MIDCONTINENT PERSPECTIVES

Midwest Research Institute
Kansas City, Missouri

April 8, 1980

Denis Hayes
Director, Solar Energy Research Institute
Vice President, Midwest Research Institute
Golden, Colorado

The Solar Prospect

One of the fringe benefits of my new job is that I get to travel around the country and be exposed to different perspectives. In Atlanta a few weeks ago, I was discussing the Middle East situation and its meaning for energy in the United States when a woman in attendance made a very strong statement. “By golly,” she said, “I’m not going to have my son go over there and get killed fighting Arabs for gasoline.” And then she looked at me with a sly grin spreading across her face and said, “Now, if we were fighting Yankees....”

Similarly, it’s a pleasure to come to Kansas City and look at some of the different perspectives here. Like everyone else in the United States, I grew up to the strains of the musical *Oklahoma* and thought that everything was up to date in Kansas City. I expected to find all of the houses here with solar collectors on them. However, I found that the drive toward solar energy here is substantially slower than would be indicated by economics, by environmental concern, or by a desire to build a city that is in the best interests of the citizens of today, or the children of tomorrow. Kansas City is not unique in this regard. The same can be said for most of America and for most of the world.

This is tragic. For we are in serious trouble. We are in trouble as a nation and as a civilization. America runs on oil, and for the last ten years we’ve been running out. Domestic production, excluding Alaska and Hawaii, peaked in 1969 and it has been going down steadily for the last decade.

As a consequence, we have turned increasingly to foreign sources for this most valuable of our energy sources. In the process, almost without realizing it, we have stumbled into a vulnerable position. This vulnerability was brought home with traumatic emphasis in 1973-1974 during the Arab oil embargo.

As a result of the oil embargo of 1973-1974, an interagency group of the federal government developed a crude but far-reaching national energy plan known as Project Independence. It is perhaps fitting in 1980 to look back on the ambitious goal of Project Independence, which was to make the United States a net exporter of energy by 1980. It is now 1980, and we import three times as much oil from the Middle East as we did in 1972, the year before the embargo.

The flow of international oil is dependent upon a long, thin line of tankers that ply unstable oceans and operate through vulnerable straits. Much of this oil originates in lands where a single event – a *coup d'etat*, an assassin's bullet, or an untimely natural death – could alter the course of government. We've seen such a development in Iran.

Although we have failed dramatically to realize the goal of energy independence by 1980, we would nonetheless be well advised to begin seriously pursuing a high degree of energy self-reliance with great vigor. It appears possible that we will be reminded again of the circumstances which originally motivated our goal of oil independence.

The centerpiece of American energy policy is to displace imported oil. To that single goal, almost every other energy consideration has been bowing. It's not an unintelligent way to plot a national energy strategy. But at times the way we have pursued it has seemed uninformed by a broader vision of where we ultimately want to be.

The next few decades will necessarily be a period of transition. Whatever will be born of that transition is likely to be fundamentally different in important respects from what exists today.

We can look to history for guidance. In the 19th century, Western civilization switched from such energy sources as wood, wind, and animals to coal. That shift made possible the transition from an agrarian society, mostly dependent on the norms of feudalism for its governance, to an industrial society with vast implications. These changes affected the distribution of power throughout society, forms of government, and the ways people chose to lead their lives. The industrial revolution was not caused by the switch to coal as an energy source. Instead, the industrial revolution made possible the utilization of coal for energy. Industrialization was already taking place when the age of coal arrived. Windmills were in fact mills producing lumber and flour. With the switch to coal, the process of industrialization became so accelerated that it could legitimately be termed a revolution.

The 20th century has witnessed a similar transition, from a principal dependence on coal to a principal dependence on oil. This transition has brought with it a series of consequences. Probably the most notable in the United States has been our increasing dependence on the automobile. Almost every person in this room arrived in an automobile. It runs on gasoline or diesel fuel. Its lubricants are petroleum derivatives. Its belts, plastics, seat covers, dashboard, and antifreeze are made from oil, as is the asphalt of our roads.

The automobile is an astonishingly flexible means of transportation. Unlike fixed rail systems, it cannot easily be paralyzed by sabotage, by labor difficulties, or by floods or other natural phenomena. The car moves easily around obstructions. The automobile has fundamentally reordered the design of our cities, with important implications for social stratification, settlement patterns, distribution of wealth, investment strategies for banking institutions, and all sorts of things that are somewhat different because these patterns evolved.

Similarly, petroleum has led to an aviation revolution on a global front. Jet planes and other rapid forms of long distance transportation have reshaped the planet and our image of the planet. They have shrunk the earth. In past eras it was a major journey getting from Kansas City to London. Now one can board a plane this afternoon and be in London tomorrow morning. This has important implications for the way we perceive the planet and its various interdependencies.

It would be naive to believe that we are going to move from principal dependence on oil to principal dependence on anything else without experiencing important social changes. I am not sure what these consequences will be, but I am confident there will be changes. For the most part, these consequences are not the kinds of things that determine policy or that shape investment decisions. For example, if one source of supply produces electricity at 6¢ per kilowatt hour and another one produces electricity at 7¢ per kilowatt hour, nearly every institution in the United States will decide to invest in the source which less expensively produces the electricity. I would argue that fifty years from now people living in the world that we shaped in very large measure by just such decisions will regret our criteria for making that decision. Price is one consideration, and an important one. Today, it probably is the wrong criterion to rely on, if we are to rely on just one criterion. I think we can make a compelling case for relying on several other criteria.

There are four criteria I'd like to focus on: national security, individual and community self-reliance, economic vitality, and the environment.

The criterion of national security does not require a great deal of elaboration. The national security implications of our current energy objectives are fairly straightforward. They appear on the front page of the paper almost every day. We, as a country, can gain appreciable advantages if we can find a way to power ourselves with indigenous resources. Different people would pay different premiums for that. The fact that there seems to be a good chance that the United States will send naval vessels to patrol the waters in the Middle East implies rather strongly that we should be willing to pay a premium to have control over a large fraction of these energy sources ourselves.

This is not the way the system is currently operating. Today, one who builds a factory in Kansas City and needs low grade industrial process heat gets a significant tax advantage if Iranian oil is used instead of Kansas City sunshine. The oil comes off pretax earnings as an expense. On the other hand, one who makes a capital investment in solar equipment can only subtract from his gross earnings the very low operating expenses of solar energy. To put solar energy on an even footing with imported oil, we need at least a 28% tax credit or an accelerated depreciation schedule. It's in our national interests in terms of national security to design a tax system which encourages companies to turn to solar energy.

Next, let's look at my second criterion, self-reliance at the community level, and even at the individual level. It's highly improbable that most American communities are ever going to be wholly self-sufficient for their energy. But there is a wide range of choice between having all of our energy coming in along pipelines and power lines and having that energy coming from our rooftops.

In the past we have increasingly relied on elaborate and sometimes fragile transmission and distribution systems and upon sources of supply that, as they become depleted, must inevitably become more expensive. We should begin to move in other directions – not toward independence, but toward a much higher degree of self-reliance. Two days ago in Colorado, a snowstorm knocked down the power lines and all the lights went out. Rooftop photovoltaic arrays leave residential and commercial structures less vulnerable to nature. Most of us would be willing to pay a little more in order to have more control over our own affairs.

The third criterion is economic vitality. This is a difficult area because over the past few years the economic seers of our country have had such an abysmal record that it's becoming difficult to say anything with assurance. Someone recently said that what the nation really needs is a major job training program for economists to teach them a useful trade!

It goes without saying that one key criterion with enormous implications for American productivity, for the overall vitality of the economy, and for the level of employment that is likely to exist in the country a few years hence is that we structure our investments so that we get just as much bang for the buck as possible. In energy, we are just not doing so. We are willing to spend several times more to produce a kilowatt hour with a new power plant than to save a kilowatt hour by using a more efficient refrigerator.

We should not be proud of how much energy we use but, rather, of how much work we do. If we can do more work by using less energy, so much the better. For example, the Plains Indians transported their loads on buckskin sleds dragged over the ground behind horses. In order to move five times as much, they had to get five times as many horses. If they had had wheels and then had converted those sleds to wagons, each horse could have pulled five times as much. American energy policy has been wholly preoccupied with breeding more horses when it ought to be inventing new wheels. Unfortunately, we are not using most of the wheels we already possess.

America was built in an era when oil cost $2 a barrel. Most recent investments were made when oil cost $6 to $8 a barrel. ‘ Today, international oil costs roughly $35 a barrel. Now, if we have $2-a-barrel oil, certain investments make sense. We invest a given amount in insulation, labor, efficient machinery, and energy. If one of these elements increases disproportionately in price, then economic optimization says that we should start investing more heavily in the others. A few years ago it made sense to have houses with roof insulation of perhaps R-12 or R-14. Today it makes sense to have roof insulation of R-38. And if we are looking at that house over its expected lifetime, the optimal insulation should probably be at least 50% higher than that.

Unfortunately, the real costs of energy are, for the most part, hidden from the people who are making the investment decisions. Let me give you a concrete example. Everyone is familiar with residential refrigerators. Soon we will be able to buy a refrigerator that uses only half as much energy as our present refrigerators but is in every other way just the same. It will cost about $60 more. Before the end of this year, this refrigerator will be sold in this country by a Japanese company. It is already being marketed in Japan.

This does not begin to approach the technical limits of what can be done to conserve energy. A kid at the University of California at Davis bought a new refrigerator and by tinkering around with it got his master’s degree. He made a total investment of $50 and when he finished the refrigerator used less than one-fifth the amount of electricity that it required when he bought it.

But let’s go back to the Japanese refrigerator. The interesting question is, does it cost more to save electricity by investing in the refrigerator or does it cost more to buy an inefficient refrigerator and have our society build more power plants to make more electricity for our less efficient refrigerators? It turns out that for that particular investment, it’s about one-seventh as expensive for our society to invest in efficient refrigerators as it is to invest in inefficient refrigerators plus the new power plants to run them.

The whole point is that if we Americans invest a little more money to keep our food cold, or even seven times more money to keep our food cold, we are much wiser to invest a little more money and have six times that amount of money left over to invest in something else that gives us more jobs, more energy, and more everything. Investments in increased energy efficiency are the best energy investment available to us today.

Refrigerators are a modest example from which to make a sweeping conclusion. But the United States today needs 20,000 megawatts of base load capacity to run household refrigerators. A new power plant takes about ten years to build. During that same ten years we will replace most of the existing household refrigerators. If we replace them with efficient ones, we will have freed the equivalent of ten existing large nuclear power plants for other purposes. Our food will be just as cold and we will possess the energy equivalent of ten large new power plants at one-seventh the cost of building ten new power plants.

Finally, our fourth criterion relates to the environmental consequences of our energy choices. We know that there are important environmental price tags associated with different energy decisions. We know, for example, that acid rains caused by the combustion of high sulfur fuel are now having a negative impact on agricultural and forest productivity. They are wiping out fish from most of the lakes in the Adirondacks and are substantially harming our external relations with Canada, whose citizens are upset by our acid raining down on their crops.

These costs can be measured, as can the costs to human health. One easy way to measure the cost to human health is to look at declining productivity in the work force. We spend much money to train our workers. If due to black lung or cancer a worker cannot produce as much or as long as expected, we have a real economic cost. We can also measure the amount of money that we have to spend on health bills that would not be necessary if our energy were obtained from environmentally benign sources.

How do we assign an economic premium for the important human dimension of our decisions? What is the premium for suffering and premature death? These are genuine costs that we are bearing as a society and they are very big. If we choose energy sources that are destructive to the environment and harmful to human health, then we must pay the cost. It is inescapable. We should be willing to invest a premium in order to find energy with less destructive effects.

In essence, we are at a genuine crossroads. There is nobody now arguing that we can continue our existing dependence on liquid petroleum fuels without paying costs in terms of national security, economic vitality, self-reliance, and environmental deterioration. There is nobody down there making more oil and there are a lot of us up here taking that oil from the ground. A transition is inevitable and it is likely to be a relatively speedy one.

We are now at the point where there are a number of very attractive choices available to us. The most attractive opportunities are in the field of conservation. The next most attractive choices are investments in renewable technologies that directly or indirectly harness the rays of the sun.

The advantages are not simply economic. Our energy choices will have sweeping fundamental implications for the nature of society. Solar technologies afford us a far higher degree of flexibility in social design than any of the conventional alternatives that we might be able to choose instead.

Around the country, in small but important ways, the solar choice is now being made. We are only making the first few faltering steps in a very long journey, and it is not at all assured that we will reach our destination. But I think that we will. I think it will be the most exhilarating journey we can undertake. The end result will be an attractive and sustainable society for ourselves and for our children.

The choice cannot be made, in its fundamental sense, by an American President or by an American Congress. If it is to be made, it must be made by each and every one of us.

Thank you.

QUESTIONS AND ANSWERS

QUESTION: Would you discuss photovoltaics?

ANSWER: Photovoltaics are among the “sexiest” solar technologies. They enrapture the public imagination because they have many attractive features. They are capable of absorbing certain wavelengths of solar radiations, using this energy directly to generate electricity.

Photovoltaic arrays are modular. There is no particular advantage to clustering a million kilowatts of them together over clustering 10 kilowatts of them together. There is no particular economy of scale, but rather an economy of mass production. We want to produce a lot of them, but how we distribute them does not seem to have important economic implications. They produce no pollution, produce no bomb-grade materials or radioactive wastes, and have no moving parts. They operate at ambient temperatures. They just sit on rooftops or on walls or in gardens, and whenever sunlight hits them, they produce electricity.

They have some disadvantages. When sunlight is not reaching them, they do not produce electricity. If one wants electricity at three o’clock in the morning, photovoltaics cannot produce it unless the electricity was produced in the afternoon and stored. They are also very expensive. Today, photovoltaic arrays cost roughly $6 a peak watt. In order for them to be competitive against a peaking unit on a conventional grid, that cost must fall to about 70¢ a peak watt. That’s a formidable price decline. However, I am confident that we can reach the goal by the mid-1980’s if we receive the proper support. With the use of advanced materials and concentrating lenses, the cost could fall substantially lower.

QUESTION: This is an announcement and an invitation. The local Solar Society will meet here tomorrow evening to discuss how well our passive solar homes made it through the winter in Kansas City.

ANSWER: I’d like to talk about passive solar design because I think most people may not know much about it. There are two broad categories of solar space heating. The first of these, active heating, collects solar energy on the roof or somewhere else and uses a pump or a fan to move it to a storage area and then draws it out of storage as it is needed. The solar collectors you see on roofs are connected to active solar systems.

Another approach is to incorporate solar design into the architecture of the building itself, so that sunlight penetrates through windows facing south and is absorbed in tiles, in containers of water, or eutectic salts. Passive systems generally have very few, if any, moving parts.

My own house is of a passive solar design. Most of our windows face south and they are shielded by an overhang that blocks the summer sun but lets in the low winter sun. We also have an active solar water-heating system for our hot water needs. The passive design meets most of the space conditioning requirements of the house simply through intelligent architecture.

QUESTION: Can you give examples of biological energy sources?

ANSWER: People who speak of solar energy generally think of collectors – on rooftops. This is an important part of the current solar market, but it is only a fraction of what we are talking about at the Solar Energy Research Institute (SERI) when we talk about harnessing sunlight. We really mean anything that captures, stores, and then utilizes sunlight within a couple of decades of the time that it arrives on Earth.

For example, the foliage of a tree has chlorophyll which captures some of the energy of sunlight. The tree uses that energy to separate carbon from the carbon dioxide in the air and to grab hydrogen from the ground through its root system. It combines that hydrogen and carbon in hydrocarbon bonds. Later, when the wood is burned, these hydrocarbons are reoxidized into carbon dioxide and water. As they burn, they give off the energy originally captured from sunlight. The energy that warms your toes by the fireplace is sunlight that was bottled by a tree and is given back to you again. So wood from a tree is one example of a biological energy source.

A fireplace, however, is a very inefficient way to harness that energy source and, in fact, may cause a net drain of energy from the house. An efficient wood stove is a more effective way to convert sunlight in hydrocarbon bonds into useful thermal energy.

There are a variety of other bioenergy sources that we are just now beginning to pay more serious attention to. Wood waste is used in many parts of the country by the forest products industry and the pulp and paper industries as an important fuel source. They generate their own electricity and process steam using the residues, the parts of the tree that are not needed to produce furniture or paper.

Throughout much of the American Midwest there is a growing use of alcohol fuel. Alcohol is receiving a great deal of federal attention. It can be combined with gasoline or diesel fuel as an octane enhancer, displacing more costly and environmentally destructive octane enhancers, including tetraethyl lead. Alcohol fuels, once again, represent sunlight that has been captured by plants.

In the longer run, there are a number of new crops and new processes to convert them into liquid, gaseous, or solid fuels. One exciting prospect is the possibility of efficiently converting cellulose from trees, newspapers, or agricultural residues into alcohol. If we master this process – and we know a half dozen possible avenues to pursue – we should be able to obtain ten grades of liquid fuel from our waste streams.

New crops that potentially could be grown include a variety of aquatic organisms, including water hyacinth and ocean kelp. SERI is funding a major ocean kelp project now. A variety of terrestrial plants are also being explored. In the future, Midwestern farms, instead of optimizing simply for protein production, may optimize for a combination of protein and fuel production that might lead to different crop rotation patterns. In addition to corn and soybeans, they might also plant Jerusalem artichokes or sweet sorghum – something that gives a high energy yield. Although farmers might then produce somewhat lesss protein, they will produce a far more valuable combination of fuel and fuel products in this new era of high energy prices.

QUESTION: My understanding has been that the bottleneck has been the difficulty in converting cellulose to sugar. Is there any estimate with known processes of how much of the cellulose one would have to convert to sugars in order to have a feasible process?

ANSWER: We want to convert all of the cellulose that goes into the process into sugar. We do not expect to convert 20 percent of the cellulose into sugar and lose 80 percent of it. In an efficient process, we will convert most of it, and what we do not convert, we will send through the process again. The problems we face in cellulosic conversion are not problems of efficiency but of contamination, of finding suitable bioconverters, and of basic engineering development.

QUESTION: This is a major agricultural region. What solar applications and renewable resource applications are there to farms and grain processing?

ANSWER: My hunch is that major solar penetration in the United States is likely to first take place on Midwestern farms. There are many reasons for this. Farms have a lot of land area and many potential feedstocks. They have much wind and sunlight. They have agricultural residues .hat contain the hydrocarbon bonds we have talked about. Moreover, the energy needs of the farm – low-grade heat to dry grain and to warm barns and higher grade heat to perhaps sterilize dairy equipment, electricity to operate lights, motor fuel to run tractors or pump water – all can be met with solar sources.

Farmers are comfortable making major up-front capital investments that pay off over a long period of time. They are much more accustomed to making that kind of investment than is a typical homeowner. Another reason is that farmers are better tinkerers. They have equipment that frequently breaks down and often they care for it themselves. Solar equipment will need a little tinkering for a few years. Finally, farmers are more interested in reliability of energy supply than they are in anything else. They are willing to pay a premium to have energy when they need it. Anything that gives a farmer a higher degree of control over his energy supply will be of interest, both to the farmer and to his lending institution. So I think that solar prospects for farms are very good indeed.

QUESTION: When wanting to invest in solar energy, how does the typical American homeowner get authoritative information on what equipment to buy?

ANSWER: First, go to your library. I'd especially recommend Bruce Anderson's Solar Home Book and Ed Mazria's Passive Solar Energy Book. You might also call the National Solar Heating and Cooling Information Center. It has a toll-free number, 800-523-2929. This national information center will send you general information and the names of local solar dealers and contractors. Finally, for more detailed technical questions, you should call MASEC, the Mid-American Solar Energy Complex in Bloomington, Minnesota. It is a federally funded solar center serving your region. MASEC's telephone number is 612-853-0400.

QUESTION: In your opinion, is there a net gain in energy by producing alcohol grain farm products

ANSWER: When you do it right, yes, and when you do it wrong, no. But even when it is "no," you can frequently find yourself converting a relatively less desirable fuel, perhaps coal, into a relatively more desirable fuel, like alcohol. If you do it right, you can get a substantial net gain.

Whenever we produce commercial energy in the United States, we have generally upgraded it from a less useful form. The lights in this room are using electricity that contains a third of the energy in the coal that went into the power plant. If you look at the two, you can say that you had a substantial net loss of energy.

In the nuclear field, this is complicated by the energy needed to fabricate the power plant as well as the huge amounts of energy needed to enrich the uranium fuel. Nuclear power plants typically operate six years or more before they “pay back” the energy initially invested in them. So far, for example, the plant at Three Mile Island has produced no net energy. More energy was consumed building the plant and enriching its fuel than the plant produced before the accident shut it down.

Similar controversies swirl around the net energy obtainable from crops. To oversimplify: if you grow corn for energy, if you plow deep and use lots of nitrogen fertilizer, if you transport the corn a long distance to a distillery, and if you grow a better energy crop than corn, you can produce a very substantial net energy gain. If you do not intend to mix the alcohol with gasoline, you can leave some water mixed with the alcohol, thus reducing the energy inputs needed for distillation and increasing the net energy gain.

Finally, the real value in corn is protein. Making alcohol does not damage the protein in corn, but uses only the carbohydrates. The remaining mash or DDG can be fed to cattle as valuable food.

I hope all this has given you some food for thought. Thank you very much for inviting me to Kansas City.

DENIS HAYES is Director of SERI, the Solar Energy Research Institute at Golden, Colorado, and is a Vice President of Midwest Research Institute, which operates SERI under contract with the United States Department of Energy.

SERI, now in its fourth year, has a staff of some 800 persons and a budget in excess of $125 million.

Hayes, the youngest director of a National Laboratory, has had a remarkably distinguished career: Senior Researcher, Worldwatch Institute; Director of the Illinois State Energy Office; Guest Scholar at the Woodrow Wilson Center at the Smithsonian Institution; and a member of the Governing Board of Stanford University, from which he was graduated and where he was student body president. He is also a member of the Governing Board of the Federation of American Scientists; the Aspen Institute's Energy Committee; and the National Petroleum Council.

The author of the book Rays of Hope, which outlines the transition to a post-petroleum world, and many other publications, he has also appeared on CBS' "60 Minutes," "Meet the Press," "Issues and Answers," "The Today Show," and "McNeal-Lehrer Report."

Top

MIDCONTINENT PERSPECTIVES was a lecture series sponsored by the Midwest Research Institute as a public service to the midcontinent region. Its purpose was to present new viewpoints on economic, political, social, and scientific issues that affect the Midwest and the nation.

Midcontinent Perspectives was financed by the Kimball Fund, named for Charles N. Kimball, President of MRI from 1950 to 1975, Chairman of its Board of Trustees from 1975 to 1979, and President Emeritus until his death in 1994. Initiated in 1970, the Fund has been supported by annual contributions from individuals, corporations, and foundations. Today it is the primary source of endowment income for MRI. It provides "front-end" money to start high-quality projects that might generate future research contracts of importance. It also funds public-interest projects focusing on civic or regional matters of interest.

Initiated in 1974 and continuing until 1994, the sessions of the Midcontinent Perspectives were arranged and convened by Dr. Kimball at four- to six-week intervals. Attendance was by invitation, and the audience consisted of leaders in the Kansas City metropolitan area. The lectures, in monograph form, were later distributed to several thousand individuals and institutions throughout the country who were interested in MRI and in the topics addressed.

The Western Historical Manuscript Collection-Kansas City, in cooperation with MRI, has reissued the Midcontinent Perspectives Lectures in electronic format in order to make the valuable information which they contain newly accessible and to honor the creator of the series, Dr. Charles N. Kimball.