Island was an adequate emergency response system. So we have, within the industry, established an emergency response plan that will serve as a pre-planned, organized approach for improving the overall coordination and communication in the event of another emergency situation. It will also set up procedures for operations and for shutdowns, and will establish a national inventory of experts and equipment that can be rushed on-site promptly when needed. Incidentally, we have in southern California a nuclear power plant that has operated for 12 years, producing enough kilowatt-hours to save the rate payers up to $7 million in each of these years. Over its 12-year operating life, San Onofre Nuclear Generating Plant has experienced 12 near full-load shutdowns of the turbine generator, and in no case has the unit experienced operating difficulties or problems.

As a nation, we cannot give up the nuclear option. Further, I don't think that we can give up the option to recycle plutonium, nor to develop the breeder reactor. To me the best place in the world for plutonium is behind 12 inches of high-tensile steel and some 18 feet of concrete, making kilowatts rather than being a threat in the minds of many throughout the world. If we don't recycle plutonium and if we don't build the breeder, the rest of the world is going to do it, and it will become a producer of electricity in the world anyway.

The most dangerous course of action this nation could take as a result of Three Mile Island would be to abandon the nuclear option as a source of electric power. If that were allowed to happen, the consequence for the country's economic and general well-being would be crippling. Our productivity would go down, and our ability to compete in the world market would decline to where, in my perspective, we would be a third-rate nation. In 1978, 7 percent of all capital spending in the United States was for nuclear plants. Eighty-three such plants are currently under construction. Seventy-two are in service at the moment providing about 13 percent of the nation's total electricity. Best estimates for the year 2000 call for nuclear power to provide 35 to 40 percent of our nation's electricity.

Conservation too will play an important role in our energy future. Our company is committed to it. We expect to spend $20 million in our conservation program in 1979. But the fact is, conservation over the long term can only slow the growth in the demand for electricity — it will not stop it. Here in California, for instance, prior to the oil embargo of 1973, we had forecast the need for over 11,000 megawatts of new generating capacity to serve what we then expected to be the 65,000 new customers we would add each year over the next ten years. The only number that has not changed in this estimate is the new customers number. We expect as many as 90,000 new customers this current year. We must have additional capacity to serve them. Since the oil embargo, we have reduced our forecast of 11,000 megawatts by some 6,000 megawatts because of current and anticipated customer response to the call for conservation. We have achieved that conservation in part because the price of the product has gone up dramatically, tied as it is inseparably to the soaring cost of foreign oil. But nevertheless, this is a significant company/customer effort. The fact remains, however, that we still need 5,000 megawatts of new capacity for the coming decade. That's about 40 percent of our existing capacity, and about half of this new capacity is expected to be nuclear. This will come from San Onofre units 2 and 3, which are currently under construction, and a share that we have in a nuclear power plant under construction near Phoenix, Arizona.

Other large increments of our future capacity are moving along as scheduled. These include a major coal-fired station at one of five proposed sites in southern California where for the first time in this state we're going to attempt to burn coal as coal. We plan to build a combustion-turbine "peaker park" near Lucerne Valley. A peaker park is a series of combustion turbines, similar to jet engines, that can be put into operation on short notice. Unfortunately, they require a sophisticated fuel. They can burn coal-derived fuels, oil and liquid, but they can't burn coal. So we have to have a synthetic fuel program under way to provide fuel for them.

We are working very hard in research on virtually every known feasible alternate source for generating electricity. Our R & D program for 1979 totals $32 million, one of the highest outlays of any investor-owned utility in the United States. We're already participating in a number of alternate energy projects — solar, wind, thermal, fuel cells, and magnetohydrodynamics. In addition, we are actively pursuing the development of synthetic fuels including gasified and liquefied coal and shale oil. But we are dealing with new and untested technologies. Realistically, these alternative energy resources can be counted on to contribute only a small percentage to our generating resources by the turn of the century.

The cost of these sources will be high, almost prohibitive. For instance, our 10-megawatt solar plant that is now being built near Barstow is expected to be completed in 1981. This is a pilot plant, and the cost per kilowatt-hour of electricity will be in the neighborhood of 80¢. Electricity from our 3-megawatt wind turbine that is being built in the desert will probably cost around 12¢ per kilowatt-hour. And from our first geothermal plants and coal gasification plants, electricity will be in the range of 14 to 15¢ per kilowatt-hour. Compare these figures with nuclear power, which currently costs 1.5¢ per kilowatt-hour, coal about 2.3¢ per kilowatt-hour, and oil about 4¢ per kilowatt-hour. Over the long term as technology is developed, I expect the solar and wind costs to go down, particularly when photovoltaics start to come on the scene. But until then, our energy options, at least the economic ones, are limited because customers cannot afford to pay 3 to 20 times more

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for their electricity than what they would with existing means of production.

Coal and nuclear power are here now as alternatives to imported oil. They are economic, we have the technology. Other so-called alternate energy sources are not here and now, nor will they be to any significant degree for at least another decade or two. The answers to our near-term energy futures are clear. What we need is the necessary decision-making process that balances the conflicting interests, and toward this end, I hope we will all work together. □

Dean A. McGee
Chairman and Chief
Executive Officer
Kerr-McGee Corporation

We all know that coal is one of our most viable alternative energy sources, and I would like to try to put the coal business into perspective with regard to our overall energy situation. Coal satisfies all of the criteria necessary for a near-term major addition to our energy supply. It is plentiful, the technology to use it is available now, there is an existing infrastructure on which to build, and because of its chemistry, coal can be converted into a wide range of fuel products. For these reasons, coal is the cornerstone of the government's program for offsetting the growing shortfall in the domestic supply of hydrocarbons.

Coal comprises some 70 to 80 percent of this country's energy reserves, but at present it only supplies about 20 percent of our energy requirements. Domestic production of coal has increased only slightly in the six years since the oil embargo. And in these six years, many new regulatory restraints have been placed on the mining, transportation, and burning of coal that have substantially increased the cost of its production and use. The government's programs for developing the technology for the conversion of coal and for first-generation demonstration plants have been few. Thus for a decade or two, most of the coal used will have to be burned as solid fuel.

Coal, of course, was the fuel of the Industrial Revolution. It was coal that powered the transition from an agricultural and wood-burning economy to an industrial one. But the use of coal did not grow with the economy. The United States is estimated to have about 30 percent of the world's recoverable coal reserves. Of the estimated 1.7 trillion tons of coal reserves in this country about 214 billion are recoverable at present cost and with present technology. Coal is widespread geographically, with mineable deposits in 37 of our states.

Coal production grew rapidly in the early years of this century. Of the total energy produced in 1923, coal provided 73 percent, and oil and gas 23 percent. This level of production was not surpassed until 1947 when coal comprised 51 percent of the total energy produced, and oil and gas 45 percent. During this period of 24 years, total energy demand in this country grew steadily, but petroleum fuel captured most of the growth.

Following World War II, a number of large-diameter gas transmission pipelines were constructed. In 1954 the United States Supreme Court decided that the Natural Gas Act of 1933 gave the Federal Power Commission authority to control the wellhead price of natural gas. These two occurrences made an abundance of below-replacement-cost, clean, natural gas available in most parts of this country, and the production and use of coal declined steadily. In the early 1960s the production of coal declined to less than 400 million tons. By 1976, coal's share of the energy market in this country had dropped to 20 percent, and oil and gas had risen to 76 percent. Production of coal has continued to increase slowly and currently is around 700 million tons annually.

For the past quarter of a century, coal has been the victim of federal energy legislation and regulation. Energy price regulation, environmental restrictions, safety and health requirements, use controls, and often contradictory and overlapping government policies have effectively limited the production and use of coal. As an example, my company has been trying since 1975 to put a large surface coal mine into production in eastern Wyoming. A brief review of what has happened in the intervening 4½ years will illustrate the type of problems the coal industry must now overcome to assume a larger share of this country's energy demand.

A lease on the coal property was obtained from the government in 1966. The lease has a clause requiring that approximately 10 million tons must be produced by June 1, 1986. The initial application for the permit to mine was made in February of 1975. Preparation of an environmental impact statement was begun in 1976. In 1977 a new re-

vised mining plan was required. In April of 1978 the government advised that the plan would have to be changed to conform fully to the requirements of the Office of Surface Mining. In 1977 an application for a mining permit was also made to the Wyoming Department of Environmental Quality. The original application to the state of Wyoming was one two-inch-thick report. The recent application was six three-inch volumes, and in addition one state agency required 50 copies. We do not yet have a permit to mine, but unless we mine 10 million tons of coal by 1986, we could lose a very valuable property. Here are some of the more interesting questions that some of the regulatory agencies ask. How will the cattle trails be reestablished in the final reclaimed area? What color will the service buildings be painted? Where will the blasting materials be stored? And many more going on in the same vein.

With the sharp, continuing increase of world oil prices since 1974 and the plan to reserve gas for premium uses, the cost disadvantage under which coal has competed for decades is beginning to be reversed. Coal at the mine mouth now has a competitive advantage in a number of areas. However, the cost of transportation, storage, environmental and health and safety requirements, increased severance taxes, and royalties has significantly offset any mine-mouth cost advantage. Partly to stay competitive, there has been a shift from underground to lower cost surface mining and from eastern to western coal. Sixty-three percent of the coal mined in 1978 was from surface mines. In 1970 the production east of the Mississippi River accounted for 93 percent of total coal production. It is estimated that by 1990 this percentage will have shrunk to 59 percent. The occurrence of very thick coal seams (up to 100 feet) with thin overburden in eastern Wyoming and Montana is largely responsible for this shift.

As the domestically produced supply of oil and gas continues to decline — and it will — the future for coal seems to lie in two areas: for electric power generation and as a raw material for the production of synthetic fuels. Unless the government uses the authority it now has to mandate that the existing oil- and gas-fired utilities shift to coal, there will not be a dramatic increase in the production of coal. The future for a greatly expanded use lies in this country's success in transferring its energy base for liquid and gaseous hydrocarbons from oil and gas to coal. The technological challenge confronting the adaptation of coal utilization to our existing infrastructure is related to three characteristics of coal: It is dirty, it is solid, and coal resources are not always located at points of major use.

Because this country is responding to an energy crisis, coal-utilization concepts under most vigorous development today are those that can be commercially implemented at the earliest date. These are, for the most part, an engineering upgrading of first generation coal-utilization technology, namely direct coal burning, coal liquefaction, and coal gasification. But these processes are a stopgap measure.

The coal industry of the future will probably be structured around an entirely different concept, similar in many respects to the way the petroleum industry is structured today. The petroleum industry developed a technology for the separation of crude oil into components that best fit a wide spectrum of needs. The ultimate coal industry can be visualized as having the same general characteristics, with coal being separated into many components to fill an equally wide spectrum of energy needs. To achieve this, the coal industry is in need of a technological breakthrough, a concept that would do for coal what distillation has done for petroleum.

The needed coal-separation process should remove ash and other impurities and should separate coal into a hydrocarbon fraction for liquid fuel uses, another hydrocarbon fraction for gaseous fuel uses, and a high-carbon, high-BTU fraction suitable for electric power generation. At the present time, the technology for breaking coal into these general end uses is not available. However, many separate coal-conversion concepts for producing clean-burning fuel, synthetic crude oil, and synthetic natural gas are beginning to merge into a concerted effort for the optimum utilization of coal. Perhaps the needed breakthrough is just over the horizon. Coal, the United States' most readily available, largest energy resource, has not yet begun to fulfill its potential for making a large contribution to our energy needs.

As for the world situation in coal, as you probably know, Australia and South Africa are large producers. Of course, the European countries — Germany, France, Britain — have been producing coal for centuries. But we recently have had visits from both the French and the British asking about the possibility of acquiring equity interests in coal deposits in this country. They anticipate that Europe alone will need some additional 85 million tons of imported coal by 1985. So the world is going to look to the United States in the next decade or two for a part of its coal needs. □

Knowing I was scheduled to be the last speaker, coming after several distinguished experts, I decided that flexibility would have to dominate my preparation. So I came up with a list of some 50 points I thought ought to be mentioned in a symposium on energy. Then I sat and crossed items off as they were covered by others. Soon I began to worry that nothing would be left for me to bring up — and that almost happened. In fact, the other presenters covered everything on my roll except one issue. That one, amazingly, was not even so much as mentioned. It is merely the energy program of the administration in Washington! I say amazingly, because, after all, President Carter, you may remember, came down from Camp David and delivered a major TV address billed as the most important of his career. He said he wanted Congress to approve, and the nation to back him in, a massive project to create a syn-

Energy Perspectives

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thetic fuel industry in the United States to cost over $100 billion. To carry this out, he proposed two new government agencies: one, the Energy Mobilization Board with duties to expedite things, to beat the other bureaucracies over the head so they'll quit standing in the way; and the other, the Energy Security Corporation, a new operation with that $100 billion to spend to get synthetic fuel rolling.

Now, as we all know, in the United States there are two ways to get something done. Either the government does it, or free enterprise does it. Perhaps the nation is divided into three halves on this subject. One half says, "The way you get things to happen right is keep the government out and let free enterprise, which made this nation great, do the job." Another says, "What? Look to the selfish, profit-seeking private sector? They certainly do not have the nation's interest at heart! Government action is the only way to go." Approximately half the people in the nation believe the private enterprise system, and big business in particular, is no damn good. Another half says the government is a wasteful, inefficient, incompetent bureaucracy and can't do anything right. A third half holds both these views at once.

Now, both of these extreme views are wrong, particularly as applied to energy. You can rightly be accused of being out of date if you imagine that a total free-enterprise, private-sector solution to the energy problem is in the cards for the United States. The situation is much too political for that and isn't going to change. The government is in energy in a big way, and the government is going to stay in it. But the government really is a big, wasteful, inefficient, largely incompetent bureaucracy, and you can't get anything done without the expertise — management, technological, economic — of the private sector. So the trick, the name of the game, the real solution to the problem — as is true of a number of other problems involving science and technology in our nation — is to have the right combination, the right roles and missions, the right teaming up of government and private industry. This is what we have to work toward.

Those who think in terms of the private sector's handling energy matters alone look upon the President's program as taking hundreds of billions of dollars out of the private sector and handing them to a government agency to do a job it is not competent to do. The government will hire a huge group of amateurs to direct synthetic fuel approaches — what and where and on what time schedule, and with what kinds of technologies, controls, and allocations. Of course, there will be some outstanding people at the top — not outstanding in the sense of having energy experience, because that is ruled out by the peculiar U.S. interpretation of conflict of interest — and a good many of the government's staff will be trying desperately hard to do what is right for the nation. But by and large, it just isn't in the cards to solve the energy problem with syn-fuels if that whole program is going to be directed by a new government agency, with industry simply trying to respond to the highly politically dominated decisions of the government. The environmentalists are also concerned about this approach because they see the proposed new Energy Mobilization Board as simply a way of getting around the reason why all the other regulatory bureaucracies were put into existence in the first place.

But there's more to it than this. There are a lot of alternatives to the energy problem in the United States and they all have their zealous advocates and their detractors. The conservationists, for example, say that for less capital investment and technological effort than will go into syn-fuel we could pay for changeovers in industry, our homes, and our cars, so as to use a lot less energy. A barrel of oil saved is a barrel produced. And if you can save it with less cost, with less change of lifestyle, with the least concern about the environment, then that's the thing to do.

Another voice comes from the nuclear advocates who argue that we have allowed that whole area to become emotional and political, and that, while past attention to safety, waste disposal, and so forth may not have been totally adequate, we certainly can rise to the additional requirements. And there are those who will tell us that the reserves of oil in the existing oil wells can be doubled if we apply new technology to bring the oil up when it becomes reluctant. Of course, that will cost money, but not as much as creating a whole new synthetic fuel industry under a massive government program. There are solar advocates who favor solar panels on the roof to heat water, solar cells to go from sunlight directly to electricity in homes, and solar conversion on an industrial basis through techniques such as biomass or through Caltech's Harry Gray's catalysts to break up ordinary seawater into fuels of

hydrogen and hydrogen peroxide.

Of course, there are also detractors of these alternatives. (Most of the claimed negatives you are familiar with, but let me describe one with which you might not be. Imagine that millions of homes come to have solar panels on their roofs, and they're generating some or perhaps all of the electricity needed. Now, these panels must be kept clean. Even with the greatest of ingenuity in the design of brushes and other aids, millions of homeowners will have to use roof ladders once a month. Considering the statistics, we can expect that the number of deaths and broken bones will exceed automobile fatalities and injuries.)

All energy alternatives have shortcomings, all need effort for solid development, all need government/private cooperation. To fully satisfy our criteria, they all need environmental and safety controls. In total, they're all tough to bring off. So we need to work on a lot of alternatives in parallel, not knowing which will really work out. Synthetic fuel is just one option.

Let's consider more carefully a completely free-enterprise solution to syn-fuel. Imagine that we are the Board of Directors of a large corporation that knows how to create synthetic fuels from coal, and we decide to go do it. We know that we have a ten-year period ahead of us before we will get any return on our investment. The investment will be around $10 billion because we have to be talking about doing this on a substantial scale. We will need to meet severe environmental requirements set by the government. These we can only guess at, and they will get more severe all the time, even as we engage in the planning and the building of the facilities. We will also face the possibility of being sued by the government based on anti-trust laws, because to be successful we will probably have to put together a syndicate of large corporations. Private suits on numerous grounds will also be filed. Finally, after several years, when we get the whole thing operating and we are producing substantial output to meet the requirements of society at a price we believe is sensible, and that the market is willing to pay, the government will step in and clamp on a new and lower ceiling price that we are permitted to charge. When we complain that the new price is so low we will not realize anywhere near a fair return on investment — we wouldn't have gone into it in the first place had we known they were going to apply that price control on it — the easy thing for the government is to say, "We know you're lying. You're obviously making money hand over fist." If you think you can make the public believe we really need the return, then you're too naive to be on the Board.

Anticipating all this, the Board of Directors will veto the investment at the outset.

So, we have rejected a totally government-run syn-fuel program as too incompetent and political, and a private program as unreal. But a sound and practical way to set up this project exists. Its emphasis is on assigning the right roles and missions to government and the private sector. The scenario goes like this: The government announces that, for the government's own use, it wants to purchase from the private sector synthetic fuel to be made from coal through a competition. The government states the quality and nature of the fuel it wishes to buy and the delivery schedule. It offers a ten-year contract with a price adjustment factor for inflation during that period. The government uses a formula for deciding on the competition winners with credit given both for low price and early start on deliveries. The government sets standards as to safety and pollution that it agrees not to tighten without upward price adjustment. The government plans to obtain these requirements — say of the order of a half to a million barrels a day equivalent — from at least two sources. The government provides immunity from antitrust if companies wish to create a joint venture to bid on the proposal. The government provides a proper cancellation fee if it wishes to cancel part way through the ten-year priod.

If the government were to issue this request for proposals, a number of firms of high competence and substantial financial backing would bid. The submissions would be sensible from the standpoint of the bidders because they otherwise would not submit them. Doubtless the prices quoted in the proposals would be higher than existing petroleum prices but, from what we already know of the technology and economics, not so high as to vitiate the program. The requirements for access to suitable land and water resources for the coal would be included in the proposal and ultimate contracts. State or federal land would have to be made available at particular locations at stated price ranges as part of any deals made. Obviously, the legislation creating the program described could include provisions for the designated government contracting agency to have some of the same powers to accelerate law suits and regulatory approvals that President Carter has envisaged for his otherwise quite different Energy Mobilization Board.

If this program were created, it would fully cover the requirement to get started in a meaningful way on synthetic fuel. It would set up the option to broaden the program later or keep it as a lower level program. The worst that could happen, from the standpoint of the government, is that if foreign oil did not rise enough in price during the contract period — and we would welcome that unlikely occurrence — the government would overpay somewhat for the fuel it would have purchased for its own needs.

As to appropriate roles for both the private sector and the government, we notice that in this proposal the government is not at all involved in the technology, an area where it has the least contribution to make. The government creates a guaranteed minimum market for the output of the private sector. The government sets safety and environmental standards, which it alone can and must do. The free-enterprise industry takes a calculated investment risk, choosing the technology it favors. If it wins the competition, it will direct its program. The government will not. □