

right now. It could be less than that but certainly not more.

Also, some other countries have cut back their production, and they are now determined to maintain the real price and, in fact, to make slight adjustments upward in the years to come. What that means is that it is going to be more difficult to get out of the recession than it was in the previous period. When the industrial countries as a group again move out of this recession, or out of a period of slow growth, into a normal growth path, then they will hit against the ceiling in OPEC oil production. Then, prices will rise again.

I expect that the decline in gasoline demand due to price increases will be less than the decline in U.S. oil production so that the net effect will be increased demand for oil imports from the transportation sector. What this means is that our dependence on foreign oil in the years to come—through the mid-1980s and possibly beyond—is not likely to change much from what it has been in the recent past.

The problem is that nations cannot really afford this very high-priced oil. What happens is that we pay for it in dollars; they deposit most of it in the bank because they cannot absorb all that revenue. It is like writing a check to somebody who does not cash it. When these countries start cashing in, then we have to deliver goods and services to them. We are writing a check on the future; our children will have to pay for it.

Much more serious is that most of the oil that we import comes from the Middle East, which is a rather unstable part of the world. The very heavy influx of capital breeds instability, as it has done everywhere in the world. The area is also unstable because of unresolved questions related to the Arab-Israeli conflict and continued Soviet aggression in the whole region from North Africa to the Persian Gulf.

All these factors add tremendous pressures and uncertainties as to these countries' ability and willingness to continue to produce as much oil as the market demands. If they do not, then, of course, the price will adjust—the price will rise much faster than the 3-5 percent/year in real terms that most people are projecting now.

We need a great deal more time in the industrial countries to make the transition to coal and nuclear power and other sources of energy. Even if time permits, there are certain limitations on how much of a shift to coal, nuclear, and other sources can occur because of environmental problems, political constraints, and other factors.

Further complicating the potential for shifting to alternative energy sources is the fact that we need liquid fuel for transportation. Therefore, we have to go into the synthetic fuel business at some point. The lead time required to develop the technology and build the plants and the very high capital cost of synthetic fuels present truly staggering hurdles. Perhaps even more formidable than the technical and economic challenges is the public opposition to nuclear power and, perhaps, synfuels to be overcome.

So what it really looks like when you assess all these obstacles is that the industrial countries are not likely to reduce their dependence on Middle Eastern oil through the mid-1980s and beyond—maybe through 1990. After that, I really cannot forecast.

Because of this dependence, the chances are probably better than 50 percent that there are going to be more

interruptions in supply in the Middle East. If these interruptions occur, they will lead again to higher prices, and those higher prices, in turn, will add to inflation and will reduce GNP. The consensus forecasts of 3-5 percent price increases that I mentioned earlier are all based on the assumption of business as usual. The effects of future interruptions will be to make prices rise above the 3-5 percent/year range.

Another major factor contributing to a longer-term negative outlook is that, in general, industry is projecting lower oil reserve additions worldwide. We are projecting an annual discovery rate of about 15 billion bbl and an annual consumption rate of about 20 billion bbl. If you are an OPEC member and you see that happening year after year, then you know fairly certainly that world oil reserve additions have peaked and are on a decline path. This trend means that sometime in the future the value of your oil is going to go up, and nobody really knows what that value is going to be.

There have been many studies that have attempted to estimate the long-range price of oil by focusing on the cost of alternative sources of energy. But much information is speculative. We used to say that shale oil would sell at \$5/bbl, or even as low as about \$3.50/bbl in the early 1970s. Now we are talking about \$35/bbl. Each time the price of oil goes up, the cost of all alternatives seems to get more expensive too; the same is true for liquid synfuels, alcohol, and other options. Forecasting the cost of alternatives and, therefore, how they will compete with oil prices is very speculative. So my guess is that OPEC does not really have a solid basis for long-range planning any more than the industrial countries. They will continue to act on a year-by-year basis and see what the market will bear.

The only empirical basis that we have for estimating the cost of producing liquid fuel from coal is the South African experience. We know that the cost of the plants there was very high. We also know that, if you were to build the same plants today, they would be much more expensive than when they were first built. This tells you that, if you leave it to private industry alone, it would be a long time before enough synfuel plants could be built because of the high capital cost and the continuing high cost of capital. What is needed first is an energy mobilization board with powers to fast-track the approval process, to reduce lead times, and to provide some certainty that the plants can be built. Then you have to get some form of money from the government to get plants started. You will not get much enthusiasm from industries to put money into synfuel plants right now. The cost is very high and the benefits are not too clear. For example, it may cost up to \$100 000/bbl of daily capacity in capital cost to build a synfuel plant to produce about 50 000 bbl/day. By contrast, to add a 50 000-bbl/day well in the biggest field in Saudi Arabia will cost about \$2000/bbl in capital cost. That is a 50-to-1 ratio in required capital costs.

Within OPEC itself, consumption is likely to continue to rise. This, in turn, will mean that exports will fall if these countries hold total production down—as is expected. Therefore, you will have increased foreign competition among industrial countries and, possibly, the Soviet bloc for the remaining available oil. Such competition could result in higher prices and, possibly, political crises.

Energy: An Overview

Milton Pikarsky

I am pleased to be with you and to share with you an overview of our national energy and transportation problems. My objective is to expand your understanding of the elements of these critical issues and to challenge you, in

your deliberations during this conference, to identify alternatives that will be helpful in responding to energy emergencies.

Today, we are at a turning point in history. Our nation

can exist only if there is adequate transportation. Crucial choices must be made to optimize our resources, needs, and desires. The fact that transportation is such an integral, essential, and visible part of our political, social, and economic life makes it both imperative and inevitable that major decisions concerning its direction be openly considered. No person in this nation is unaffected by transportation decisions.

Surface transportation has shaped the development of urban areas in the United States. It has contributed to the upward economic mobility of most citizens and has provided a standard of living that, until recently, has been the envy of the world. Our life-styles have developed around our transportation systems.

Some 100 years ago, people worked at home and walked or rode horseback to work. With the advent of public transportation, we were able to live farther from the work site and maintain the traditional maximum of 1-h travel time between residence and work location. Then, with the introduction of the mass-produced automobile and the growth in our roadway system, the eternal marriage between most people and their automobiles was consummated; urban sprawl became a way of life. We had an infinite variety of residence and work locations from which to choose. The universe in which we lived, worked, played, and reared our children was boundless.

The automobile has been called the "fifth freedom"—and with good reason. In many ways, freedom of mobility is indispensable if we are to exercise our other freedoms. The automobile enables us to live where we want, to work and to worship where we choose, and, in general, to continue our pursuit of happiness. Automobiles take us where we want to go and when we want to go—in comfort, security, and privacy—with minimum demands on our operating skills and with drivers who never go on strike. The automobile has provided the average person with a degree of personal mobility unknown to even the mightiest rulers of the past; it would be intolerable to imagine our society without it.

But the automobile's history has been inextricably linked with that of another of the nation's great contributions to modern civilization—oil. And, as much as we are unwilling to face reality, it is a fact that the age of oil is coming to an end.

This nation, like all democratic societies, establishes values, adopts life-styles, and develops land use and growth patterns in accordance with economic and societal needs. These values and needs are constantly in flux.

Periodically, significant events take place that severely affect current life-styles, and then we incrementally revise our values and adjust our needs. World War I, the 1929 stock market crash and the resulting Depression of the 1930s, World War II, the development of the contraceptive pill and its impact on the roles of women in society, the Vietnam engagement, and OPEC's embargo of 1973-1974 are examples of significant events that have had, are having, and will continue to have profound effects on our economic, political, and social life-styles.

As long ago as 1907, our national leaders warned us about our dwindling resources. In that year, in his annual message to the U.S. Congress, President Theodore Roosevelt said

We are prone to speak of the resources of this country as inexhaustible; this is not so. The mineral wealth of the country—the coal, iron, oil, gas, and the like—does not reproduce itself and, therefore, is certain to be exhausted ultimately; and wastefulness in dealing with it today means that our descendants will feel the exhaustion a generation or two before they otherwise would.

The United States only recently has begun to awaken from its dream of endless energy to face the harsh realities of the world as it exists today. In the last 30 years, people have consumed more energy than was used in all of the world's previous history. And the United States, by far,

leads the nations of the world in energy consumption. With only 6 percent of the world's population, the United States consumes one-third of the world's annual energy production. Every year U.S. citizens burn up more energy than the 500 million people of Japan, Great Britain, Germany, and the Soviet Union combined.

Our major problem today, though, is not that oil is running out, but rather that the enormous outflow of U.S. dollars for oil is stimulating the growing U.S. trade deficit. In turn, this development is causing the value of the dollar to shrink in relation to other key currencies. As a result of OPEC actions, the world price of oil at the end of 1979 was two times the price at the end of 1978. This was the largest percentage increase in a single year since 1974, and there is little evidence that the upward spiral of oil prices will not continue. This action is causing severe pressures on our international relations and is directly related to the unemployment-inflation cycles we are currently experiencing. Today, this nation imports about one-half of its petroleum at an annual cost of \$65 billion—more than \$7 million/h or more than \$120 000/min.

The transportation sector of our economy is the major user in this glaring overconsumption. In the United States, transportation accounts for 50 percent of the total oil consumption, compared to only 20 percent in West Germany and 15 percent in Japan. The private automobile, which accounts for one-half of that consumption, or 28 percent of the U.S. total, is at least twice as high as that found in other industrialized countries. An interesting statistic is that automobiles account for 95 percent of all urban passenger trips in the United States, compared to only about 58 percent in Great Britain, 42 percent in Switzerland, and 22 percent in Japan (which has a well-developed public transit system).

This kind of consumption will come to an end—oil is a finite resource. It is simply a matter of time, and we are now beginning to realize that that time may be extremely short. In the United States, despite massive and significant efforts, oil production can only be maintained near its current levels for the next two decades. Although oil-well completions in 1980 will be nearly double those of 1973, we will need both enhanced recovery and new Alaskan production to maintain the 1979 level—a production level considerably lower than that of 1973.

Most experts are predicting that world oil production will peak some time in the mid-1980s and, after that time, supply will decrease as demand continues to grow. The International Energy Agency, for instance, predicts that the nations of the industrialized West will be faced with an oil shortage of anywhere from 4 to 12 million bbl/day by 1985. As OPEC's productive capacity declines, prices will rise steeply and the nations of the world, including our allies, could become engaged in a bitter struggle for an increasingly scarce resource. The result could include serious international tension with the possibility of military intervention, resource wars, and, perhaps, even armed conflict on a global scale. As a 1978 report by a U.S. House of Representatives Foreign Affairs Subcommittee declared

Never before in the history of mankind have so many wealthy, industrialized, militarily powerful, and large states been at the potential mercy of small, independent, potentially unstable states which will provide, for the foreseeable future, the fuel of advanced societies.

Note that this 1978 statement was made before the Shah of Iran was overthrown, before the embargo of Iranian oil, and before the invasion of Afghanistan by the Soviet Union. World events in the past year clearly illustrate how vulnerable foreign sources of oil are to the internal politics of the Arab nations and to the long-standing goals of Soviet ideology.

Since 1973, despite conservation efforts that have reduced total energy consumption by more than 10 percent, crude oil consumption in the United States increased by more than 12 percent. Imports of foreign oil have increased

from about 25 percent of all demand in 1972 to more than 48 percent during 1979; and this situation occurred despite a 5 percent reduction in gasoline consumption during 1979.

If the economy of this nation is to thrive, we must begin at once to alter past patterns of wasteful use of energy in every sector of our society. We must realign and reassess our national priorities in such a way as to ensure continued economic prosperity, while, at the same time, providing the best possible life-style for our people. This will not be an easy task but, with clearly defined goals, it can be achieved.

Chief among these goals must be a reduction in our dependence on foreign oil. This can be achieved in two ways—both of which are necessary if we are to survive as an independent, strong nation.

First, we must increase production of all our domestic energy resources, including domestic oil and gas, shale oil, synthetic fuels from coal, solar energy, and nuclear power. Although this is feasible, it will require time—at least several decades—to bring these resources onstream, as well as billions of dollars in capital investment.

Second, we must conserve, and conservation is the underlying reason for this conference. In some circles, this implies rigors, hardships, and doing without. It is particularly frightening in the transportation sector—the sector that now consumes the majority of our petroleum resources—because it means limiting what we have come to know as the freedom of mobility. Our whole life-style has been built on easy mobility. We define our worlds by where we can travel. The thought of shrinking those worlds is frightening in a very basic psychological way. Yet, conservation is our greatest energy-consumption priority.

Our challenge in transportation is to find ways of maintaining the same mobility for both persons and goods and carrying out the same activity with a reduced amount of oil and, ultimately, without any oil. To achieve this goal, we will need to understand the user's needs in a way that we never have before. All too often we have addressed almost all of our attention to the technology of mobility. It is time to concentrate on why the user needs and values mobility and to be creative in looking for a variety of ways in which we can either change those values or meet mobility needs in a more energy-efficient manner, particularly in emergency situations.

Recently, politicians, planners, and academicians have proposed several methods for curtailing the transportation sector's oil consumption. I will briefly outline several of these approaches.

One of the best-known solutions to oil conservation is the legislation that requires improved gasoline consumption of the notorious automotive "gas guzzler". The average U.S. automobile is extremely inefficient; it converts only 15 percent of the energy in gasoline into usable power. The U.S. Department of Energy (DOE) has estimated that each incremental improvement of 1 mile/gal in the fuel economy of all automobiles would save about 400 000 bbl/day of oil.

Another method of reducing petroleum consumption is to develop engines that can replace the inefficient internal combustion engine as well as gasoline substitutes from coal, oil shale, and biomass. DOE has been working with private

industry to develop gas turbine, Stirling, and other improved types of engines as well as motors that can use alternate fuels. But these technologies are still in the research stage, and, since it takes an average of 20-25 years to go from the laboratory to commercial production, they will not reach the marketplace until the 1990s at the earliest—after the energy problem has already reached crisis proportions. The same is true of electric automobiles, whose proponents say will replace the second automobile now owned by 35 percent of U.S. households. One government forecast estimates that, by the year 2000, 10-15 million electric automobiles could be on the road. General Motors does not forecast a much larger market share than this estimate during the remainder of this century. Its recent announcement of a nickel-zinc battery design breakthrough projected commercial introduction of an electric automobile in 1985, with a projected market share of less than 10 percent by 1990. But the ultimate energy saving projected for these vehicles is surprisingly low—only about 300 000 bbl/day of oil, or 2 percent of current consumption, according to one study. Another option for personal mobility is public transportation and other ridesharing modes—an option that can play a significant role in energy conservation.

When we speak of public transportation, we traditionally think of buses, trains, or trolleys. But I believe our concept must broaden to a more generic term, that is, high-occupancy travel, as we attempt to find alternate solutions for the single-occupant vehicle, particularly in suburban areas. Are you aware that carpools and vanpools have been found to be the most energy-efficient form of journey-to-work transportation? They provide the door-to-door convenience of an automobile and can provide badly needed additional capacity to the public transportation system at peak hours. Taxipools and jitneys, if carefully used, can provide energy-efficient local circulation for shopping, recreation, and other desirable discretionary trips.

A key to improved energy-efficient mobility is a much-increased range of services and options: rail, bus, vanpool, taxi feeder, local jitney, and private automobile. Each mode serves the trip length, type, and density that are most cost- and energy-efficient for that particular mode. The automobile will remain our most useful vehicle. However, it will simply be used more efficiently.

Several petroleum-conservation measures have been described here. We also know that it is imperative to increase conservation through the efficient use of available energy supplies. Conventional wisdom tells us that, in view of rising prices and uncertain supplies, conservation is a good investment. The question is, "How can we do it?" Restrictions, rationing, and regulations are obvious possibilities for the near term. Education, dissemination of information, and financial incentives also are important. But the real challenge is to develop energy contingency plans in a manner that will permit us to sustain our life-styles, will expand opportunities for individual choice and advancement, and will provide the basis for economic growth. This is our challenge—yours and mine.

Energy-Transportation Overview

Louis J. Gambaccini

With the first oil wells in 1859 came a new source of energy for the United States—one that almost completely replaced coal, firewood, and water for more than a century and became the world's chief source of energy. But oil now is becoming a marginal resource. Although estimates vary, there are approximately 652 billion bbl of proven crude oil reserves in the world today. Until the latter part of the 1970s, petroleum producers were able to augment this

supply with 24 billion bbl/year. Now, a situation exists where the world's consumption rate is 42 percent higher than the discovery rate, and depletion runs on the order of 6 billion bbl/year. Although it will continue for some time to supply a major share of the world's energy requirements, oil is expected to reach its peak production by 1990, followed by a precipitous decline for the next 30-40 years.

OPEC members control some 70 percent of the 6.5