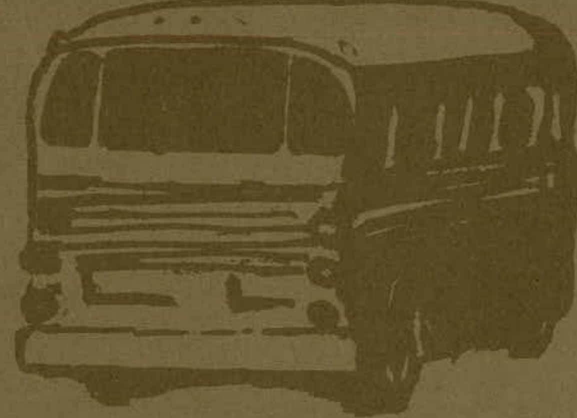

SPECIAL REPORT 191

Considerations in Transportation Energy Contingency Planning

Transportation Research Board
Commission on Sociotechnical Systems
National Research Council

NATIONAL ACADEMY OF SCIENCES WASHINGTON, D.C.

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SPECIAL REPORT 191

Proceedings of the National Energy Users' Conference for Transportation
conducted by the Transportation Research Board
and sponsored by the U.S. Department of Energy
and the U.S. Department of Transportation

Transportation Research Board
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NATIONAL ACADEMY OF SCIENCES
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Notice

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The views expressed in this report are those of the individual authors and do not necessarily reflect the view of the committee, the Transportation Research Board, the National Academy of Sciences, or the sponsors of the project.

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Preface

Energy use and contingency planning are matters of serious concern to those in the field of domestic transportation. This seriousness is reflected in the attention given to contingency planning in the event of possible energy shortfalls by participants at the National Energy Users' Conference for Transportation.

The conference, held in San Antonio, Texas, April 13-16, 1980, was sponsored by the Office of Conservation Policy and Evaluation, U.S. Department of Energy, and the Urban Mass Transportation Administration, U.S. Department of Transportation, and was conducted by the Transportation Research Board. More than 80 persons participated in the four-day meeting.

The overall planning and direction of the conference was the responsibility of a steering committee, selected by the Transportation Research Board and chaired by Sidney Davis. Significant committee contributions were made by William Barker, Donald H. Camph, Vincent M. Helman, Sarah J. Labelle, Milton Pikarsky, William P. Schlarb, Richard Shackson, and Earl Shirley. At the federal level, Carmen Difiglio and Richard Steinmann provided substantial and continuing support to the committee's efforts. Joseph R. Stowers, assisted by Ronald H. Bixby, served as conference consultant.

Specifically, the conference sought to focus attention on energy resources used for domestic transportation and the formulation of public policy related to contingency planning in the transportation life of the nation. In addition, the conference aimed to generate a collection of research papers and other materials that, when published as part of the conference proceedings, would be a useful resource for decision makers and others involved in energy contingency planning.

This volume contains the proceedings of the conference. Part 1 takes note of the conference's aims and directions and includes the keynote addresses that dealt with overviews of energy issues and resource availability at home and abroad. Part 2 summarizes the conference's findings and recommendations and represents the distillation of the views expressed in the workshops and resource papers. Part 3 reports on the session and workshop discussions. Part 4 includes the resource materials and papers that were prepared for the conference and have been edited for inclusion in this report. Part 5 lists the participants and their affiliations.

Part 1
Introduction

Conference Aims and Directions

Sidney Davis

The 1973-1974 embargo by the Organization of Petroleum Exporting Countries (OPEC) made us acutely aware of our dependency on foreign suppliers for a substantial share of domestically consumed petroleum. While there have been small, but significant, decreases in crude oil and product imports over the past year (due to the near doubling of world oil prices), the United States is still heavily dependent on petroleum imports, especially those from OPEC-member nations. Of particular importance is the portion of this OPEC supply that is accounted for by OPEC's Arab members. In 1973, the petroleum shipments of these countries to the United States amounted to approximately 0.91 million bbl/day—almost 15 percent of total domestic imports. By 1979, these shipments grew to an average of 3 million bbl/day, or about 37 percent of total average daily petroleum imports.

There is clear evidence that OPEC's powerful market control over the supply of crude oil will continue to be used as an instrument of political policymaking. Because of the uncertainties surrounding OPEC-U.S. relations, the possibility must be realistically confronted that we will continue to face either a partial or a total supply embargo by one or more of the OPEC-member countries, as well as a continuation of sharply rising administered prices. At the same time, it must be recognized that product shortfalls may be triggered by natural or catastrophic disasters, severe weather conditions, hostile actions that may result in the temporary loss of a supplier, or other events that may significantly reduce normal supplies or may impede the transportation or production of crude oil or products. Therefore, one of the objectives of a national energy policy should be to improve the country's ability to cope successfully with such situations. An instrument of this policy is contingency planning—an attempt to determine the methods and the extent to which the nation can insulate itself from such events.

OBJECTIVES

The national energy users' conference was designed to focus more detailed attention on the energy used in domestic transportation and, ultimately, on the formulation of public policy regarding contingency planning in the transportation sector of the nation's economy. There is particular concern about the United States' ability to respond to an energy shortfall through a downward adjustment of petroleum demand without causing severe problems for households, for the economy in general, or for particular economic sectors that are unusually sensitive to petroleum-product availability and price.

The conference was specially structured to accomplish several objectives. The first of these objectives was to establish a setting in which discussion of energy contingency issues, as they relate to transportation, could take place among persons who had special modal interests or who represented different public- or private-sector concerns with respect to energy planning, production, or use. To achieve this goal, a common frame of general reference was encouraged by (a) three keynote addresses, included in Part 1, that presented an overview of world and domestic energy supply-and-demand issues and (b) a panel discussion that focused on petroleum supply logistics, alternative supply-and-disruption scenarios, and the nature and consequences of federal allocation mechanisms. The eight workshops that followed these presentations provided an opportunity for participants to devote specific attention to particular energy contingency questions that had unifying themes or subject focus. For example, the workshop on consumer behavioral responses to past energy shortages was set apart from the workshop on the capacity of transportation systems to meet energy contingencies.

The conference had a second objective—that of organizing the growing body of research work related to contingency questions. The publication of the conference proceedings, including the resource papers prepared for this meeting, is viewed as a useful tool by which to access the literature on contingency planning and energy use.

ORGANIZATION

The conference opened with keynote addresses on international and domestic issues that confront contingency planners. These remarks are included in Part 1 of this report. Session 1, the first of six major working sessions, featured a panel discussion dealing with supply logistics, disruption scenarios, and allocation mechanisms.

Sessions 2 through 4 evolved around eight workshop groups that focused on the following issues:

1. The ability of urban transit and paratransit systems to meet changing travel demands due to energy shortages;
2. An examination of specific issues related to intercity passenger transportation capacity and contingency planning in the event of a product shortfall;
3. An examination of issues related to intercity and urban freight transportation, with an emphasis on data needed for determining response strategies and the capacity of the freight system to respond to fuel shortages;
4. A documentation of consumer responses to recent product shortages, patterns in these responses, the relation between contingency concerns and more permanent actions directed toward energy conservation, and suggested policies and actions based on these insights to consumer behavior;
5. An examination of the problem of and opportunities for effective energy contingency planning at federal, state, and local government levels, as well as the institutional, political, regulatory, and fiscal factors associated with the implementation of contingency plans;
6. A detailed description of the proposed gasoline-rationing plan, state responsibilities and options under the plan, coupon-distribution options, white markets, equity aspects of alternative coupon-distribution criteria, and alternatives to gasoline rationing;
7. A review of the relation between contingency and conservation planning, the various initiatives to provide mobility in contingency situations and the competitive-complementary relation between them, the identification of the relevant actors whose participation is critical to the implementation of contingency plans, the mechanisms for motivating their participation, and the examination of promising areas of new initiatives in the movement of people in urban areas; and
8. The identification and review of how energy contingencies are likely to affect urban passenger travel, strategies (by the government, the private sector, and individuals) for energy conservation in an emergency, criteria for strategy analysis, an evaluation of these strategies, and recommendations for appropriate responsibilities for various public- and private-sector organizations, including consumers.

Session 5—a technical plenary meeting of the conference—dealt with the role of governments, consumers, and the private sector in conservation planning and contingency planning. Summary reports of the workshops were given during session 6, the conference's closing session; these reports appear in Part 3.

Conference participants are fully aware that the topic of contingency planning is highly volatile and is subject to intense scrutiny as unexpected energy shortfalls cause us all

to once again wonder why we did not prepare well enough. It is hoped that the work of this conference will point the nation toward better and more improved contingency policies and programs and will help reduce the impact of energy shortfalls that most surely can be expected in the future.

Keynote Addresses

Energy World Viewpoint

Herman T. Franssen

To give some perspective to our current view of the international energy situation, it is helpful to go back a few years and see how our understanding of the world's energy supply and demand has changed.

Apparently, we do not always improve our ability to forecast. Most forecasts made in the early 1960s were more accurate for 1985 than forecasts made later in the 1970s. In part, this is explained by the optimistic future outlook for continuing high gross national product (GNP) growth rates after the long period of high growth rates through the 1960s.

Equally important is the fact that forecasters failed to recognize the changing relation between GNP and energy consumption. Over about a 10-year period, the marginal rate of increase in energy consumption per unit increase in GNP has been cut nearly in half—from about 0.9 to 0.5. A large part of this drop is the result of shifts in growth from energy-intensive industries--that is, extractive industries, such as mining, and heavy-manufacturing industries—to less-energy-intensive industries, particularly service industries. Of course, energy price increases have also been important in providing an incentive for efficiency.

Almost no one in the 1960s recognized the potential impending international petroleum crisis. World reserves were continuing to be discovered through the 1950s and well into the 1960s at a more rapid rate than reserves were being depleted by world consumption. Even when oil supply interruptions occurred, such as in Iran in the 1950s, there was no crisis because alternative sources of supply were readily available. The major western oil companies, the Seven Sisters, had almost complete control of oil supply.

Not until U.S. oil production peaked and began to level off a decade ago did many people recognize that this favorable supply situation could not go on indefinitely. There had been some peaking of production levels in significant foreign oil fields in the past—for example, in some Latin American areas—but these events had little impact on U.S. thinking because they had always been overshadowed by new discoveries somewhere else.

Only one important geologist comes to mind who, during this period, recognized that production levels could not long continue to increase at the rate that consumption was increasing. M.K. Hubbard performed an analysis for the National Academy of Sciences showing that the rate of discovery of new reserves would soon have to peak and that world production levels would begin dampening demand within a relatively few years (see M.K. Hubbard. Energy Resources. Committee on Natural Resources, National Academy of Sciences, Washington, DC, 1962).

However, the generally optimistic view of the future market did not change until the early 1970s when conditions changed very rapidly. U.S. imports grew very rapidly as consumption continued to grow after U.S. production had peaked. And then came 1973—the year when the oil embargo hit and when natural gas production peaked. When natural gas production peaked and began to decline at the same time as we had declining domestic oil production, the declining natural gas production was translated into more demand for oil. Those who could not get the gas, mainly industrial users and utilities, had to switch to oil.

Domestic oil production continued to decline until Prudhoe Bay was brought into production several years later. And the net result was that we began to import a great deal more oil in a very short period of time.

So it was then, when the embargo hit, that we really became aware for the first time that there was a major problem. In 1974, the U.S. government came up with a comprehensive energy plan for the first time. Project Independence, in its original form, would make the country independent of foreign imports by 1980. That was in May 1974. By November 1974, when the analysis work for Project Independence was finished, the study reported it could be done by 1985. The problem is that the study was much too optimistic about supply, and the forecast never materialized.

The Project Independence staff was also too high on forecast demand because they did not anticipate the high price increases that have occurred since. When these increases occurred, demand was reduced from its previous high annual rate of growth. Also, expected high economic growth rates did not materialize.

A large part of the error in Project Independence forecasts of demand was due to a failure to recognize the shifts that have been occurring in industrial growth toward the less-energy-intensive service industries, as mentioned previously.

Because the Saudi Arabians, after 1974, wanted to continue to accommodate us and because the Shah of Iran needed money for his ambitious development program, OPEC continued to produce more oil than the market needed after 1974. The result was that the price of oil in constant dollars declined through the end of 1978. It was not until the summer of 1979 that the price was back to where it was in constant dollars in 1974.

As late as the summer of 1978, most studies projected very stable prices through 1985, with perhaps some small increases after 1985. People in industry still did not get the message about what was happening to the world oil market. Companies like the Ford Motor Company and the Chrysler Corporation went more slowly in the development of energy-efficient cars than General Motors, largely because they had a poor perception of this international situation.

When the Iranian revolution occurred, Europe was having a very cold winter. In addition, oil stocks were very low because companies were expecting no substantial oil price increases in 1978. They had let their stocks go down, expecting that they could replenish them in the winter of 1979 at moderate prices.

So, when all these things happened at the same time, the demand for oil was quite substantial—everybody wanted to get all the oil they could get at almost any price. Spot prices rose to $40/bbl, or even higher in some cases, and that was followed by the official OPEC price increases in the spring and summer of 1979.

In January 1979, projections were generally that the price of oil would go as high as $20/bbl by the end of the year. In fact, the average price turned out to be much higher and was close to $30/bbl by the end of 1979.

The outlook in the next year now is for slight increases in price. Oil demand is down by at least 2 million bbl/day in the industrial countries as a result of the recession in the United States. However, at the same time, OPEC production is down by about 3 million bbl/day from what it was last year. The primary reason is, of course, that Iranian production has been reduced—to about 1 million bbl/day

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 enthusiasum 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

billion bbl of oil produced worldwide. In order to stretch revenues from this fixed reserve, OPEC intends to market what amounts to 400 billion bbl of crude oil over the next 30 or more years. For the Middle East, this basic OPEC policy appears to be a wise investment strategy. For the United States, which controls less than 5 percent of the reserve and consumes 30 percent of all petroleum worldwide, the prospect of a chronic limitation on oil could spell economic disaster.

Some oil experts believe that the answer to this energy crisis is to restock the world's reserves by substantially increasing oil exploration. For China, Mexico, and Brazil (which now has the largest offshore operation in the world), big finds have resulted. But, for the United States, the new frontier of offshore drilling on the Outer Continental Shelf, with a few exceptions, has been less than successful. Many companies have abandoned or delayed further exploration.

Energy experts believe that alternatives, such as oil and gas from coal, may become cheaper than finding, developing, and producing new oil and that coal liquefaction and gasification will undoubtedly be the new waves of the future in energy. However, because of the lack of government funding, guarantees, and tax incentives, synfuel plants in the United States are not expected to produce commercial quantities of oil or gas before the mid-1980s. Other energy users are looking to alcohol fuels to extend whatever marginal supplies of high-quality liquid fuels will be available in the United States.

Because of the lead times required to develop and establish any new technology on a commercial scale, our choices are limited, as indicated by the following:

1. Given existing circumstances, oil reserves in the United States are projected to last approximately nine years.
2. If current foreign diplomacy prevails, imported oil from Saudi Arabia will only be able to supply half of our demand in the 1980s (11-12 million bbl/day).
3. Only 7.2 percent of the rest of the nation's energy needs will be met by nuclear power in 1985, compared to previous estimates of 12.7 percent, and synthetic fuels from U.S. coal deposits will not be ready for commercial delivery until after 1985.

Thus, it appears that, throughout this decade at the very least, we will be witnessing a transition to a remix of energy supplies—one where (a) oil and natural gas will supply only 60 percent of our energy needs; (b) synthetics, solar, and other unconventional energy forms will begin to contribute to the total U.S. energy supply; (c) nuclear capacity will increase only slightly; and (d) coal production will reverse its historic decline and represent nearly 30 percent of the total U.S. energy supply by the end of the decade.

The significance of what I have just outlined is that we are living in the last decades of the petroleum era and, in the United States, where petroleum accounts for about 45 percent of our energy base, substantive changes in energy direction and use are required.

The greatest challenge, perhaps, will be in the transportation sector, which is heavily dependent on petroleum. As such, it places an inflexible demand on the highly concentrated and portable energy characteristics found in oil, unlike any other consumer sector in the nation. The private automobile, which consumes 60 percent of the energy devoted to transportation in this country, is the biggest consumer. These vehicles use an amount of fuel nearly equivalent to our foreign oil imports.

Significant issues revolve around the need to greatly reduce automobile use and to place increasing reliance on public transportation. However, it should be stressed that it is the total efficiency of the urban area and of its complete transportation system that counts—not the efficiencies exercised by the individual elements. That is why we rely on transportation solutions that incorporate a family of vehicles—for example, automobiles, vans, small and large buses, rail transportation, and downtown people movers.

In my judgment, great opportunities for petroleum conservation in transportation rest in the proper application of this family of vehicles, with each member used in the most energy-efficient manner. With limited gasoline supplies in the rural and outlying suburban areas, the automobile and the van can be very useful. We can adapt the flexibility of bus services to serve areas of moderate density and to link urban centers not served by rail transit.

These elements of an effective surface transportation system can produce substantial reductions in petroleum consumption in the years ahead, but only if the areas served are gradually reshaped into energy-efficient development clusters. Thus, within the confines of today's urban sprawl, petroleum-efficient patterns must emerge. One prime ingredient is the opportunity for adequate housing near major employment sites. Today, the work trip consumes 44 percent of our gasoline. In well-oriented communities, many walk trips are possible. For example, in a tightly developed downtown area, with housing in adjoining sectors, 70 percent of the trips of one block or more in length are walk trips. This approach should be expanded by cooperative ventures between employers and housing agencies.

Where the walk trip is impractical, the next best energy saver is the multipassenger vehicle for short trips. The opportunity to carry many people on relatively short trips was the trolley's success story early in this century. However, much of the linear or strip development that resulted from the trolley era has disappeared or fallen into disrepair; new commercial development tends to occur in clusters at key intersections. Thus, light rail transit (LRT), a variant to the trolley, is more appropriate to serve these medium-density residential and commercial areas.

More than 80 percent of the housing units that will be occupied in 1990 are already in place. More than 25 percent of these are located in suburban settings where the characteristic pattern of movement in commutation trips is from dispersed settlement areas to similarly dispersed work areas. Such travel patterns are difficult to serve with regular-route bus or rail service. However, these areas are prime candidates for subscription bus service (if the residential trip-ends are reasonably clustered), vanpools, or carpools. However, as time passes and gasoline becomes precious, developers of industrial parks may choose to enhance nearby residential opportunities for their clients.

The question that needs to be addressed now is, "How do we take the energy we do have and develop a new petroleum-efficient transportation system?" The answer must come from pursuing a combination of public transit investments and urban redesign incentives to reduce petroleum consumption by channeling new residential and employment investment to urban areas already furnished with appropriate infrastructure (e.g., sewers, water supplies, governmental services, highway access, and public transportation facilities). This will require joint land use and transportation policies and an irrevocable commitment to public transit facilities. Ideally, the outcome of a joint-development initiatives program will be to concentrate funding in major transit corridors to begin a process of land use reorganization in many areas.

Since World War II, our private investment and land use decisions have undercut much of the potential petroleum efficiencies of our nation's urban centers. The suburban sprawl of the 1950s and 1960s, with its energy-inefficient, single-family residential patterns, along with the continuing relocation of major corporations to the edges of the urbanized United States, has created an automobile-commuting work force of 87 million people and an ever-increasing reliance on the automobile. As a result of this dispersion, our urban centers have lost both business and population, while the public transportation operations that served these urban centers have deteriorated. In short, our urban design efficiencies have been undermined.

In the long run, transportation energy consumption can only be brought under control by formulating an urban redevelopment strategy that stresses modification of out-migration and low-density development patterns. Of

direct relevance to this redevelopment strategy is the expectation that the largest growth in the number of households in the 1980s will occur in central cities. As such, the 1980s will probably offer the last opportunity to implement a cost-effective redevelopment strategy.

One of the most frustrating developments in federal policymaking in the past five years has been its failure to recognize the integral relation among dense urban design, public transportation, and petroleum conservation. Although the gravity of the long-term petroleum scarcity is well understood, the planning required to finance and advance urban redesign moves ahead haltingly. At the same time, the actions required to carry out restored and expanded public transit operations to blend with urban revitalization are financially starved.

Energy-efficient land use changes should be developed now with a guaranteed commitment from government that activity centers will be linked and supported with reliable public transportation. I envision the transportation system of the future as one developing out of the following principles or directives:

1. Public transportation links between major activity centers, as well as circulation and feeder services within these centers, should be guaranteed or given a permanent commitment by government, such as dedicated sources of funding for initial development, operation, and improvements.
2. Pedestrian facilities should be made a prime element of public transportation systems, particularly where they support community-centered public transportation services.
3. System design should include features such as parking facilities and traffic restraints, and economic disincentives should be developed to manage the use of the automobile.
4. Recognizing that the provision of bus services to low-density residential and rural areas is quite costly, paratransit zones should be established immediately with the clear understanding that, in the future, support for vanpooling and carpooling rather than bus services will be offered in these areas.

How, one might ask, can this country finance such a drastic shift in transportation development? Consider that the cost of automobile ownership and operation in 1979 increased by $0.04/mile, and we traveled 1.5 trillion miles in the United States. Thus, the cost of travel by automobile increased by roughly $60 billion in just 12 months—in a year when our total federal outlay for public transportation was less than $4 billion. Any country that can afford to increase its spending on automobile travel by $60 billion in a single year certainly can afford public transit. Securing continuous funding for public transportation and determining the fiscal responsibilities of various levels of government are the primary issues.

The substantial long-term petroleum saving is of great national value; hence, the federal government has the prime responsibility for the major systems that link centers of activity and circulation within these centers. State and local governments are responsive to service needs of residents and commercial interests and, as such, should lead in the funding and development of local and feeder bus systems. Rural areas and free-standing cities need paratransit and the special transit services that are usually provided by county governments.

This suggests the need for financial commitments from all levels of government. To borrow a page from the successful highway program, the federal commitment to public transportation should be the carrot requiring a continuous source of state and local funding of the system. Why not establish binding intergovernmental agreements that mandate state legislative and local policy based on continuing public transportation support as a requirement for federal funds? For example, the limited federal funds available for new rail systems could be awarded only to communities approving new and continuous funding resources for the local matching-fund portion of the project cost and continued operations.

Funding of public transportation should be considered in the larger context--within the framework of a transportation energy-management program. The public has been and continues to be supportive of public transportation programs. Political leaders perceive this and, in the absence of countermoves by special interests, will make commitments to transit programs. But public transportation appears pale when placed against the marketing forces of the automobile society. Thus, if the principal long-term goal is an energy-efficient society, it is the transportation energy-management program that must be understood and nurtured for the public benefit. The question is how to assemble a long-term systems approach that will endure the short-term whims of our political system. I suggest that we start with simple goals, such as reduced oil imports and state aid consumption quotas. Once we are accustomed to this approach, rational long-term objectives for subsets like transportation petroleum-consumption goals for 1985 and 1995 can be established and accepted by the several publics.

The first step in meeting these long-term goals is the continuance and expansion of national programs, higher fuel-economy targets for automobiles (especially after 1985), similar actions for other vehicles, rationing when appropriate, and further technological development of vehicles fueled by other energy sources.

After the projected national targets are deducted from the original goals, missions in transportation petroleum conservation can be assigned to states and to regions within states. This is a most important step if the needed participation of the private sector is to be attained. The transportation community is quite adept at approaching established programs for capital improvements, operational expansions, and marketing of public transportation. Similarly, paratransit is being rapidly developed with substantial private-sector participation. In fact, most of ridesharing's success has hinged on good private-sector participation.

Regions and municipalities can lead in efforts to make existing transportation paths more petroleum-efficient with the development of traffic signals and other traffic management efforts. These can be easily identified, quantified, and implemented.

Park-and-ride programs that are petroleum-efficient are less of a science and more of an art today. But, with petroleum conservation the prime mover in park-and-ride, such programs can be readily produced.

Highway space allocation programs are in their infancy. They operate as a joint venture between the land use management agency—usually local government and a particular road authority, which can be either a local agency or the state highway or transportation department. It works like this: The road authority measures traffic and identifies any remaining space available for additional future traffic during peak periods. The local government or governments traversed by this critical system link agrees to an equitable allocation of this remaining space (i.e., what remains before overcrowding occurs) and, through the appropriate zoning or permit process, assigns such space to vacant or underdeveloped properties, as well as growth assignments to existing developments. Such assignments may carry commitments to use of paratransit and transit in exchange for increased development potential. Routine traffic monitoring and reporting of traffic growth control this release of space allocations to developers. For example, if, in the third year of the program, traffic growth is less than anticipated, the rate of space released to developers can be increased by mutual consent. This actively permits extensive in-filling of development up to the limit of traffic capacity with these benefits:

1. Petroleum conservation through less congestion,
2. Increased employment density with improved opportunities for public transportation, and

3. Firm commitments to the use of paratransit and public transportation from the private sector.

Another intergovernmental joint venture involves local government and the public transit agency—that is, the enactment of a code or ordinance that requires the developer to provide on-site transit improvements, such as shelters, pedestrian paths to bus stops, bus pull-out lanes, and, where needed, bus turnarounds. This is accomplished prior to the issuance of building permits. The transit agency is obliged to identify existing and future services; the local government ascertains facility needs and staging commensurate with the developer's program. These efforts result in improved awareness by all parties of the opportunities for petroleum conservation through public transportation.

Traffic signal programs, park-and-ride, highway space allocation programs, and transit enhancement codes are important elements in any transportation energy-management program. No single mode of transportation and no individual element will do the job. Within the confines of transportation improvements, a system approach is required. Greatly increased public and private cooperation is also necessary for a productive program.

Last, but not least, is the need to cluster development within the confines of today's urban scene. Although formation of clustered development is not the primary mission of transportation planning, clustered development greatly improves the viability of public transportation, increases the number of walk-trips and nontrips (i.e., the elimination of the need for a trip). Recognizing the link between these development and transportation advantages, the Urban Mass Transportation Administration (UMTA) evolved its Joint Development Program. UMTA is to be commended for this absolutely critical program. Expenditures on joint development are in the $50-$100 million range.

For some reason, the petroleum-saving potential of UMTA's Joint Development Program has not been examined. This should be the major thrust in the months ahead because clustered development is the cornerstone of the links among petroleum conservation, transportation, and land use.

In brief, there is no single mode, no simple solution, for substantial petroleum conservation in the near-term future of transportation. A comprehensive transportation energy management program is needed and is needed now. It must be a program with considerable involvement from the private sector. The ultimate focus must be on clustered urban development. This difficult task must be approached with the knowledge of the potential conflict between infringement of the freedom of individual choice versus community benefits and the national need to conserve petroleum.

Part 2
Findings and Recommendations

Summary of Findings and Recommendations

The conference on energy use provided a national forum for an examination of the issues and problems related to contingency planning for future energy shortfalls—especially those that are likely to affect the transportation sector in the United States. The conference also sought to provide an opportunity for the collection and exchange of ideas and resource materials that would be of service to those involved in the development and implementation of energy contingency plans.

In the session and workshop meetings, participants had an opportunity to examine and analyze the current state of the transportation sector's ability to deal with energy emergencies or shortfalls. Part 2 of this proceedings summarizes their findings and suggests strategies that may be taken to offset future energy crises and to make better use of available energy resources. These findings and recommendations evolved from the participants' consideration of six general subject areas: (a) energy supply conditions, (b) accommodating modal shifts, (c) freight and intercity transportation, (d) government and private-sector roles, (e) rationing versus fuel-tax-with-rebate plans, and (f) the contingency planning process.

ENERGY SUPPLY CONDITIONS

U.S. dependence on foreign suppliers of petroleum has made the nation vulnerable to the vacillations of unstable governments, particularly in the Middle East. Although much uncertainty exists about the future of petroleum supply levels and prices, what is known leads to these conclusions:

1. Real prices will probably continue to rise substantially, even without future supply interruptions.
2. The probability of supply interruptions in the 1980s is even greater than indicated by conditions a decade ago.
3. The severity of future supply interruptions is likely to exceed those of 1973 and 1979.
4. No major new oil discoveries or production capacities that would substantially change the above outlook are likely to materialize during the 1980s.

The transportation sector is more vulnerable than other sectors to supply interruptions and to rapid price escalation because of its heavy dependence on petroleum-based energy. For the foreseeable future it will continue to be dependent on liquid petroleum-based fuels. Coal, nuclear, and other energy alternatives, which are used extensively in other sectors, are not appropriate substitutes for petroleum-based energy needed by the transportation sector—at least not until either synfuels or electric vehicles become significant factors in the transportation sector. This is not likely to occur within the next decade. Consequently, alternative energy sources are not expected to affect the supply or price of petroleum products for transportation purposes during the 1980s.

The logistics of crude oil and refined products will probably continue in much the same geographic pattern as exists today. Refining and distribution capacity will require some improvement over the next decade. However, these systems, if properly managed, can cope adequately with virtually all possible crude or product shortfalls.

Recommendations

- To coordinate industrial and governmental actions during a crisis and to make use of industry's expertise in supply logistics, better mechanisms should be developed. One possibility is the establishment of a standby logistics organization—similar to a national wartime board and perhaps supplemented by regional logistics boards.
- To implement effective contingency plans, the Strategic Petroleum Reserve should play an important part in a supply emergency. It could help ensure that the burden of a shortfall would be spread equitably throughout society by providing the lead time needed to implement public- and private-sector contingency plans. However, less than 10 percent of this critically important crude oil reserve of 1 billion bbl has been reached.

ACCOMMODATING MODAL SHIFTS

In general, all public transportation modes have the capacity to accommodate rider shifts from automobiles. But this capacity appears to be limited to nonpeak hours, particularly in urban areas. Urban transit has the ability to handle excess capacity during daily nonpeak periods. Intercity public transportation modes have sufficient overall excess capacity to handle the demand that may be caused by an energy shortfall of 20 percent or more.

In light of these facts, though, it must be noted that the most significant energy saving in the 1973-1974 and 1979 crises came not from shifts from the use of private automobiles to public transportation but from changes in the actual use of the automobile—for example, reductions in overall travel, ridesharing, trip chaining, and improvements in automobile fuel economy. Most of this fuel saving was realized without (or, perhaps, in spite of) government action.

Surprisingly, carpooling does not appear to increase in direct proportion to the shortfall in fuel supplies at higher levels of shortage. Although carpooling does account for a major proportion of fuel saving during a shortfall (roughly 25 percent of the total urban transportation saving), other forms of automobile-use adjustments seem to be more important when product shortfalls are acute.

A wide variety of auxiliary or paratransit transportation services can provide supplementary peak and off-peak capacity. Expanded use of rental and lease vehicles, privately owned intercity buses, school buses, and various forms of demand-responsive modes (e.g., dial-a-ride, shared-ride taxi, and jitneys) can make a significant contribution to expanding the capacity of already available public transportation.

One major task of contingency planning is to identify the persons and organizations that must act in a crisis and to get them to assume responsibility. Frequently, contingency planning has narrowly focused on generating shopping lists of conservation and contingency actions without obtaining commitments of particular decision makers to act under specified conditions.

The major concerns that should be considered in the development of contingency plans include those related to the following:

1. Capacity of the physical system (e.g., vehicular-capacity mileage, personnel and fuel availability, and logistic support systems);
2. Institutional and regulatory constraints [e.g., lack of plans with clear responsibilities, lack of clear agency responsibility for planning, relative weakness of metropolitan planning organizations (MPOs) and state energy offices, labor-protection provisions that constrain the flexibility needed in a crisis, freedom-of-entry franchise constraints, and standard insurance restrictions on various forms of paratransit];
3. Political capacity to make decisions (i.e., lack of awareness by key elected officials of the important and potential benefits of conservation and contingency planning);
4. Public information about the need for contingency plans;
5. Public-sector example to help shape public attitudes toward conservation (e.g., ridesharing incentives for public

employees and staggered work hours);

6. Technical information on anticipated shifts in travel demand and related effects of shortfalls of petroleum products; and

7. Fiscal capacity to act (i.e., availability of emergency funding at all levels of government to provide prearranged support for contingency actions).

Recommendations

- Additional analytic work should be performed to determine the extent to which daily, weekly, and annual peak ridership can be shifted to off-peak travel periods.
- Contingency planning should emphasize assistance to consumers by providing information on how to best realize savings through similar actions in future crises.
- Better use of auxiliary-paratransit vehicles should be made. However, a variety of institutional rather than physical or technological constraints must be dealt with--particularly in the paratransit area.
- Decision makers must be committed to act responsibly under emergency conditions.

FREIGHT AND INTERCITY TRANSPORTATION

Contingency planners and others have not given sufficient attention to the importance of uninterrupted goods movement. Freight carriers can make only small reductions in fuel use on an emergency basis, whereas a substantial saving can be achieved through conservation actions over periods of several months or years. Reductions in speed and increases in load factors are the most effective short-term actions for both goods movement and intercity passenger transportation. Contingency planning can help to provide prearranged mechanisms and specific plans for freight consolidation, reduced frequency of pickups and deliveries, incentives for off-peak system use, and improved operating practices. Regulatory actions that can facilitate short-term responses include the even-handed treatment of competing modes in terms of fuel allocations. However, although temporary increases in truck sizes and weight limits may improve fuel efficiency, there is likely to be an increase in energy consumption if substantial shifts from rail to truck occur as a result of reductions in truck operating costs. Moreover, longer-term conservation benefits can be derived primarily from improvements in the fuel economy of engines and in other vehicle design components.

Tourist industries are particularly hard hit during shortages. Some government actions, such as the weekend closing of service stations, have exacerbated their problems, yet have provided no compensating travel services. In addition, efforts to reserve fuel for weekday automobile commuting may be a questionable priority because public transit and ridesharing alternatives may be more readily available.

Recommendations

- Contingency planning should consider the provision of improved private transportation services to tourist areas in order to reduce the relatively heavy negative impact of a product shortfall on the tourist industry.
- Carriers and shippers should be encouraged to develop contingency plans. They should be assisted in the development of these plans and informed of the benefits that can be expected from them.

GOVERNMENT AND PRIVATE-SECTOR ROLES

The federal role in contingency planning has been slowly evolving. After the 1973-1974 embargo, direct federal action took the form of imposing the 55-mph speed limit and of initiating various federal contingency actions, such as extending Daylight Saving Time and setting building-use restrictions. The Energy Policy and Conservation Act of 1975 later gave DOE substantial contingency-planning responsibility. However, the negative response to the plans that were developed resulted in their rejection, except for the plans related to building-temperature restrictions and gasoline rationing. This experience led to the passage of legislation that gave more emphasis to the role of the states in contingency planning (e.g., Emergency Energy Conservation Act of 1979). States are now required either to develop plans that meet conservation targets established by DOE or to face a DOE-imposed plan. The federal government now is the last recourse in many program areas where states and localities have the basic authority to act. The expectation is that state responsibilities will grow under the current program.

Major employers in the private sector are also being encouraged to expand their participation in planning for energy contingencies. In addition, consumers are being asked to play a larger role in providing input to the planning process.

Recommendations

- Government should serve as the last recourse; it should allow the private sector to respond to relatively minor shortfalls. Government response should essentially rest in the provision of self-help information and assistance to facilitate individual adjustments and to provide limited actions in order to reduce wasteful behavior.
- Stronger government response is appropriate when a shortage is so severe that social and economic institutions are threatened.
- Planning and response to shortfalls should occur at the lowest levels of government that can effectively handle specific problems and actions.
- Implementation of travel-demand reduction actions and of actions to compensate for hardships should generally be the responsibility of local governments.
- Responsibilities and authorities for all required actions should be agreed on by the appropriate government units before shortages occur.
- As a part of any contingency strategy, political leadership must be provided at all levels of government to guide public response to shortfalls.
- In all program areas in which state and local governments have required powers and authority, initial federal involvement in contingency planning should be limited to providing incentives, technical assistance, funding, and leadership. Regulations, reporting requirements, and sanctions should be minimized.
- More direct federal involvement in programs at the local or state levels, or stronger coercion of state and local action, should be dependent on a more reasonable waiting period as lower levels of government develop plans and implementation mechanisms for both conservation and contingencies. However, the length of time required to act will depend on the nature and complexity of actions needed in given areas. The key test should be whether states or localities are making reasonable progress in implementing such actions.
- Although there is a great deal of dissatisfaction over past experience with fuel allocation and set-aside programs, it is generally recognized that (a) states should continue to have responsibilities in these areas and (b) priority attention should be given to improving the effectiveness and fairness of these programs. States also have clear responsibilities in the areas of regulating retail fuel sales to control panic buying, planning for all transportation services not adequately covered by local plans, and providing public information programs and financial aid to local and regional agencies.
- Despite the basic state responsibility for fuel allocation, the federal government also has an attendant responsibility--that is, to protect interstate commerce. Therefore, the federal government should retain sufficient control over fuel allocation to ensure uninterrupted movement of supplies for all essential interstate activities.
- MPOs should serve as technical information sources,

forums for coordination of local plans and actions, and channels for financial support. In general, they currently lack power to directly implement conservation or contingency measures.

• Despite a strong private market orientation among participants--especially as it related to government actions vis-à-vis consumer behavior--it was felt that government should not fail to act because some sacrifice may be necessary and some opposition may occur regarding contingency plans. Energy saving may require some loss of comfort and convenience but, if a proposed government action results in a clear net gain in terms of cost-effectiveness, then that action should be taken.

• Some types of government intervention that are particularly appropriate to energy contingency planning include reducing lead times, providing funds and public information, encouraging technology transfer, improving equity (i.e., evening the load and providing services to help low-income, elderly, and handicapped groups cope with energy shortfalls), reducing work-trip gasoline use to permit non-work-trip consumption (because the work trip is particularly amenable to ridesharing), and reducing the waste of gasoline and time due to waiting in queues at service stations.

• Consumer input is an essential ingredient of contingency planning. If plans are to be implemented, they must be sensitive to the effects on those groups that will be most adversely affected by particular actions. Low-income households may fail to realize compensating benefits from contingency plans that increase the price of petroleum products and/or link rebates to a tax system in which they do not participate. Fuel shortages should not be permitted to result in drastic cutbacks of essential transportation services for the elderly and the handicapped or for other transit-dependent inner-city residents. An insensitively structured rationing plan could also place difficult burdens on people who depend on motor vehicle use for their livelihood, particularly when the option of using newer fuel-efficient vehicles may not be available.

• Private-sector involvement in contingency planning should include such efforts as (a) adjusting facility operations to conserve building and production energy, (b) promoting ridesharing and financial support of vanpooling, (c) providing or supporting transit services, and (d) revising workweek timetables and/or introducing flex-time arrangements.

RATIONING VERSUS FUEL TAX WITH REBATE

Conference participants do not support any coupon form of gasoline rationing. They maintain that administrative costs would be substantial and the program would have many technical problems and inequities. Any rationing system would take substantial time to implement and, therefore, would have to be preceded by equally strong actions to cope with unanticipated major shortfalls.

On the other hand, a fuel tax with rebate can achieve the same equity goals as fuel rationing with coupons. Such a plan would involve substantially less administrative cost and have greater flexibility and efficiency. But conference participants do recognize the difficult political issues associated with the tax-rebate alternative. Forums such as this conference provided, though, could help clarify the issues and enhance the political workability of such an alternative.

Because the nation has not yet experienced a truly serious oil shortage, it must be remembered that the political environment would change dramatically after a real crisis begins and that the public would not tolerate a program that does not work.

The proceedings of this conference provide substantial technical information regarding the effects of various types of rationing and tax-rebate alternatives (see Part 4). However, substantial additional analysis remains to be done.

Recommendation

• An analysis should be made of how commercial sectors would be handled under a coupon system, how gasohol would be treated, how more attention to a tax-rebate system would affect the behavior and the welfare of low-income groups, and how groups with special fuel needs (e.g., transit, farmer, and freight carriers) would be treated and affected.

CONTINGENCY PLANNING PROCESS

Most contingency plans that have been developed by states and MPOs are not particularly useful or substantive guides to the contingency planning process because they tend to consist primarily of lists of options with relatively weak assessments of their probable effectiveness, interrelations, or impacts on various affected groups.

DOE is completing a study of possible actions on a nationwide basis directed at revising workweek schedules as a contingency or conservation measure. Because of the severity of various effects on employers and employees, as well as difficult institutional, social, and legal obstacles to be overcome, any analysis is likely to conclude that a major effort to achieve compressed workweeks as a conservation measure under normal conditions would not be justified. Only major supply interruptions would merit such an effort.

Included among the principal findings of the participants about the contingency planning process and its many facets are the following:

1. Conservation efforts often rely on prior experience that is an essential ingredient of effective contingency action. Conversely, the behavioral changes needed to accommodate a shortfall often last well beyond the crisis, thereby serving the conservation objective.
2. Conservation and contingency initiatives are often viewed in competitive terms and discussed as substitutes for each other.
3. A principal attribute of a good contingency plan is that it give almost-equal weight to what could be called the management plan, or the logistics and mobilization process--i.e., when to take each action, who is going to do it, and what resources are to be used. Participants in this conference did recognize that not enough resource materials and discussion were devoted to the implementation of contingency plans, given the meeting's time constraint.
4. A great deal of contingency planning activity is currently under way—for example, more than 50 recent efforts in various states and metropolitan areas across the country were identified (as of February 1980). Many more are now in process. The majority of this work has been supported with funding from the Urban Mass Transportation Administration, MPOs, and transit agencies. Some important efforts have been initiated by the private sector. As a result of the Emergency Energy Conservation Act of 1979, local efforts are now being paralleled by statewide planning efforts. Most of these efforts have focused on transit service expansion and ridesharing. Some programs relate to staggered work hours. Primary interest is placed on voluntary actions by the public aided by government promotion.
5. Except where mandatory actions are necessary to ensure order (as in gasoline-purchase control), the strategies viewed as most workable are those that are voluntary in nature, can be implemented rapidly, are fair and well accepted, and have reasonably low costs. Mandatory actions to curtail travel are generally viewed as inappropriate to contingency planning.
6. No one strategy or group of strategies will solve all problems. Numerous actions to meet local, state, and national needs must be developed and implemented.
7. Actions that expand options and permit a maximum degree of personal choice are likely to be most popular, but they may be most expensive.

8. Selection of strategies should be based on different local and statewide contexts rather than on assumed uniform attributes. Federal and state plans should encourage this flexibility.

9. Although the base of available contingency plans is not large, it is probably adequate to provide a range of strategies for others who are preparing such plans.

Participants also noted that the effectiveness of various strategies, such as those discussed in this report, is likely to depend primarily on overall public acceptance and cost. [The relative effectiveness of 36 types of government or industry action in achieving each of five objectives—equity, time frame, cost, public acceptance, and overall feasibility—is described in Table 1 (see Part 3, Workshop 8), produced by conference participants. The conclusions noted above are based on this table.]

Recommendations

- Although conservation and contingency planning have slightly different objectives and may require different actions, conference participants concluded that they should be part of the same process and should be organized under the same (or similar) institutional frameworks at each level of government. The measures to take and the implementing agencies may often be the same. In addition, the same analytical capabilities and data may be required.
- Conservation planning efforts should be integrated with contingency planning programs related to clean air and transportation system management in each state and metropolitan area.
- Government should seek to stress and encourage cooperation and complementarity among the various initiatives and should seek to diminish competition among them.
- Currently, the use of cost-effectiveness evaluation to compare and select from among competing contingency or conservation measures is mistakenly emphasized. Because such a wide variety of efforts is needed to provide energy-efficient alternatives and most actions are, in fact, complementary, cost-effectiveness analysis should be used to substantiate the need for additional support and to design an optimally sized program.
- Measures of cost-effectiveness should be used to evaluate questions about whether certain government actions should be taken. For example, initiatives that improve the number of vehicle miles of travel per gallon (e.g., through speed-limit enforcement at low cost) can generally be justified on the basis of cost-effectiveness.
- More attention should be paid to the clear definition of responsibilities, authority, and resources for implementation.
- Several analyses of consumer response to past crises conclude that the availability of good reliable information is of critical importance. Better-quality data should be continuously collected to better understand responses and effects on both behavior and supply. Various public information sources, including government publications, the media, and private organizations, should be used to monitor crisis events and to provide detailed information that will assist transportation system users.
- Special groups must be brought into the contingency planning process. These include public officials, operating agencies that must implement contingency actions, trained crisis-management professionals (e.g., civil defense and disaster-relief personnel), major employers, private transportation services (e.g., truck, taxi, and bus operators), labor, fuel suppliers and retailers, and police agencies.
- An important element of contingency planning should be a regionwide or statewide dress rehearsal of actions that would be implemented in an actual emergency. A test of contingency actions would help to heighten contingency plan awareness by public officials, responsible agency staff, and the general public. Such a test would also help in identifying problems and improving implementation strategies before actual emergencies occur.

Part 3
Session and Workshop Reports

Session I: Supply Scenarios

Three presentations, intended to provide conference participants with an up-to-date look at supply conditions, highlighted the first major working session of the conference, chaired by William P. Schlarb. Stephen D. Bojack examined the U.S. petroleum distribution system; Richard F. Kilgore, the supply distribution scenarios; and George P. White, the nature of allocation mechanisms. Their remarks and comments from participants are summarized in this section.

SUPPLY POTENTIAL

In the course of a longer-term shift from overwhelming reliance on a foreign oil supply, the volatility and unpredictability of today's international political and economic scene demand that the United States prepare an emergency supply-disruption plan. Such a plan should focus on fuel use by the transportation sector because of its dominance in the U.S. economy.

The potential for oil supply cutoffs during the 1980s and 1990s is likely to be greater in magnitude and to occur more often than during the 1960s and 1970s. The Iranian experience, in which oil production has been cut by 4 million bbl/day during the course of the past year, may typify actions by other important foreign producers. The potential for conflict between old cultures and religions and the infusion of enormous oil revenues are moving other Persian Gulf producers to consider lower rates of production that are consistent with a more manageable rate of internal progress and development. The potential for a disruption of crisis proportions (i.e., 20 percent or more) exists, therefore, as key Persian Gulf producers prefer to maintain a delicately balanced world supply-demand relation for the foreseeable future.

During the 1970s, three major oil provinces outside the influence of OPEC, were brought onstream--the North Slope Alaska area, Mexico, and the North Sea. Each has the potential for significant additional development; however, to effectively alter OPEC market dominance, several other major oil areas are needed. For example, the Hibernia discovery off Canada's east coast and its Beaufort Sea discoveries in the Arctic may be major finds. However, there is no chance that either one of these Canadian discoveries would be contributing significant supplies prior to 1990.

Domestically, the signals are clear. For the next decade or two, major domestic discoveries are not likely to add significantly to U.S. oil supplies. Given the uncertainty concerning whether supplies of natural gas will increase or decrease and the doubt as to the future growth of nuclear resources in the existing political climate, it is probable that only coal and nuclear resources will gain any significant share of the energy supply market as industrial fuels. Therefore, U.S. petroleum logistics and supply are not likely to be altered significantly, nor are supplies expected to increase substantially over those the country currently has. U.S. production of conventional crude oil, for example, is expected to continue in the range of 8 million bbl/day through the 1980s and, possibly, the 1990s.

REGIONAL PATTERNS

The major U.S. movements of crude oil and refined products through the 1980s are expected to continue in much the same regional patterns as exist now. These projected movements are briefly outlined here.

A comparatively small East Coast refinery capacity will continue to depend essentially on foreign crude oil supplies. The dependence on product supply, principally gasoline and distillate from the U.S. Gulf Coast refineries, will continue. The dependence on heavy industrial fuel from Caribbean refineries run on Venezuelan, African, and some Persian Gulf crude oils is also likely to continue.

Foreign crude dependence on the massive Gulf Coast refinery complex will grow through the 1980s as offshore and onshore domestic supplies decline. Mexico is expected to become an increasingly important source of crude oil. It is hoped that this will supplant some Persian Gulf sources. Refined products, in addition to supplying the Gulf States region, will move northward to the midcontinent and then eastward to the regions in the eastern United States through major trunk systems that are expected to have adequate transportation capacity to meet foreseeable demands. This system is expected to cope with any degree of crisis shortfall.

In the Rocky Mountain and Northern Tier States, the declining supply of Canadian crude is expected to be made up by a northward movement of crude oil from the Gulf Coast. Recent finds in the overthrust belt will help to maintain this region's indigenous production levels, but they are not likely to expand supply substantially. A pipeline system has been proposed to carry crude from a Washington State import terminal to the Northern Tier States. The economic viability of the proposed Northern Tier pipeline is being tested; the outcome should be known in about one year. However, the outlook for the project, as currently put forth, is clouded because of the uncertain level of oil demand and the recent expansion of pipeline capacity northward from the Gulf Coast, as Canadian oil exports to the U.S. midcontinent have declined.

For the West Coast, the Alaskan North Slope will continue to be the major supply source during the 1980s and 1990s. Onshore and offshore production in California will play an important, although probably declining, role in supply development. Imports of refined products may not be needed, since it is anticipated that adequate refining capacity will exist in this region.

The U.S. refining capacity now stands at roughly 18 million bbl/day and is forecast to increase to 19 million bbl/day on the basis of announced development projects. As energy conservation steps take hold, this capacity may exceed future demand. But, despite the potential excess of crude oil distillation capacity, there will be a need for additional domestic refinery investment for two reasons. First, there is a growing need to process lower-grade crudes because the principal stocks of world crudes are more sulfurous and of heavier gravity than those characteristically processed in the United States. Second, the decline in demand for residual fuel oil is expected to necessitate investments to upgrade heavy-oil products to the lighter ones, principally distillates (i.e., diesel fuel, jet fuel, and heating oil). During most of the past 10 years, as refiners should have moved to progressively higher yields of gasoline and distillate, regulations have prompted them instead to produce proportionately less fuel for transportation use from each barrel of crude oil. Moreover, the increased capacity to convert heavy products to lighter ones adds considerable flexibility to the response capability of U.S. refineries in the event of a major crude oil cutoff.

RESPONSE AND ALLOCATION

The Strategic Petroleum Reserve (SPR), which was approved by the U.S. Congress in 1977, can play an important part in a supply emergency by providing time to implement a more broadly based emergency response. This, in turn, may

ensure that any shortfall can be spread reasonably and equitably through a combination of programs requiring time to implement. Unfortunately, the SPR program, which was initially to have contained 0.5 billion bbl and was later amended to reach 1 billion bbl, has not been implemented. Today, the SPR contains slightly more than 90 million bbl.

A number of rationing schemes have also been proposed. Given the perceived need for rationing (when the shortage level reaches 20 percent or more), any rationing program should be simple to understand and administer, flexible enough to respond to current need and not just historic demand, and a source of incentives to reduce unnecessary consumption. In order to satisfy these conditions, the current, highly complex allocation scheme would have to be suspended for the duration of any rationing program. The possible advent of rationing imposes not only severe institutional burdens but also increases the potential for chaos and skepticism among the general public.

Whatever the pros and cons of a rationing program, it is certain to be very costly and potentially fraught with statistical errors on the order of 10 percent of the gasoline demand. With an anticipated 20 percent crisis shortfall, the errors inherent in a rationing program may exacerbate rather than ameliorate the shortage's impact on the motoring public. Moreover, by definition, a crisis means that other coordinated actions may be required from the oil industry and government. Such actions may include temporary lead waivers for gasoline, relaxation of rules on coal burning, and the rotation (wheeling) of electric power from coal and nuclear-powered generators to displace the output of oil-burning plants.

Therefore, to properly coordinate a crisis response, it may be necessary to create an office of emergency preparedness (similar to a war-time fuel board) that requires designated representation from major refiners and relevant federal and state agencies.

Session 2: Concurrent Workshops on Capacity to Meet Contingencies

Workshop I: Capacity of Urban Transit and Paratransit Systems to Meet Energy Contingencies

DISCUSSION

Workshop 1, chaired by William Barker, dealt with the ability of urban transit and paratransit systems to meet energy contingencies. Four resource papers aided participants in exploring potential responses by these systems to a variety of energy-shortfall scenarios: Potential Use of Carpooling During Periods of Energy Shortages, by Melvyn D. Cheslow; Capacity of Urban Transit Systems to Respond to Energy Constraints, by Gary F. Taylor; Potential Roles for Auxiliary-Paratransit Services in an Energy Shortage, by Charles Carlson and Mary P. McShane; and Energy Contingency Planning for the U.S. School Transportation Industry, 1979-1980, prepared by the National School Transportation Association Energy Committee.

Carpooling

Cheslow analyzed the probable effects of three fuel-shortfall scenarios on carpooling. Various sources of data on travel behavior were reviewed to provide a basis for estimating responses. These sources included actual travel data from origin-destination studies and related sources, surveys of how people said they would respond to projected conditions, models of travel behavior, and analyses of saturation conditions in parts of the carpooling market.

Transit

Taylor highlighted the limitations of existing transit systems in responding to any major energy shortfalls. Even a modest shift (1-2 percent) of automobile commuters to transit can cause inordinate delays due to overcrowding and may leave regular transit users without service. This contrasts with the World War II situation when a 48 percent increase in transit riders was accommodated by the much larger system in existence at that time. The increase in riders that occurred then is about equal to today's total ridership. Although systems have been able to handle the moderate increases that have occurred in the last eight years, they generally have little extra capacity remaining.

The largest systems and the smallest systems have less ability to accommodate shifts to transit than those in the middle range. Generally, the largest are already operating at capacity in peak periods, or very close to their capacity. On the other hand, the smallest systems have too little rolling stock or trained personnel to carry significant numbers of passengers. Middle-sized cities, particularly in the West and Midwest, have tended to build adequate comprehensive transit systems in the past 10 years and now often have significant reserve capacity. Perhaps most important is the fact that they seem to have generally better financial support than either the very small or the large systems. Workshop participants agreed that expanded funding and planning for quick and smooth responses to future energy shortages are needed for all transit systems.

Auxiliary-Paratransit Services

Auxiliary-paratransit services may include six basic types of vehicles: conventional transit buses, over-the-road intercity coaches, school buses, taxis, vans, and regular passenger sedans and station wagons. The wide variety and large number of vehicles that exist in these six categories offer substantial transportation reserve potential. However, these fleets are, in many cases, underused. Without some preplanning and implementation, their service potential will fail to be used effectively in emergencies.

Obstacles that need to be addressed in the preplanning stages include marketing strategy and public information (particularly for unfamiliar types of service), vehicle design limitations, insurance constraints, funding to support service development and operation, assurance of fuel availability during shortages for services not covered by DOE's Special Rule 9, and, most important, labor constraints--particularly Section 13c of the Urban Mass Transportation Act.

Several types of service, it was felt, can be initiated or expanded to accommodate demand during future shortages:

1. Expanded use of rental and lease vehicles, including employer van leasing through automobile leasing companies, integrated leasing arrangements for vanpools and carpools, carpool and vanpool brokerage by automobile rental and leasing companies, and ad hoc public transportation that makes use of rented vehicles;
2. Expanded use of privately owned intercity buses;
3. Expanded use of school buses; and
4. Expansion of demand-responsive types of service, such as dial-a-ride, shared-ride taxi service, and jitney service.

About 1 percent of all automobile trips could be accommodated with these types of services. This percentage was viewed as a practical order-of-magnitude planning target. However, it was noted that the school bus fleet alone is about five times the size of the transit bus fleet. Therefore, using the school bus fleet offers a theoretical potential to accommodate several times this level of shift from automobiles.

Overview

Despite the service potential of all forms of transit and paratransit, most of the energy saving will come from changes in the use of the automobile—through reduced use, trip chaining, or ridesharing. Nonetheless, transit and paratransit systems can provide important savings in particular markets. Promotion of these modes is a politically necessary part of contingency planning and has benefits in terms of achieving greater public awareness of the need for contingency planning and action.

Many problems in achieving the potential of all modes are problems of our own making and are institutional rather than physical or technological problems. The critical task of contingency planning is to identify those persons and organizations that must act and to get them to do so in a timely manner.

CONCLUSIONS

Because this was the first conference workshop, the emphasis was on establishing a framework of ideas and information for consideration in workshops 2-8 rather than on achieving consensus. Some considerations that relate to capacity, however, led to (a) suggestions on how contingency

planning should be organized and conducted and (b) some aspects of plan content and implementation.

The objectives of this workshop were to assess the capacity of transit and auxiliary modes to meet changing needs under shortage conditions and to develop an understanding of system limitations and of the issues involved with these limitations. An important conclusion drawn by workshop participants, however, was that there are at least five basic categories of limitations that determine the capacity of the several modes of transportation to respond to energy shortages:

1. Capacity of the physical system,
2. Institutional and regulatory constraints,
3. Political capacity to make decisions facilitating transportation services,
4. Limitations caused by lack of public information, and
5. Fiscal capacity.

Physical Capacity

Some participants focused attention on the more-limited concepts of capacity. For example, can the necessary seat-miles of transit and paratransit be provided by available vehicles, personnel, and logistic-support systems? Physical capacity has several dimensions. Vehicle availability may be the most obvious constraint, particularly for conventional transit. Stockpiling of older buses is often the first option considered, but this may not be a very cost-effective approach.

School buses have design limitations for conventional line-haul transit service but may be suitable for use in small urban areas and rural areas and for auxiliary services that do not involve heavy traffic or frequent, prolonged stopping and starting. School-bus design standards are improving, but more attention may be needed to devise standards that will make them more suitable for temporary use in transit service during emergencies.

In the auxiliary and paratransit modes, the problem of vehicle availability is not primarily one of lack of vehicles because there is an enormous theoretical potential capacity offered by privately owned vans and sedans. Rather, the problem centers on standby mechanisms, a large number of which can be used in a variety of special services.

If substantial numbers of vehicles are made available for supplementary transit services, the primary capacity problem may be one of personnel—trained drivers, maintenance people, and others. School bus systems may offer potential sources of needed labor for emergencies, but special training will be required if drivers of these vehicles are to be used for supplementary transit service.

As a result of DOE's Special Rule 9, fuel allocations are assured for conventional transit and certain forms of regular services that have fuel storage facilities. However, no provision has been made for many types of auxiliary transportation services that do not have such facilities. Contingency plans should address this issue, including the need for additional fuel storage capacity and, possibly, the use of alternative fuels (e.g., varying grades of middle distillates or alcohol).

Experience shows that sufficient capacity exists to accommodate moderate shortages of up to 10-15 percent without government action to provide supplementary capacity in advance of emergencies. Shortages of up to about 20 percent can probably be accommodated satisfactorily without increases in transit capacity. All energy-efficient forms of transportation will need to be expanded to accommodate larger shortfalls, but ridesharing in its various forms offers the greatest potential for increased capacity.

Institutional and Regulatory Constraints

Institutional and regulatory constraints deserve more attention in contingency planning because they may more often be the actual limiting factor and subject to change. Perhaps the most important general factor in this area is the incapacity of existing institutional structures to act decisively to implement contingency measures in a timely fashion. In large measure, this is attributable to a lack of well-conceived plans with agreed-on responsibilities for specific officials or agencies to take specific actions under predetermined conditions. Part of this problem, however, begins with weaknesses in agencies on which the contingency-planning responsibility falls.

Metropolitan planning organizations (MPOs) may be the logical contingency planners because they have the best available data and transportation expertise in urban areas. However, they almost always lack the power and influence to get the necessary attention and commitments from senior elected officials, agency heads, and corporate officers. Legislation or executive delegation of power may be needed at the state level to give MPOs specific contingency planning powers and responsibilities—if these agencies are to be expected to take the lead role.

A similar incapacity to act probably exists in most states now, although this is expected to change rapidly in response to recent DOE regulations. A frequent problem is that agency responsibilities may overlap, or more commonly, be poorly defined. Logical roles and working relations need to be defined for governors' offices, energy offices, and various operating agencies that should have a role in implementation.

Section 13c presents a significant barrier to the use of federal funds for the most feasible forms of paratransit. This statute and the federal implementation procedures should be reviewed to limit the power of Section 13c to the protection of existing jobs, as opposed to its use to ensure that all future jobs, particularly those created on a temporary basis during emergencies, are union controlled. Any new federal assistance provided to support emergency transportation services should be as free as possible from labor-protection procedures or from any other review procedures that would limit the use of available personnel in emergencies or would cause delays in implementation during emergencies.

At the state and local levels, all statutory restrictions and regulatory procedures on freedom of entry should be reviewed and modified as necessary to permit the organization and operation of paratransit and auxiliary services—at least under specified emergency conditions. Contingency planners may be well-advised, however, to make an effort to remove most of these regulatory restrictions in general rather than just during emergencies. Public officials, transit operators, and others need to recognize that paratransit operations can often serve to supplement conventional transit services in peak periods and, thereby, serve to reduce or hold down transit deficits.

Other institutional and regulatory issues discussed in the workshop included Section 504, noise-abatement regulations of the U.S. Environmental Protection Agency, the Energy Tax Act of 1978, and unrealistic insurance policy restrictions and rates that discourage some forms of paratransit and ridesharing.

Political Capacity

The political capacity to make decisions facilitating transportation services was the third category of factors that limit a system's capacity to respond in emergencies. This incapacity is obviously linked to the fourth category—those limitations prompted by the lack of public information.

Mutually reinforcing efforts are needed to convince both public officials and the general public of the high probability of future supply interruptions and the need, therefore, for a variety of actions to prepare for shortfalls of potentially much greater magnitude than have occurred to date. On a more technical level, contingency planners need to work hard to convince public officials and the public of the potential benefits to be obtained from specific measures

that require legislative or executive action, such as funding for stand by transportation service, regulatory reform, or authorization for emergency actions.

Government and public officials should set examples to shape public attitudes directed toward fuel conservation—e.g., through ridesharing incentives for public employees, staggered work hours, and continuing reminders about ways to conserve and about cost savings that could result from specific actions.

Public Information

The cynicism of the general public about the seriousness of energy problems requires better public information activities. Blaming the oil companies or others for the energy crisis has been an understandable reaction when the public is so poorly informed about the nature of the problem.

Information on travel needs and impacts of shortages at a detailed, disaggregate level is lacking. During past shortages, government at all levels responded to problems based on the degree of dissatisfaction voiced by particular groups. This type of behavior is likely to be compounded in the future unless improved mechanisms are established for two-way communication about fuel availability, the availability of emergency transportation services, and the severity of problems within local areas.

Fiscal Capacity

The fifth category of constraints on response capability is fiscal capacity. Emergency funding is needed at all levels to provide prearranged support for both capital facilities and operations that are required by contingency plans. For example, funding is likely to be required for staff trained to provide leadership during emergencies, for fuel storage tanks, for standby vehicles, for training auxiliary drivers and maintenance personnel, and for supplementary operating assistance.

Involvement

To solve many of the problems identified in this workshop, the need to involve special groups in the contingency planning process was stressed. Such groups would include public officials, operating agencies that must implement contingency actions, trained crisis-management professionals (e.g., civil defense and disaster-relief personnel), major employers, private transportation services (e.g., truck, taxi, and bus operators), labor, fuel suppliers and retailers, and police officers.

Workshop 2: Intercity Passenger Transportation-Capacity and Contingency Planning for an Energy Crisis

DISCUSSION

Can the Intercity Transportation System Accommodate the Demand During an Energy Shortage?, a paper by Gibson W. Fairman, and Energy and the Airline Industry, a paper by K. William Horn, served as catalysts for discussion in workshop 2 of issues and concerns related to intercity passenger transportation, along with several other studies. The workshop, chaired by Vincent M. Helman, focused on the capacity of intercity passenger transportation services to handle increased ridership due to energy shortfalls and on contingency planning by different modes for an energy crisis.

In summarizing the Fairman paper, Kent G. Smith noted that Fairman's analysis of the current amount of unused intercity passenger-carrying capacity for rail, bus, and air modes indicates they could accommodate a 55 percent modal shift from automobiles. Such a shift might occur in the event of a complete cutoff of imported oil. However, many portions of these three systems would not be able to accommodate all of the demand placed on them, particularly during peak periods of the day, week, and year. Fairman maintains that marshalling potential excess capacities to handle a sudden increase in demand caused by a fuel shortage could present major logistic problems. Such problems might hinge on government rules and regulations, labor contracts, service area disputes, maintenance requirements, modal interface coordination, and difficulty in shifting demand to off-peak periods.

Horn's paper illustrates the dramatic effects that fuel price and availability have had on the airline industry in recent years. At the time of the Arab oil embargo in 1973, U.S. scheduled airlines were paying $0.12/gal for jet fuel. By the end of 1979, they were paying $0.75/gal, with a projected increase to $1.10/gal by the end of 1980. Fuel as a percentage of operating costs rose from 12 percent to more than 30 percent during the same 1973-1979 period.

As a result of fuel price increases, the airlines have taken actions to become more fuel-efficient, such as purchasing fuel-efficient aircraft and making operational improvements to increase load factors. Other steps taken include (a) reducing cruise speed, (b) expanding the use of flight simulators, (c) increasing the use of computerized flight planning, (d) developing sophisticated monitoring systems to identify aircraft that may be using excess fuel, and (e) shutting down one or more engines for taxiing maneuvers before takeoff and after landing.

One of the key problems for airlines, Horn notes, is the huge projected capital expenditure for purchasing new fuel-efficient equipment. U.S. airlines will need an estimated $87 billion during the 1980s, compared to total expenditures of $16 billion in the 1970s and $10 billion in the 1960s.

Commuter airlines have also experienced significant growth (25-30 percent/year) in the last 10 years. But, while taking on new routes prescribed by deregulation, the commuter airlines are locked into fuel allocations that ignore this expanded service.

A discussion of secondary industries, especially tourism, that depend on intercity travel was led by Michael Winnall. The 1973-1974 oil embargo and economic recession were the worst since the 1930s. The tourist and travel industry, particularly in recreation areas located long distances from large urban areas, suffered losses of up to 50 percent of revenue during the shortage. Travel from the United States to Europe dropped 17 percent in 1974.

Government actions to mitigate the crisis, such as Sunday closing and odd-even and maximum-purchase restrictions, discouraged intercity travel and, as a result, increased the impact on tourism. Future emergency actions should be coordinated among adjacent states and scrutinized as to the effects of these actions on mobility. Such scrutiny would mitigate unnecessary and adverse economic consequences.

Milton Pikarsky summarized the findings of a study conducted by the Aerospace Corporation on optimizing interurban rail service during energy shortfalls. Despite the fact that railroads account for only 1 percent of intercity travel nationally, passenger trains could provide significant relief in some high-density areas, such as the Northeast Corridor, during an emergency. Actions suggested in the study and during discussion by workshop participants included electrifying selected lines, increasing the capacity to build coaches (currently, Budd is the only builder), using longer trains, rebuilding old coaches, regeneration of energy (flywheel), using electronic controls, reducing the weight of

rail cars, using lower-grade fuel, and changing schedules to achieve higher passenger occupancy.

CONCLUSIONS

1. There is excess available passenger-carrying capacity on all intercity modes, but there are significant unresolved obstacles to using it. First, theoretical capacity and modal-shift studies based on the current intercity structure may not be valid in an emergency because the system is experiencing rapid change due to fuel price increases, deregulation, and threatened shortages. Also, projected load factors may not correspond with desired travel patterns during an emergency. Second, some aspects of deregulation, such as the limitations on discussions between carriers on how to limit service in order to increase load factors (e.g., intercarrier capacity agreements), are hampering route rationalization of the industry. Such restriction would be a serious constraint during an emergency. Third, other obstacles to increasing load factors in the short-term include user subsidies, union contracts, and work rules.

2. Although intercity rail service will be important in certain high-density corridors during an energy shortfall, it would be inappropriate for public policy to encourage a major shift to the entire rail system, which is viewed as poorly managed and unable to cope with a sudden demand for service. Since states currently subsidize some intercity rail services, some leverage exists for rail-use strategies at the state level. For example, weekend day-trip packages could serve as an alternative to automobile travel.

3. Fuel price increases have been the greatest incentives for conservation within the airline industry. However, the incremental jump in projected capital expenditures for the 1980s, accompanied by the increasing percentage of operating revenue devoted to fuel and by doubts about fuel availability, have created a capital squeeze within the industry. As a result, the airline industry is looking for front-end capital to turn over the fleet faster for fuel-conservation purposes. The question of whether this capital requirement is a function of normal fleet-replacement cycles or energy conservation was raised but not resolved.

4. Insufficient hard data were presented on the level of diversion from the automobile to intercity modes, or among intercity modes, during emergency periods. For example, an on-board survey conducted by one airline in January 1974 noted a 4.1 percent diversion due to energy concerns. At the same time, airlines were averaging 1100 flight cancellations/day due to reduced fuel allocation. For the June-July 1979 period, the diversion factor was only 2 percent.

5. Because significant amounts of tourist-recreation dollars are spent in the economy, a discussion of appropriate strategies for reducing shortfall effects on the tourist industry raised these questions: Should the strategy be to facilitate travel to remote resorts (e.g., maintain precrisis recreation patterns), or should it be left to the resort industry to become more competitive with close-in recreational opportunities (e.g., by offering lower prices or special packages). No definitive answer was offered at this time.

6. The appropriateness of such actions as odd-even and maximum-purchase restrictions should be considered closely in terms of any negative economic and mobility impacts—especially on intercity travel and related industries. Most of these actions are undermined, for example, if service stations do not stay open. Public- and private-sector efforts at the local level should be tried first.

7. The role of government in developing and promoting intercity strategies should not interfere with discretionary travel choices, including intercity travel, because consumers can best make the decisions on how to conserve in this area. However, government should provide leadership and should promote a wider range of choices, including actions that will accommodate changes in discretionary travel behavior (e.g., retail stores that are open 24 h/day and day trips on intercity rail). Government should also make sure that fuel allocations to the various intercity modes are equitable and politically acceptable.

Workshop 3: Capacity of and Strategies for Freight Transportation During an Energy Crisis

DISCUSSION

The capacity of and strategies for freight transportation systems to respond to an energy crisis were the primary concerns of workshop 3, chaired by John E. Murray. Two papers provided workshop members with an overview of likely industry responses to an energy shortfall. John N. Hooker examined the Effects of a Sudden Fuel Shortage on Freight Transport in the United States: An Overview, and Donn D. McMorris discussed Issues in Developing Contingency Plans for Intercity Freight.

Hooker maintains that the potential responses of the freight transport industry to save fuel during a sudden 20 percent reduction in fuel supplies depend on the particular logistics and economics of each freight transport mode during a crisis. However, based on available data, some general conclusions can be reached about what is possible.

For example, short-term modal shifts from truck to rail are unlikely due to the lack of incentives to save fuel available to the shipper-customer and capacity constraints faced by the railroads. The most effective way to cut intercity truck fuel use in a crisis, short of reducing service, is to slow down. Consolidation and reduced frequency of runs may be the appropriate responses for local trucking. Railroads may be able to increase freight-car use, and the maritime industry may be able to pool vessels during an emergency. The best preparation for contingencies is to cut fuel consumption now through programs that are too long and involved to implement during an emergency.

McMorris, in describing the trucking industry's perspective on the issues confronting contingency planning for intercity freight, notes that past emergency regulatory decisions on fuel allocations failed to consider the production or distribution functions of the trucking industry. The current allocation structure is inequitable because it does not account for the diversity of fuel-purchasing patterns (e.g., wholesale, retail, gasoline, and diesel) inherent to the industry. As a result of the Voluntary Truck and Bus Fuel Economy Improvement Program—a joint industry and government effort initiated in 1975 to help find long-term, marketplace solutions to the energy crisis in the commercial vehicle industry—the purchase of new and more fuel-efficient equipment by the industry is making a significant contribution to fuel conservation. Additional savings are possible if all states comply with the allowable federal maximum truck size and weight limits of 80 000 lb and trailer combinations of 65 ft.

Although the role of local government in developing contingency plans for the freight sector was not specifically discussed during the workshop, the resource papers do recognize that urban goods movement has been largely ignored by contingency planners at all levels of government. The fuel saving and potential response to a crisis from this sector of the freight industry may be best explored at the local level. Actions, such as maximum use of federal highway funds for railway or roadway overpasses

and underpasses in order to reduce the frequency of stops and idling, may also be pursued at the local level.

CONCLUSIONS

The resource papers pointed out that the amount of fuel that can be saved by freight transport during an emergency without a substantial reduction in service is relatively small. However, appropriate actions should be taken to save this fuel as a credit for the industry against short-term reductions in fuel supply. The workshop discussion focused on what the federal government, freight carriers, and shippers can do to adjust to a sudden fuel shortage. These actions are summarized below.

Federal Government Response

1. An even-handed energy tax policy should be implemented that provides conservation tax incentives to both private individuals and businesses, based on the return in potential savings (e.g., home weatherization, diesel engines with a bottoming cycle for trucks, and solar-powered railroad signaling devices).
2. Labor practices that frustrate energy conservation, as well as jurisdictional conflicts related to vehicle use, should be studied and resolved. Agreement constraints that handicap the basic economic potential of intermodal transportation should also be evaluated.
3. Although no consensus was reached as to the role of government during a crisis, it was felt that strategies for resolving fuel-allocation inequities during an emergency should commence immediately. One mode of freight transport or type of carrier should not be favored over another, as was the case under DOE's Special Rule 9 during the summer crisis of 1979 (e.g., truck versus rail and barge). Specifically, DOE's three-tiered emergency allocation system for middle distillates should be reviewed in terms of the fuel requirements of the transportation industry that support priority users.

Carrier Response

1. Shippers should be encouraged to take advantage of carload and truckload rates in order to reduce the frequency of deliveries.
2. Both fuel-inventory security and fuel quality available should be improved in order to reduce losses and unnecessary maintenance.
3. Truck drivers should be encouraged to observe the 55-mph speed limit.
4. Empty mileage should be reduced by pooling arrangements for truck, rail, and waterborne freight modes.
5. The use of maintenance and fuel-saving devices, such as radial tires for trucks and welded rail for trains, should be stressed.

Shipper Response

1. Freight movement should be consolidated, especially to accommodate emergency schedule changes.
2. Vehicles should be loaded to the legal maximum.
3. Shipping frequency should be reduced by increasing retail and middleman inventories.
4. Flexible pick-up and delivery hours during emergency periods should be permitted.
5. The energy-saving benefits of urban transport practices, such as rerouting, computer modeling, driver training, and improved maintenance, should be reviewed and used.

Session 3: Concurrent Workshops on Energy-Response Experience

Workshop 4: Consumer Behavior in Response to Past Energy Shortages

DISCUSSION

The behavior and responses of consumers to past energy shortages and their future implications were the primary concerns of workshop 4, chaired by Sarah J. Labelle. A variety of resource papers and presentations gave participants several perspectives on how consumers have handled themselves and energy shortfalls in the recent past and how they are likely to react in the future in the event of other energy crises.

The papers and presentations available to the workshop included Policy Implications of Urban Traveler Response to Recent Gasoline Shortages, Robert L. Peskin; Response of Freight Transportation to Fuel Supply Shortages, Rita E. Knorr; Predicting Consumer Response to Gasoline Shortages, Harold Wakeley; Consumer Reactions to the 1979 Gasoline Shortage, Jill L. Haberman (in conjunction with a presentation by Lois Jacobini); and Short-Run Traveler Responses to Alternative Gasoline-Allocation Plans: Some Modeling Results, Joel Horowitz. A paper by William B. Tye offered some insights related to analytical models of gasoline demand during an energy emergency.

The sectors of travel demand examined in workshop 4—urban passenger travel and rail and truck freight movement—account for 58 percent of the total transportation fuel consumption and 30 percent of petroleum use in the United States. These sectors are totally dependent on petroleum and would be affected almost immediately by any supply interruption. Any disruption in supply would result in short-term adverse mobility and economic consequences in these sectors. Both sectors have only limited alternatives for travel, and no major modal shifts (e.g., from automobile to rail or bus, or from truck to rail) are anticipated. As a result, both the urban passenger and freight sectors are expected to continue their dependence on petroleum at least during the 1980s. With only a gradual change toward a more varied transportation system, the lessons of past shortages should be useful in preparing for future energy contingencies.

The workshop papers and presentations document the short- and long-term responses of urban travelers and intercity freight movers to the fuel shortages associated with the 1973-1974 embargo and the 1979 summer crisis. Some behavioral theories that help to explain these responses, as well as the data, methods for analysis, and new data required, also were detailed. The emphasis was on actions that government can take to ease the burden of the shortages on those least able to absorb extreme short-term price and availability changes and that can keep the transportation system functioning during shortage conditions.

The workshop sought to present a complete picture of documented responses. Peskin discussed urban passenger response studies and surveys in the literature related to the 1973-1974 shortage period. Peskin indicates that the availability of fuel was more important than price as a determinant of demand. The changes in travel behavior varied by household income, with higher-income households making fewer adaptations to the shortage. The work trip proved least flexible for all households, with required changes accommodated in the discretionary category of travel—shopping, recreation, and family activities. Modal changes for the journey-to-work trip did not appear to be the most likely responses during a shortage. Transit and carpooling incentives, paired with automobile disincentives, could be effective in producing gasoline-conserving options for urban travelers.

The quantity and quality of response data vary significantly between the passenger and freight sectors. Because little information was available from the literature, Knorr conducted original data collection on intercity freight response. This collection relied primarily on a telephone survey of carefully selected carriers and shippers to identify the responses. The importance of urban goods movement was emphasized because of its effect on intercity freight transport. One problem that occurred during the summer shortage of 1979 was the inability to properly use intercity equipment because of tie-ups at terminals due to waits for local pickup and delivery trucks that were affected by gasoline shortages and gasoline lines.

Wakeley's paper highlights the bases in psychological theory that explain behavior in past shortages and that focus on the differences between short- and long-term patterns of behavior. He emphasizes the need for high-quality, consistent information from the government and the media during a shortage situation.

In general, the evaluation of the most recent shortages in 1979 has not yet appeared in the literature. Informal sources, such as newspaper reports of the extent of the shortage and communications with state and local planning staffs were used in Jacobini's presentation to identify regional variations during the recent shortages. The U.S. Chamber of Commerce and two trade associations also provided data.

Tye, represented by Timothy Tardiff, looked at several queuing models applied to gasoline lines in a shortage situation. Tye maintains that results depend heavily on the assumptions related to the model on market mechanisms (e.g., congestion pricing). Tye notes that minimum-purchase requirements and incentives for demand suppression have the greatest potential for queuing management.

Horowitz used preembargo data to test a method to model the likely short-run responses of urban travelers to gasoline shortages under different rationing plans (e.g., price increases or white-market coupon system).

Peskin, Knorr, and Wakeley all stress the importance of good reliable information as a major action during a contingency that contributes to economic stability. The behavior modification modes suggested by Wakeley indicate that quality information during a crisis is extremely important to consumers and is the basis for rational consumer decision making. Therefore, information sources (e.g., government, media, and private organizations) bear a heavy responsibility for monitoring crisis events and for developing rational alternative courses of actions for consumers to follow.

CONCLUSIONS

This workshop focused on urban travel responses, i.e., where urban households are the principal decision makers for passenger travel and carriers and shippers are the decision makers for goods movements. Although agreement was not always reached on these data or their interpretation, the workshop participants identified general patterns in the responses, and these patterns are briefly noted here.

Urban Households

1. The energy-shortage impact during both the

1973-1974 and 1979 periods varied according to income, age, and automobile ownership.

2. Variations in impact according to demographic area (e.g., urban, suburban, or rural) were extreme; this suggests information and allocation problems.

3. Work trips were maintained, but nonwork travel was adjusted significantly.

4. The effects of changes in nonwork destinations, trip lengths, and trip frequency were not predictable by using current analytical methods, despite the fact that these effects were severe for specific industries (e.g., resorts and tourism).

5. No agreement was reached on the importance of fuel price in a contingency. Debate centered on whether past experience provided a large-enough price difference to expect a change in demand in the short term. Price elasticities that have been estimated at lower price levels may not remain constant at future higher price levels.

6. Public transit was used when available; however, capacity constraints limit the potential of this mode.

Goods Movement

1. Most responses were cost-based decisions, and operational strategies were used in the short term.

2. Availability of fuel is the most crucial problem. Allocations may be the best way to ensure supplies.

3. Contingency planners do not seem to recognize the importance of uninterrupted goods movement.

4. Urban goods movement was not addressed in any great detail because of the scarcity of reported data. However, significant problems do occur in this area, especially at intermodal terminal transfer points and in geographic areas with odd-even rationing restrictions.

Relation Between Contingency and Conservation

1. Conservation strategies in place would make it easier to deal with contingencies.

2. The tendency of existing planning efforts is to focus on conservation rather than contingency management.

Appropriate Government Policies and Actions

1. Information flow is a key area for improvement because government credibility is a problem.

2. Allocation management could be improved at both federal and state levels.

3. Travelers must have viable alternatives; their options should not be limited.

4. Response mechanisms during a contingency should not be heavily dependent on data because the need for quick decisions outweighs the time required to collect and process data.

Issues

1. Contractual agreements with labor can affect operational shortages for both transit and goods movement.

2. There is a need to collect better-quality data on a continuing basis to better understand responses and impacts on both behavior and supply.

3. Government can focus its actions (a) to react to the burdensome impacts of rapid price changes or (b) to speed the onset of price increases as a natural market mechanism for the regulation of demand.

4. The lack of clear national programs for the long run makes funding and implementing contingency actions difficult.

5. The need for flexibility in allocations and in the physical distribution network for fuel may overshadow the importance of demand management in a contingency.

Workshop 5: Governmental Response and the Regulatory and Policy Environment That Affect the Performance of the Transportation Sector

DISCUSSION

Members of workshop 5, chaired by Donald H. Camph, examined the relative roles, responsibilities, and capabilities of various levels of government to deal with the transportation sector's performance, especially during energy shortfalls. The bases for discussion were three resource papers related to government responses and the regulatory environment surrounding the issue of energy contingency planning. These papers were Selected Issues Related to Governmental Responses to Energy Shortfalls in the Transportation Sector, by William H. Crowell; Missed Opportunities--Institutional, Social, and Political Barriers to Governmental Responses to Energy Crises, by Catherine E. Massey and Wallace B. Toner; and Government Agencies and Fuel Shortages--Past Actions, Current Problems, and Future Opportunities, by Charles Carlson.

Emerging Roles

Crowell characterized the emerging roles of the three basic levels of government in energy contingency planning. The federal role is becoming well defined through major legislation and recent regulations. The Emergency Petroleum Allocation Act of 1973 gives the Executive Branch the authority to determine in what manner scarce petroleum resources will be distributed by user group and geographic area and to determine reasonable prices for these products. The Energy Policy and Conservation Act of 1975 gave the President many contingency powers, including the standby gasoline-rationing program, and authorizes the President to implement energy conservation plans for states, the strategic petroleum reserve, and the scheduled improvement of motor vehicle energy efficiency. Subsequent regulations spell out the rationing program, allocation and price-control schemes, state conservation goals, and improved speed-limit enforcement. The regulations also establish the framework for state set-aside programs and retail motor vehicle fuel sales. The federal government now has rather extensive authority in the energy contingency area, with actions ranging from mild voluntary programs to almost complete control of supply allocation and price of fuels.

Because of the broad role that has been defined for the federal government, as well as because of the national structure of the industries involved, the states have been left in a veritable wait-and-react role. Their principal involvement in contingency planning and implementation is their incremental control, within the overall context of federal guidelines, over the supply and retail sale operations of motor fuel. States also have the responsibility to develop conservation plans under the emergency allocation act and have been given conservation goals for 1980. Generally, the states are on a difficult middle ground between the more fully empowered federal agencies and the various local and metropolitan agencies that must grapple with the direct impacts of shortages.

Together, federal and state responsibilities can be characterized as pertaining largely to fuel-shortage correction actions. Crowell, however, feels that when the real shortage is actually defined the burden of response falls heavily on local officials and agencies (and, of course, on the traveling public). The social, economic, and fiscal

impacts are most keenly felt locally, and the principal transportation services and management schemes are generally under local or metropolitan control. Furthermore, the states have been inclined to depend greatly on locally controlled transit, paratransit, and other local programs to achieve conservation goals.

Crowell observes that people in the United States have a reason for underplaying the potential seriousness of energy crises and for resisting moves to alter energy use, but such actions go against a strong tradition of carefree energy consumption. He contrasts U.S. tax and pricing policies with those of all other major industrialized petroluem-importing countries. These policies have tended to increase U.S. vulnerability to energy shortfalls and have been a factor in delaying the development of alternative energy sources.

A close parallel in governmental roles was noted between the emerging energy contingency planning process and the approach used in attempts to implement transportation control plans under the Clean Air Act and its amendments during the 1970s. Because of the notable lack of success of those past efforts and the disheartening similarity to these efforts of the general approach being followed in the energy field, Crowell suggests that there are important lessons to be learned on what to do and not to do from these experiences in preparing for future events.

Barriers

Massey and Toner, in examining the barriers to effective local governmental response to energy shortfalls, note that the recent mood in this country to limit governmental influence on daily life reflects a growing lack of confidence in the government's ability to solve problems. The desire and ability of individuals, community groups, and corporations to solve problems must be recognized. Government should do a better job of identifying what the public wants and needs; then, it should do the least that is necessary to facilitate individual responses to energy crises.

According to Massey and Toner, the two basic forms of institutional barriers that exist at the local level are government fragmentation and regulatory constraints.

No mechanism exists at the local or regional level to provide comprehensive energy conservation-contingency planning. The solution rests in having local governments identify—prior to a crisis—what mechanism will be used for coordinated comprehensive planning and will ensure that each entity's role is clearly defined.

The most important regulatory constraints are the time delays required to obtain approvals for supplementary transportation, such as new private commuter bus routes and jitney services. State and local governments must revise or streamline regulatory procedures to permit the timely entry of alternative services during a crisis.

Other barriers that need to be addressed include the positive image of driving alone (advertising should stress a positive image for ridesharing), the rigid concept of the nine-to-five job (government should set guidelines for employers to follow), and the failure of government to set an example (free parking should be eliminated and contingent transportation services for employees should be fostered).

Government Agencies

On the other hand, Carlson urges consideration of a greatly increased top-down approach, with numerous new federal requirements for planning and controls at all levels of government. His review of governmental actions in 1979 stresses the lack of preparedness for contingency actions. To the extent that states or localities had prepared plans, they were largely shopping lists of possible actions, mostly voluntary, with no specific implementation procedures. Numerous actions were taken, however, by all levels of government. For example, DOE made adjustments to its allocation program, notably by setting aside fuel for transit and for use by states in hardship cases and for special needs, and DOT took actions to encourage retention and rehabilitation of old buses. An executive order was issued to empower all governors to regulate retail motor-fuel sales. Carlson summarizes a wide variety of emergency actions taken by state and local governments.

He describes four basic continuing problems that inhibit effective governmental action:

1. DOT and DOE have not satisfactorily organized themselves to either respond to shortages or require localities to undertake broad energy conservation programs; they are not in a good position to coordinate other federal programs.
2. Federal transportation programs allow too much state and local autonomy and provide no clear requirements or priorities for conservation and contingency planning or action.
3. States have not assumed enough responsibility. They have deferred to the federal government because of a perceived lack of interest, responsibility, or constituency for conservation-contingency planning.
4. MPOs lack a mandate for contingency planning mechanisms to bring key private-sector actors into the planning process. Funding and federal requirements do not exist.

New federal policies, including the Emergency Energy Conservation Act of 1979, may help to remedy some of these problems. Each state will be required to implement a contingency plan that meets specified conservation targets in the event of a fuel shortage. Failure to meet federal planning requirements or targets can result in the imposition of a federal contingency plan. These new requirements may provide the needed incentives for action at state and metropolitan levels.

Carlson argues that DOT should make the development of state transportation energy conservation-contingency plans a condition of project funding. DOT should also require the designation of lead plans for transit, paratransit, and ridesharing services. He also recommends the creation of a federal emergency fund that states and localities can tap during a fuel shortage to expand transportation services.

CONCLUSIONS

In order to focus group discussion and ensure that a set of concrete, though necessarily limited, policy recommendations would result, two questions were posed for consideration by the workshop participants. The questions were (a) should government do anything at all to plan for shortage situations, and (b) if so, what levels of government should assume what roles in preshortage energy contingency activities? The intent was to focus on the appropriate role of various levels of government in preparing responses to energy-shortfall situations. The approach was to identify institutional, social, political, and economic constraints that necessarily define the nature and extent of energy contingency planning and plan implementation. To a degree, responses by employers, unions, private institutions, and the general public were also considered.

General Principles

To provide a framework and several criteria for answering these questions, a set of general principles relating to energy contingency planning was derived. These principles are outlined below.

1. The government should be the actor of last resort, thereby allowing the private sector to effectively respond to relatively minor shortfall situations without undue governmental interference.
2. Overall planning for and response to shortfalls should occur at the lowest levels of government that can effectively handle specific problems and actions. The rationale for this is to avoid overlapping plans by higher

levels of government that (a) are not responsive to local economic and social conditions and (b) would be perceived as outside interference in a local or regional concern.

3. The implementation of plans and policies for travel-demand reduction and minimization of socioeconomic hardships (after any allocation schemes and odd-even or minimum-purchase plans have been put into effect) should be handled strictly at the local level, with state and federal involvement limited to technical support, political leadership, provision of information relating to the shortage, and appropriate funding.

4. It is essential that, prior to any shortage, the responsibilities, authorities, funding capabilities, and leadership roles of all relevant agencies and actors be clearly established to avoid delays, overlapping, or missed opportunities when a crisis actually occurs.

5. Any plans that are created must be the result of a dynamic process that (a) will effectively reflect changing energy and transportation conditions and (b) will guarantee that the various strategies of these plans can be quickly implemented and are relevant to the supply shortage conditions at hand.

6. It is important that strong political leadership, rather than merely bureacratic policy support, be provided at all levels—if the plans are to be more than simple laundry lists of possible actions and if the public's consciousness of the potential for energy shortages is to be sufficiently raised to support plan development and implementation.

As the above principles suggest, workshop members arrived at a generally positive response to the first policy question. The general consensus of the group was that government, at all levels, does have some legitimate role to play in planning for and responding to shortage situations. However, expectations as to what government should or can hope to accomplish should be fairly limited. It was argued that the nature of many shortfall situations, both in terms of predictability and the speed at which they are manifested, make it clear that employers and individuals will tend to make operational and life-style adjustments on their own on the basis of self-interest and at a rate and diversity that government is ill-equipped for. When the manifestations of shortage conditions become evident, government's response should essentially be to provide self-help information and assistance to facilitate individual adjustments and to consider a limited set of policy options that would reduce wasteful behavior induced by a panic atmosphere.

When a shortage is so severe or chronic that social and economic institutions are threatened, a stronger governmental response may be appropriate.

After extensive discussion of the nature and appropriateness of federal involvement in energy contingency planning and implementation, consensus was reached on the following points related to the second policy question posed earlier.

1. Initially, federal involvement in energy contingency planning should be limited to providing incentives and assistance (both financial and technological) to state and local governments to develop plans. Federal involvement should be combined with political leadership at the highest levels—falling short of rules, regulations, reporting requirements, and sanctions. Neither the Clean Air Act approach by EPA nor the Emergency Energy Conservation Act approach by DOE were considered very effective. They may also have been counterproductive.

2. If, after a period of two to four years, the light-handed approach proves ineffective in inducing state and local governments to develop meaningful energy contingency plans, more direct involvement by the federal government in ensuring that such plans be developed may be appropriate.

3. To the degree possible, maximum flexibility should be retained in allowing local and state governments to develop effective energy contingency plans. It should be noted that institutional relations among state, regional, and local governments vary widely throughout the United States and that such plans should respect these differences.

4. The federal government should recognize the authority and responsibility of local units of government to develop and implement energy contingency plans. In the end, it should provide technical and financial support not only for plans and their implementation but also for plan-related activities that are longer-run conservation and air quality tactics (e.g., ridesharing). Given the demonstrated cost-effectiveness of energy contingency and conservation tactics, such as employer-based ridesharing outreach and marketing programs, categorical funding directed to local, regional, and state governments for support of such programs is appropriate.

Major State Roles

The major roles for state governments in the overall contingency response process should be (a) to work with DOE in the areas of allocation and set-aside; (b) to implement, when necessary, gasoline-panic control mechanisms (e.g., odd-even or minimum-sale schemes and regulated service station operating hours); and (c) to play a general overview role in guaranteeing that necessary planning is occurring throughout the state, in addition to providing necessary financial and informational support to regional and local agencies and the general public. The types of plans that were in place before the mid-1979 crisis were generally viewed as shopping lists of potential actions; these proved neither sufficient nor realistic. Future state plans should only be used as a summing up or as regional and local plans that are actually scheduled for implementation (after federal and state allocation and odd-even and minimum-purchase actions have been taken).

Under existing federal programs, MPOs have the main responsibility to develop and coordinate contingency planning in urban areas. There was general agreement that the basic institutional problems of these organizations (e.g., lack of final authority, no elective base, and existing political animosities) make MPOs an inappropriate agent to carry out the actual planning and implementation of strategies. It was felt, however, that they could provide a useful forum, within which the various local agencies and operators could coordinate their efforts. Thus, MPOs would still provide the mechanisms for the flow of federal financial support.

All of the on-the-street programs directly affecting the level, location, and timing of travel should be handled by the local transportation, transit, and economic development agencies that are most familiar with the nature and political sensitivities of such strategies. This action could help to minimize the public perception that such plans are being imposed on them by higher levels of government.

Workshop 6: Gasoline-Rationing Strategies

DISCUSSION

Workshop 6, chaired by Carmen Difiglio, reviewed several aspects of gasoline rationing. Participants were aided in this review by the presentation of several papers: Background Information on DOE's Gasoline-Rationing Plan, by Edwin J. Curle; Economic Allocation of Gasoline Shortages, by Difiglio; Household Characteristics and the Determinants of Travel Behavior, by Robert Gorman; and

Driver- Versus Vehicle-Based Rationing and the Potential for Coupon Sales Between Different Income Groups in Michigan, by Martin E. H. Lee.

Rationing

Curle and Difiglio, in their presentations concerning gasoline rationing, suggested several trends or actions for consideration by contingency planners. [A report to the U.S. Secretary of Energy has been prepared based on the following trends and conclusions.]

Congress expects that gasoline rationing would somehow allow all drivers a constant percentage of their existing travel at no increase in cost. But, short of being able to interview all drivers and verify their responses, it is impossible to distribute ration coupons in such a way as to precisely achieve this objective. Any feasible distribution scheme will result in the need to have a market in ration coupons that allows drivers to purchase extra coupons or realize income on coupons that individuals do not want to use for travel.

Rationing is not likely to be available soon enough to prevent gasoline shortages for a significant period of time after an emergency occurs. Gasoline shortages could cost consumers about $6 billion/month in lost time and gasoline due to waiting in queues.

A gasoline tax (with revenue rebate) can achieve the same income objectives as gasoline rationing. With either approach, the price of gasoline is increased because of a surcharge, represented by a tax or the use of a negotiable coupon that could be sold for a value comparable to the gasoline tax per gallon. Either system will save consumers approximately $100 billion if a 30 percent shortfall occurs; this would be money that, under decontrol, would accrue to the petroleum industry. Either system could treat consumers identically by distributing tax rebates or by using coupons with the same entitlement criteria and by providing rebates in as timely a fashion as coupons.

Gasoline rationing would depend on unavailable data to work properly. Gasoline supply data would not be available until three to six months after these data are required. This delay would make it difficult to decide how many gasoline ration coupons to distribute.

If the federal government were to offer to buy and sell coupons at a fixed price, there would be less need to have gasoline-supply data and no need to impose gasoline price controls. Such a system is called fixed-quantity rationing (i.e., when only a fixed number of coupons is supplied by the government).

The fixed-price rationing system and the tax-with-rebate plan are very similar in terms of how they work, despite the fact that the administrative requirements of fixed-price rationing are similar to those for fixed-quantity rationing. Fixed-price rationing and the tax with rebate would work best without gasoline price controls; however, fixed-quantity rationing requires price controls.

The current DOE plan allows the direct sale and purchase of coupons at prices determined by DOE. However, the decision to elect that option is not explicitly connected to the availability of gasoline-supply data or the desirability of retaining gasoline price controls. Instead, the fixed-price rationing system would be used if the white market does not perform properly or if DOE makes serious errors in providing the right number of gasoline coupons.

Income Distribution

Gorman and Lee used two independent data bases—one for Michigan and the other for the nation—in the resource materials they prepared for the workshop. But, although their numbers differed somewhat, the following conclusions were supported by their data sets and their analyses.

A small minority of households accounts for a disproportionate use of gasoline. Although certain attributes can be identified that generally characterize these households (e.g., males, higher incomes, more drivers per household, and more of a need to use vehicles for work), they are not homogeneous groups and cannot be identified as any specific user category. Further, vehicle- or driver-based distribution of ration coupons to households would result in transfers of income from higher-income households to lower-income households. However, the amount of income transfer would be significantly greater if licensed drivers were the basis for distributions.

Vehicles owned by urban, suburban, and rural residents average similar annual fuel consumption. However, rural residents appear to achieve more person miles of travel for a given level of fuel consumption. If ration coupons are distributed equally to all drivers of vehicles and the efficiency of travel remains relatively similar among geographic classifications, then the percentage reduction of mobility that would be induced by rationing for urban, suburban, and rural residents would be almost equal.

The percentage distributions of travel among travel purposes do not vary substantially among most income groups. Work-related travel does not form a higher percentage of low-income household travel, and low-income households do not have a lower percentage of so-called discretionary travel. In fact, the lowest income group as a whole has a lower portion of total travel for work and a higher portion for social and recreational travel—probably reflecting the fact that more retired and unemployed persons are in the lowest income group.

The recreation trip has significantly higher occupancy than the work trip. Consequently, work travel in its current form is not necessarily less discretionary than the recreation trip.

Vehicle allocation of coupons would best replicate existing travel patterns. However, a significant number of households have more vehicles than drivers (16 percent), and the plan would encourage households to obtain more vehicles. The plan aids in preserving the status quo. Thus, many higher-income households can continue to drive much more than the average. An ideal plan would encourage change in this regard during emergencies.

CONCLUSIONS

A majority of workshop participants concurred that gasoline rationing should be avoided and was not likely to work. They also found the tax (with rebate) approach to be a more viable alternative. However, significant concern was raised as to whether this approach would be politically feasible to establish as a standby contingency plan. Several workshop participants expressed the hope that forums such as this conference can help clarify such issues. Thus, these issues would serve to enhance the political viability of an alternative to rationing that would be administratively simple and quick to implement.

The workshop group identified several areas to be addressed before an improved rationing or a tax-rebate plan can be advanced.

1. Critical-user categories, such as transit and other energy-efficient forms of public transportation, farming, and freight, will require individual attention—either through special allocations or by special income-support programs to prevent these user groups from being outbid in the marketplace.
2. More effort is needed to analyze the income effect of the rebate on the market price of gasoline and the individual behavior of consumers. In particular, individual behavior with coupons—especially the behavior of low-income consumers—or rebates will differ significantly. This behavior needs to be understood.
3. How gasohol would be treated in any plan requires further study.
4. More attention needs to be given to how the commercial sector would be handled in either the rationing or the tax-rebate plan. The business sector desires a system that provides certainty and does not impose high transaction costs to acquire gasoline-purchase rights.

Neither the tax-rebate nor the rationing plan will account for product logistics under emergency conditions. Existing DOE expertise should be supplemented by establishing an organization, similar to a wartime board, to commandeer critical industry personnel who are experts in product logistics and industry operations. This national board could be supplemented by regional fuel boards. Their activities would not concern end-user allocation; rather, they would assume that a maximum amount of product would be made available and that critical wholesale requirements would be met.

Consideration must be given to a review of regulatory constraints on fuel production to maximize the amount of product that can be produced from a limited supply of crude.

More attention needs to be given to the conference's concerns with the existing rationing plan. More workable alternatives should be developed and analyzed in greater depth. These alternatives may not be politically popular, but they should be a constructive, realistic response to the realities of a true petroleum emergency—something this nation has not yet experienced. It must be remembered that the political environment will not remain constant after an emergency occurs and that the public will have no tolerance for a program that does not work.

Session 4: Concurrent Workshops on Strategies for Meeting Transportation Energy Contingency Situations

Workshop 7: Movement of People in Urban Areas During Contingency Conditions

DISCUSSION

Contingency Transportation Plans for Urban Areas and Their Potential Impacts, a paper coauthored by Darwin G. Stuart and Richard J. Hocking, served as the primary resource for workshop 7. The workshop was chaired by Frederick P. Salvucci.

A broad overview of recently developed energy contingency plans in several states and urban areas, the Stuart-Hocking paper covered five major topic areas: (a) complementary packaging of energy conservation actions, (b) estimating the individual and cumulative impacts of such actions, (c) staging alternative contingency plans in response to the different levels and durations of shortfall, (d) uncertainty regarding effectiveness, and (e) implementation issues.

Stuart, in summarizing this joint research effort for the workshop group, stressed the lack of substantial experience to use as a guide for contingency planning but noted that a great variety of ways exists in which various actions can be packaged to produce complementary conservation, or coping, actions. Much uncertainty exists regarding the effectiveness of past actions taken during energy crises because of lack of experience and data. Therefore, it is suggested that planners be more realistic and deal with ranges of expected impacts when they are evaluating strategies. This may be particularly true for more severe shortfall scenarios. Little has been done in evaluating the distribution of impacts on affected groups.

In another presentation, Anne Marie Zerega summarized research being conducted by two consultant firms on the energy conservation potential of alternative work schedules. This study by Jack Faucett Associates and Peat, Marwick, Mitchell and Company, will not be completed until September 1980, and no preliminary report is available. However, sufficient work has been completed to give DOE an appreciation of the many obstacles related to achieving any major changes in workweeks, particularly in the private sector.

Alternatives, however, that have been evaluated include different levels of compliance with targets for workweek changes. One alternative assumes that 70 percent of the labor force shift to compressed workweeks, which is about the maximum potential when all essential services are excluded from compliance. This results in an estimated 22 percent saving in work-trip gasoline consumption, or about 7 percent of the total gasoline consumption. A more realistic alternative results in an estimated saving of 18 percent for work travel, or 5 percent of the total gasoline consumption.

Several major institutional, social, and legal obstacles are being analyzed, including labor-protection laws, requirements for overtime (for more than an 8-h day) pay, and opposition to various plans by labor leaders and the U.S. Department of Labor. Potential negative effects on some industries include decline in productivity, overhead cost increases, complications in the management of employees, loss of parttime employment, and overall reduction in the gross national product.

Due to all problems involved, DOE concludes that a major effort at achieving compressed workweeks on a national basis is not justified as a conservation measure under normal conditions. Only major supply interruptions could justify such an effort.

CONCLUSIONS

Workshop participants concentrated on three questions:

1. What is the proper relation between conservation and contingency planning?
2. To what extent, and in what way, should the competitiveness or complementarity of various contingency-conservation actions be dealt with?
3. When is government intervention better than doing nothing at all, or what types of governmental actions are worthwhile and under what conditions?

<u>Integrating Planning</u>

In response to the first question, the group concluded that conservation and contingency planning have different objectives but that they should generally be part of the same process. In conservation planning, the objective is to reduce fuel consumption, and the time frame may include both short- and long-term initiatives. However, in contingency planning, fuel is not available, and the objective is to manage the situation while maintaining mobility and reasonable order. The focus in such an instance should be mainly to help people cope, and the time frame is usually a short-range one.

Despite these differences in objectives and time frame, the group concluded that there are several reasons for the close integration of conservation and contingency planning.

1. The measures often are the same or similar for both types of planning. Furthermore, the actors and institutions best able to implement programs are often the same. The same analytical capabilities and data bases are needed to plan and evaluate the best ways to implement actions under both types of planning.
2. The effectiveness of many contingency initiatives depends on prior preparation. Often, the best way for that preparation to be accomplished is when it is part of a conservation program. This should involve the mobilization of resources, the dissemination of information, and the building of the infrastructure required to implement the various actions that are part of the program. Conversely, the behavioral changes needed to accommodate a shortfall often last well beyond the crisis; therefore, the contingency initiative becomes a conservation strategy, particularly if this aspect has been carefully thought out.
3. The multiple benefits of various initiatives can frequently be used to help motivate people to action. That is, it may be easier to get people to take the required actions if they can see that it will result in long-term energy savings, as well as provide greater ability to cope with energy shortfalls.
4. The extreme uncertainty about when shortages will occur, how severe they will be, and how long they will last requires preparations for a wide variety of scenarios. Thus, workshop participants concluded that there is an economy of scale in carrying out both conservation and contingency

planning as part of the same process. Moreover, the danger exists that confusion and lack of credibility will result if the two are not part of the same process. In other words, if different people from the same agencies or people from different agencies go out talking about the same things, the credibility of both efforts decreases.

Major factors in the social, economic, and political environment will strongly influence the receptivity by many institutions and individuals of contingency-conservation actions, and these considerations should be integrated into any approach to deal with shortfalls. A particularly significant example is the severe inflation the nation is experiencing. Many conservation-contingency actions will ask people and institutions to undertake new initiatives at a time when they feel weakened and threatened and are already committing their resources to cope with the inflation situation. On the other hand, particularly because of rising real fuel costs, many conservation-contingency strategies will help people to cope with inflation as well as the energy situation. Thus, programs should be designed to motivate individuals and the private sector to action in their best interests.

In summary, the response to the first question, then, is that conservation and contingency planning do have different objectives, but they should take place as part of the same process. Such a process should be integrated with programs similar to those for air quality improvement according to the Clean Air Act provisions and for transportation system management according to DOT requirements.

Competition or Cooperation?

The second question, which deals with the competition or complementarity of various contingency-conservation actions, finds that many conservation and contingency initiatives are often viewed in competitive terms and discussed as substitutes for each other. The workshop concluded that coping with the uncertain gasoline supply of the 1980s will require the use of many initiatives; most of them will have to complement each other. Government should seek to stress and encourage cooperation and complementarity and should seek to diminish competition.

The bureaucratic fragmentation of urban transportation programs is the underlying reason for this situation. One or another initiative is often presented as a solution to everything, but is more often motivated by the desire to stop another action rather than to promote the favored one. For example, advocates of transit, paratransit, carpooling, and vanpooling often criticize the effectiveness or importance of other modes, while advocates of rationing or high gasoline taxes often argue that no other contingency plans are necessary if the favored program is pursued.

In fact, in the context of gasoline rationing or high taxation, measures to help people cope with the reduced supply of gasoline and with high prices are more necessary. Effectively dealing with the uncertain gasoline supply of the 1980s will probably require much more transit, paratransit, carpooling, and vanpooling services. As a result, it is counterproductive to fund one program at the expense of another.

A high benefit-cost ratio at the margin for one initiative is principally an indication that an initiative is not being exploited enough. Furthermore, a significantly larger program should be undertaken to the point that, at margin, the benefits of further expansion of the program may not be worth the added cost.

Cost-effectiveness then becomes an important consideration, but it should not be used in negative competition among energy modes. Instead, cost-effectiveness should be used to help decide what additional resources need to be mobilized to increase overall effectiveness.

Paying excessive attention to trade-offs among programs is thus destructive. The institutional energy and talent needed for different initiatives (as well as the benefits they produce) are usually different and not in direct competition. Given the major threat facing the nation's mobility, the cost of any reasonably effective program is less than the cost of inaction.

The appropriate use of cost-effectiveness information is, therefore, to design an optimally sized program that mobilizes additional resources rather than undermines other initiatives resulting in energy efficiency. It is much more important to discourage people from use of single-occupant vehicles (which now represent more than 65 percent of the journey-to-work traffic) than to worry excessively about which energy-efficient mode they will use, since all the energy-efficient modes, including walking, now total less than 35 percent of the journey-to-work trips. This point is underscored by the fact that the nation will be dealing with a very new situation in energy emergencies, and the accuracy of predictions concerning the effectiveness of various programs is likely to be quite uncertain. Therefore, it is all the more important for government to set a tone of cooperation and willingness in efforts to try new energy-saving initiatives.

The workshop participants maintained that categorical funds should be established for such initiatives, which would then minimize competition among energy-efficient modes. Because congressional action would be required for this, one immediate implication is that, under current DOT programs, ridesharing plans would be funded from the highway program rather than from transit funds.

Government Intervention

The question of trying to decide when government intervention is better than doing nothing led participants to conclude that no definitive answer is reachable and viable at this time. However, some tentative conclusions were reached.

Initiatives that improve the number of vehicle miles of travel (VMT) per gallon of gasoline (e.g., enforcement of speed limits, programs to encourage proper maintenance of tire pressure, and use of low-viscosity oil) and programs that encourage more person miles traveled per VMT (e.g., increased use of transit, paratransit, and ridesharing) are generally positive and, when effectively planned, are clearly worth pursuing. Actions that change some mobility, either to enhance other kinds of mobility or to maintain order and reduce lines at the gasoline pump, are much more problematical and difficult to judge.

The current presence or absence of government regulation should not be a criterion for future government involvement, according to workshop participants. If experience under past government regulation has demonstrated that the costs of regulation have exceeded the benefits and if continuing net losses can be expected under future energy-supply scenarios, then the regulations should be eased or eliminated. However, government should retain standby authority to impose future controls under appropriate threshold conditions (e.g., retail fuel price controls).

Conversely, opposition to government regulation should not necessarily be the criterion for no regulation if a net overall benefit is expected. For example, EPA programs have been maligned, but they, in fact, broke the ground for energy contingency work and provided a basis for planning some initiatives and implementation strategies. So it is often necessary for government to act—a role to be defended when intervention, as in the EPA case, was justified.

It was concluded that a primary criterion for government intervention should be in the determination of such factors as the amount of petroleum energy saved and the gain to be made in VMT per gallon of gasoline or person miles of travel per VMT. If these steps are substantive in relation to the negative effects of regulations, then government intervention may be justified in the face of any opposition that may occur.

Some regulations may involve stopping one kind of mobility in favor of another without a clear justification in terms of net overall benefits. The weekend closing of service stations is one example that should be questioned from this standpoint.

Government intervention is particularly appropriate to reduce lead times, provide funding, provide public information, encourage technology transfer, improve equity by evening the load (i.e., providing service to help low-income, elderly, and handicapped groups), artificially reduce work-trip gasoline use to permit non-work-trip use (because the work trip is particularly amenable to ridesharing), and reduce wasting gasoline and time in queues at gasoline pumps.

The workshop reached no further conclusions regarding appropriate criteria for government intervention, but participants agreed that this subject requires continued study and review in order to reduce needless government intervention, as well as to provide clear justification for intervention when warranted.

Workshop 8: Urban Passenger Strategies

DISCUSSION

Workshop 8, chaired by David T. Hartgen, focused primarily on urban passenger strategies that can be incorporated into local and state transportation energy contingency plans. Primary attention was paid to the technical feasibility and effectiveness of such strategies.

The workshop sought to identify and review contingency strategies undertaken by governments, business, and consumers to assess their effectiveness. The participants also strove to review the statistics of contingency planning and its content and to suggest possible viable strategies. Two primary resource papers aided the group in achieving these objectives: Contingency Transportation Plans for Urban Areas and Their Potential Impacts, by Darwin G. Stuart and Richard J. Hocking, and The 1979 Energy Crisis: Who Conserved How Much?, by David T. Hartgen and Alfred J. Neveu.

A number of recent studies incorporating many strategies and activities were reviewed in the resource paper by Stuart and Hocking. They maintain that the key activities necessary for plan preparation are (a) an inventory of available resources; (b) clear, coherent, and correct information from the government; and (c) an emergency-oriented plan that identifies actions to be taken under various circumstances. The capability to cancel, change, or increase actions and their intensity, based on monitoring key indicators, also is important.

Until recently, few cities or states had begun preparation of contingency plans. However, this activity has accelerated greatly in 1979 due to the summer shortages and the passage of the Emergency Energy Conservation Act. A review of contingency planning at different levels of government was recently conducted for the New York State Department of Transportation. More than 50 such activities were identified as of February 1980, and many more are in process now. As a result of the Emergency Energy Conservation Act, local planning efforts are now paralleled by statewide plans for possible mandatory demand-reduction targets. Increased coordination between local and state planning groups will be required if these efforts are to proceed without overlap or conflict.

Although the structure of the planning process is different in these plans, the results to date are surprisingly similar. Most focus on transit (e.g., capacity, operations, and fuel availability), ridesharing, and staggered work hours. Primary interest is placed on voluntary actions by the public and on promotion and encouragement by government.

Hartgen and Neveu describe recent work in New York. However, they note that, during the summer shortage of 1979, consumers saved gasoline in ways largely neglected by planners. Consumers took actions related to purchasing fuel-efficient automobiles (maintaining their mobility), vacations, and shopping travel rather than those the government encouraged, such as transit, carpooling, driving 55 mph, and having tune-up work done on their vehicles.

Wide geographic and demographic variations were found to exist in consumer response. Given this behavior, the ability of current contingency plans to either help consumers save or effect savings for them is seriously questioned.

Judgments vary about the effectiveness of actions to smooth the gasoline-purchase process. The prevalent view is that rationing by lines is not an appropriate policy, politically or technically; hence, actions to smooth purchasing are important. These include the odd-even purchase, minimum-purchase (price or tank), and flag systems. The actual energy saving from such actions is minimal, however. The use of state set-asides, as part of a planned strategy to relieve spot shortages during emergencies and to reduce hardship at other times, varies extensively. Some states have let their set-aside program evolve into a monthly maintenance system that overlaps normal federal allocations. Other states totally suspend the set-aside program during nonemergency periods.

The range of potential strategies for use in energy contingencies is extremely broad and is rapidly expanding as more cities, states, and private businesses engage in plan development. Rather than discuss numerous strategies, the workshop participants separated into small groups and identified the characteristics of several selected strategies deemed generally feasible, effective, reasonable in cost, and fair. The results, which are summarized in Table 1, are categorized according to gasoline purchasing, internal vehicle efficiency, traffic flow, nonwork weekday travel, recreational-vacation travel, work travel, public information travel, government travel, and business and industry travel.

CONCLUSIONS

Table 1 summarizes the conclusions reached by the workshop participants in their consideration of the most viable urban passenger strategies likely to be effective during an energy emergency or shortfall. An examination of Table 1 suggests the following trends or outcomes.

1. Except where mandatory actions are necessary to ensure order (as in gasoline-purchase control), the strategies viewed as most viable are those that are voluntary, can be implemented rapidly, are fair and well received, and have reasonably low costs. Mandatory actions to curtail travel are generally viewed as inappropriate to contingency plans.
2. No one strategy or group of strategies will solve all problems. A variety of actions must be developed and implemented.
3. Actions that expand options and permit a maximum degree of personal choice are likely to be most popular. However, they may also prove the most expensive.
4. Selection of strategies should be based on different local and statewide needs rather than on assumed uniform attributes. Federal and state plans should encourage and focus on this type of flexibility.
5. Although the current base of available contingency

Table 1. Evaluation of suggested urban passenger strategies based on five objectives, as developed in workshop 8.

	Objective					
Area and Strategy	Equity	Time Frame	Cost	Public Acceptance	Overall Feasibility	General Comment
Gasoline-purchase control						
Odd-even	Good	Good	Low	Good	Good	Presents panic state on major metropolitan level
Minimum purchase	Good	Good	Low	Good	Good	Gives better price level than ½-tank rules
Rationing (white market)	Medium	Poor	High	Fair	Fair	Aids demand reduction
Rationing (tax)	Poor		Low	Poor	Poor	Aids demand reduction
Vehicle efficiency						
Voluntary vehicle maintenance	Good	Poor	High	Good		Produces 3-5 percent saving over two years
Speed-limit reductions	Good	Good	Medium	Medium	Good	
Tires, options, operation	Good	Good	Low	Good	Good	
Efficiency-based vehicle taxes	Medium	Good	High	Poor	Good	
Mandatory tune-ups	Good	Good	Medium		Fair	
Parking incentives and disincentives	Good	Good	Medium	Good	Fair	
Traffic flow						
Multicolor sticker plan			High	Low	Fair	Is similar to federal plan
Flex-time incentives	Good		Low	Good	Good	
Radio information on traffic dimension	Good	Good	Low	Good	Good	
Work, ridesharing, transit						
Employer-based ridesharing	Medium	Medium	Low	Good	Fair	
Time-schedule changes	Medium	Good		Good	Good	Has hidden social costs and low implementation costs
Transit amenities, expansions	Fair	Good	Medium	Good	Good	Has overall small impact on most cities
Nonwork weekday travel						
Parking changes	Good	Good	Low	Poor	Fair	
Public information program	Good	Medium	Low	Good	Fair	
Removal of 13c restrictions		Good	Low			
Recreational, vacation, weekend						
New transit specials to recreational sites	Good	Medium	High	Good	Fair	Could be combined with occupancy restrictions
Automobile-occupancy restrictions at public sites	Good	Good	Low			
Weekend sticker plan	Good	Medium	Medium	Low		Is unpopular
Weekend driving plan		Good	Medium	Low	Poor	Is unpopular
Community-based recreation promotion	Good	Medium	Low	Good	Good	
Public information						
Gasoline-dealer information system		Good	Low	Good	Good	Provides information to dealers
Governor's emergency information office	Good	Good	Medium	Good	Good	Provides key information resource
Local area hotline	Good	Good	Medium	Good	Good	Complements state system
State travel and gasoline hotline	Good	Good	Medium	Good	Good	Complements local systems
Government						
Across-the-board service reduction	Good	Good	Low	Good	Good	
Government flex-time schedule	Medium	Good	Low	Good	Good	Sets example
Ridesharing promotion	Good	Good	Low	Good	Good	Sets example
Priority given to plans	Good	Good	Low	Good	Good	Sets example
Business and industry						
Business contingency plans	Good		Low	Good	Good	Is essential for work-travel focus
Alternative fuel use				Good	Fair	Could help business switchovers
Building ventilation, lights, water	Medium	Good	Low	Good	Fair	Has overall low impact
Removal of federal regulations					Poor	

plans is not large, it is probably adequate to provide a range of strategies for others who are preparing such plans.

In summary, workshop members concluded that strategies can be developed that are appropriate for local and state consideration. However, their effectiveness, if implemented, is likely to depend primarily on the overall public acceptance and cost of these strategies. Moreover, the workshop members urged that such planning should begin soon in those locales where nothing has yet been done.

Session 5: Role of Governments, Consumers, and the Private Sector

Although other conference sessions and workshops focused on technical and institutional issues without specifically addressing the questions of how different interest groups are affected by and might respond to fuel shortages, Session 5, chaired by Richard Steinmann explored the role that various sectors (e.g., public, private, and minorities) could play in dealing with energy emergencies. Three presentations were made that dealt with the role of the federal government, consumers and minorities, and the private sector in this area.

FEDERAL ROLE

Robert Conly examined the role of the federal government by focusing on several current DOE programs related to energy contingency planning, as well as on the history of these programs.

Interest in contingency planning dates only from the Arab oil embargo of 1973-1974. During that period, congressional action related to contingency measures took several forms, such as the extension of Daylight Saving Time, the imposition of a 55-mph speed limit, and the implementation of building-use restrictions. In addition, consideration of planning for future similar emergencies began to emerge. Further congressional action in the form of the Energy Policy and Conservation Act of 1975 followed. This act gave DOE a variety of mandates and included provisions for federal contingency plans and rationing.

Response to these mandates was fairly slow in coming due to the complexity of the issues involved and the controversy likely to attend any federally mandated program. This situation was highlighted by the response received from Congress to DOE's proposals, once they were submitted for the required congressional approval. The negative reaction, including rejection of all contingency plans except the building-temperature restrictions and the rationing plan, led to the passage of legislation that now governs contingency planning at the federal and state levels. The Emergency Energy Conservation Act of 1979 requires that the states develop plans capable of meeting federally set targets for energy consumption. Failing this, a federal standby plan--to be developed by DOE--would go into effect. This act also detailed new criteria under which a rationing plan that would replace the one previously rejected would be developed.

Session 5 participants noted clearly the existence of changes in the federal role. Provisions of the Emergency Energy Conservation Act involve the federal government to a much lesser extent than before in directly managing an energy emergency and allow for increasing responsibility at the state level. It had become clear that, as the programs required by the Emergency Energy Conservation Act (e.g., federal rationing, federal energy-emergency standby plan, and state energy-emergency plans) were developed, some additional shift in the federal role—probably toward greater responsibility at the state level—should occur.

CONSUMER ROLE

The role of transportation consumers, and minority users in particular, was discussed by Maudine Cooper. Cooper described the impact that rising energy costs and potential supply disruptions might have on minorities. Such groups, particularly the poor, use less energy per capita but would likely suffer much greater dislocation than others. Dependence on both public and private transportation among these groups makes them vulnerable to transit service cutbacks during emergencies and to the cost increases associated with operating the older, second-hand, inefficient portion of the automobile fleet during periods of rapidly rising fuel prices.

Cooper calls on contingency planners to be sensitive to energy needs and issues that involve the poor, minorities, and consumers in general. The contingency planning process must involve these groups in order to weigh strategies in terms of their sensitivity to equitable impacts and conservation responsibilities. Rationing, for example, must be administered carefully so as not to result in inconveniences that are not in proportion to those suffered by others. Transit services, especially in central cities, will have to be augmented, not reduced, in the face of rising fuel costs. Plans that remove vehicles operating in central business districts (CBDs) and other activity areas for use in serving suburb-to-CBD trips may be counterproductive to the needs of the poor and minorities.

To offset the lack of knowledge about the needs of minority groups and others, contingency planners must have consumer input. Planners will have to be much more sensitive to these consumer needs if contingency programs are to receive the acceptance required for success.

PRIVATE-SECTOR ROLE

The role of the private sector was discussed by W.F. Borrelis. Borrelis detailed the steps taken by the United Services Automobile Association (USAA) to save energy and to prepare for future energy problems.

The USAA's interest in energy began after the Arab oil embargo. As the price of energy rose, company management became convinced that action was necessary. Initial activities concentrated on the four-day workweek and on facilities. Building temperatures were adjusted, lighting levels reconsidered, and water-heating requirements reduced. It also became increasingly clear that some attention had to be paid to employees' work trips. Vanpooling became the centerpiece of the company's efforts in this area. Beginning slowly with five vans in 1977, the program expanded by early 1980 to more than 90 vans. Carpool and transit incentives were also undertaken. These steps resulted in travel to and from work by more than 50 percent of USAA's 4600 employees in some type of high-occupancy vehicle.

Contingency plans were also developed. The company has obtained equipment and permits in order that fuel may be supplied to vanpools on site. Facility energy-user requirements could be further reduced and arrangements could be made with transit carriers to supply large vehicles to replace vanpools going to certain areas. The company has prepared for a range of potential energy shortfalls.

While the USAA experience is exemplary, it is clear that the private sector could and should have a major role in contingency planning. Company facility operations can be adjusted. Employee ridersharing and transit programs can save significant amounts of energy. And company contingency plans can prepare its employees to cope more easily with energy emergencies. On the other hand, questions, such as those on the effect that vanpooling has on the automobile left at home and the amount of travel conducted on the fifth day of a four-day workweek, need to be considered more thoroughly to evaluate the total energy saved by such actions.

CONCLUSION

Overall, session 5 emphasized that all sectors of the nation need to become involved in contingency planning.

Furthermore, problems in developing a single federal response made it obvious that increased responsibility at the state and local levels and action by other public- and private-interest groups are essential. The issues raised in regard to consumers and, especially, members of minority groups highlighted the need to involve these groups in any planning process. The localized nature of many of these issues argues strongly for consideration of contingency strategies at the lowest level of government possible. The principal conclusion drawn from this discussion is the need for all sectors to be prepared to play key roles in contingency planning and strategy implementations.

Part 4
Resource Materials

Potential Use of Carpooling During Periods of Energy Shortages

Melvyn D. Cheslow

Carpooling has been proposed by many planners as an important approach for reducing energy use in the transportation sector (1,2). They have pointed out that, by raising the average load factor of commute trips in the United States from 1.2 persons/vehicle to 2.0 persons/vehicle, the total fuel use by automobiles could be reduced by about 20 percent. However, they have also indicated that carpooling has not increased substantially since the early 1970s and that, even during the oil embargo of 1973-1974, there were no appreciable increases in ridesharing by commuters. Carpool-matching programs have generally not increased carpooling by more than 1 or 2 percent (3). Hence, there is a major concern about the capability of this option to absorb much of the excess travel demand, if a new period of gasoline shortage were to develop.

There are few studies of the potential increase in carpooling during a shortage situation. Thus, it is difficult for the planner to assess the amount of travel that might be carried out by those willing to carpool. This paper attempts to draw together and assess some of the literature related to the potential of carpooling.

The paper will discuss four types of data from which the use of carpooling during fuel shortages can be estimated. These are

1. Travelers' behavior during shortages in 1973-1974 and in 1979,
2. Travelers' estimates of what they would do in a shortage,
3. Estimates from mathematical models, and
4. Saturation levels determined from market segments with current high carpooling levels.

Each of these data sources produces different estimates, but the estimates appear to be compatible when classified by the level of fuel shortage that might occur. Three levels are discussed in the literature—10 percent, 20-25 percent, and 30-50 percent. After the four data sources are reviewed, the level of carpooling that might occur for each of these levels of fuel shortage is discussed.

It should be mentioned that the level of carpooling attained will depend not only on the level of the fuel shortage but also on the duration of the shortage. Because travelers may not know this time frame in advance, they will probably increase their response the longer the shortage continues. Temporary approaches to meeting a shortage will have to give way to more permanent alternatives.

In addition, the level of carpooling attained will depend on the existence of carpool-matching programs operated either by planning agencies or by employers. These programs have start-up times of at least several weeks. Therefore, areas without operating programs would not see initial levels of carpooling as high as those with existing programs.

The prevalence of carpooling will depend on the ability of travelers to carry out other, preferred conservation options. Hence, the existence of good local transit service and of a national capacity to make and sell highly fuel-efficient vehicles would somewhat reduce the switch to carpooling. Introduction of flex-time programs would allow some commuters to take transit during less-congested times, while others would be able to carpool by matching schedules with coworkers or neighbors.

Before beginning the assessment of carpooling, it is useful to consider the relation between various measures of carpool use. Four such measures are often used:

1. C = Participation rate—fraction of automobile commuters in multiple-occupant vehicles;
2. A = Average occupancy—persons per vehicle (the inverse of A can be used to estimate the number of cars needed by travelers);
3. M = Average multiple occupancy—persons per carpool vehicle; and
4. P = Fraction of vehicles used by carpoolers (e.g., 1-P is the fraction of vehicles with one occupant).

A report by Kendall (4) indicates the relation among these variables: $C = [1 - (1/A)]/[1 - (1/M)]$ and $P = (A - 1)/(M - 1)$. Figure 1 (4) illustrates these relations. For example, the current average vehicle occupancy is about 1.15 and the multiple-vehicle occupancy is 2.3. About 23 percent of automobile commuters carpools, and about 12 percent of vehicles has carpool occupants (1).

The number of vehicles on the road can be related to participation rates by using the fact that 1/A is the number of vehicles per person. The relation used is derived from $C = [1 - (1/A)]/[1 - (1/M)]$; this relation is expressed as $1/A = 1 - [1 - (1/M)]C$.

One must either know or assume the value of M, the average multiple occupancy, in order to assess how the number of vehicles changes during a shortage. Most of the studies reviewed herein do not discuss how M might change. So, it is generally assumed that M remains unchanged. However, if large-scale increases in carpooling occur, it is likely that the average value of M will increase from the level of 2.3.

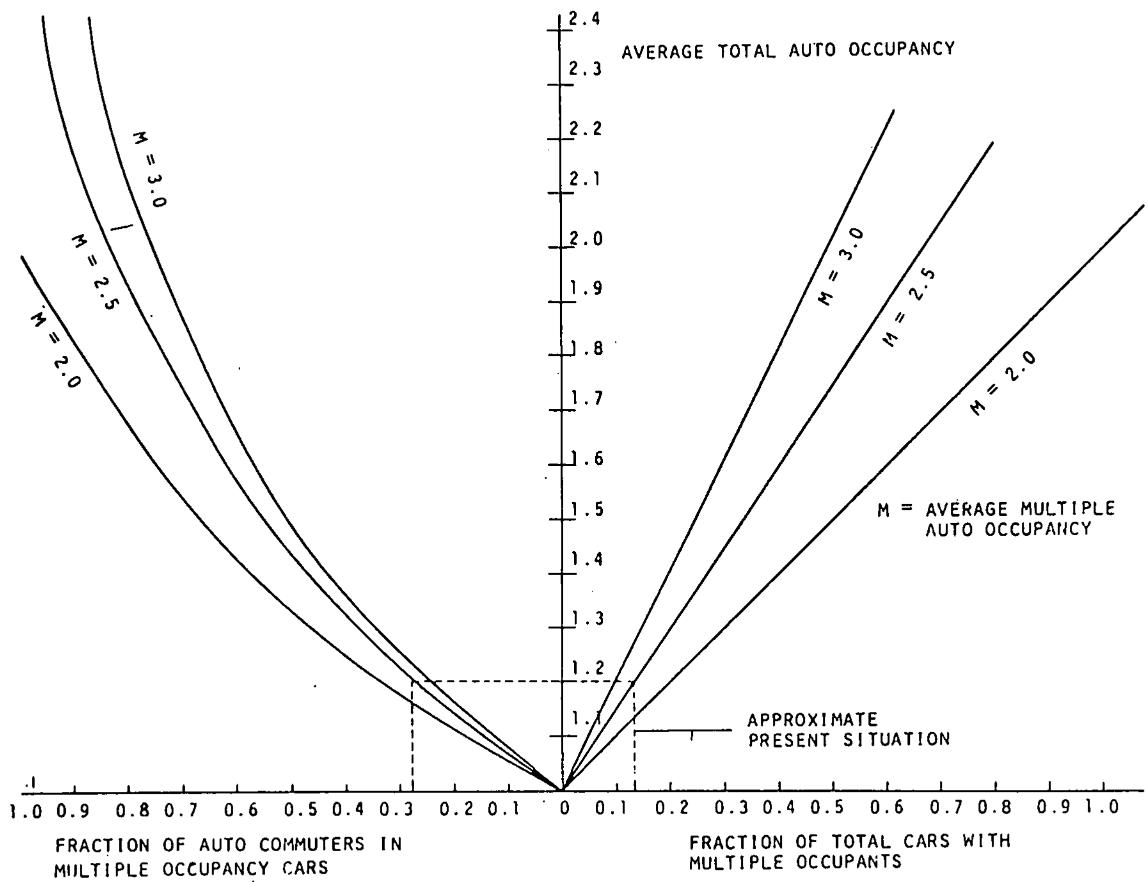
CARPOOL FORMATION DURING PREVIOUS SHORTAGES

The oil embargo of 1973-1974 stunned the U.S. citizenry with an abrupt shutoff of exports to this country of up to 15 percent of our crude petroleum needs. Estimates made after the embargo ended showed that some of this shortage was made up through imports from neutral countries and from non-U.S. refineries. The net shortage during the fall-to-spring period (1973-1974) was only about 9 percent.

A national survey, which was in progress in 1973, was used to obtain information from travelers about their responses to the shortage (6). Of course, many drivers spent long periods in queues to purchase gasoline, but the major travel response was to reduce the number of automobile trips by about 20 percent while decreasing total miles traveled by a smaller amount. The survey showed that much of the reduction in automobile trips was a net loss of travel; very little of this reduction represented shifts of commuters from driving alone to carpooling, transit, or walking. The number of commuters engaged in carpooling increased by less than 4 percent during the embargo. Only 1 percent of commuters shifted from driving alone to carpooling—hardly a major change. In fact, most travelers appeared to adjust to the shortage by cutting back vacation and recreation travel and by combining shopping trips.

During the 1979 shortage, a survey was undertaken of traveler responses in New York State (7). About 14 percent of household heads said that they increased their carpooling to work. This number becomes 18 percent if the New York City area is omitted. Of course, many of the cities in New York State are more compact than some southern and western cities that began their economic lives after the automobile era commenced in 1920. However, even half the 18 percent is higher than the 4 percent estimated in 1973-1974. This disagreement may come from earlier carpoolers who included themselves in the 1979 survey. The

Figure 1. Relation between carpooling and automobile occupancy.



levels of shortage were about the same in both periods. These two sources indicate that a 10 percent shortage would produce an increase in the number of carpoolers of 1-14 percent. The number of vehicles on the road would decrease by a factor depending on M, the average number of occupants in carpool vehicles. If this factor did not change, the number of vehicles would decrease by about 1 - 8.5 percent. Hence, the fuel saved by carpools during the commuting periods would be less than 8 percent (there would be extra trip length due to the pickup and dropoff of passengers) during a time when the shortage averaged 10 percent. This again indicates that carpooling was not a major tool in meeting the previous shortages.

TRAVELERS' ESTIMATES OF THEIR RESPONSES TO FUEL SHORTAGES

Because previous fuel shortages have generally remained below 10 percent, other sources must be investigated to determine consumer reactions to larger shortages. Surveys of travelers have been undertaken as one approach to making these estimates.

In November 1975, Corsi and Harvey surveyed 1500 households in southeastern Wisconsin (4). They were asked their response to a limited availability of gasoline of 8 gal/week/driver, with the limitation lasting at least five years. This absolute limit per driver corresponds more to a rationing situation than an exogenously produced shortage, but there is not that much difference since a large shortage would produce government-sanctioned rationing.

The level of 8 gal/driver/week corresponds to a 1975 shortage of about 25 percent. In this situation, respondents said they would increase their participation in carpools from a current rate of 7 percent to about 18 percent. This is a sizable increase; however, the original level is very small compared to other sources estimating that more than 20 percent of commuters carpool. Other mode categories in this survey include automobile driver and passenger in a family automobile. The former might include carpool drivers. The latter refers to a common but not often acknowledged mode. It probably includes (a) workers who ride with a family member who also works and (b) workers driven by a family member who then brings the vehicle back home for other uses. The former group represents conventional carpoolers; the latter does not. The fact that this survey shows that these driven passengers would decrease with a fuel shortage indicates that the second group is definitely a measurable proportion—as much as 6 percent of all commuters.

If we assume that this survey categorizes the carpool drivers as drivers (and not carpool) and that the portion of family-driven passengers (and their drivers) who do not decrease in number with a shortage are actual carpoolers, then the survey has 19 percent of current commuters in carpools, 60 percent driving alone, and 6 percent as passengers driven by nonworking family members. Then, under a shortage, 29 percent would drive alone, 38 percent would carpool, and none would be driven.

In this scenario, 19 percent of commuters switch from driving alone to carpooling, leading to a vehicle reduction of 11 percent if the average carpool occupancy remains unchanged. More than 15 percent of commuters would switch from automobile modes to transit or other modes.

Another survey of 1500 households was undertaken in New York State in October 1979 (7). They were asked how they would respond to a 20 percent reduction in available gasoline for their automobiles. Some 17 percent of the households said they would carpool to work as one of the ways of responding to the shortage. This is compared to 14 percent who said they had carpooled in response to the 1979

shortage. If the New York City area respondents are subtracted, 22 percent indicated they would carpool. Presumably, these respondents are not currently carpooling, and the 14 percent and 22 percent groups would represent those who would switch modes. These estimates involve all commuters, not just those using the automobile. In New York State the fraction using nonautomobile modes is higher than the national level due to the importance of New York City in the statistics. If we assume 10 percent of commuters use other modes, then about 16 percent of automobile commuters would switch to carpools, which would result in a 10 percent decrease in automobile use.

CARPOOL USE ESTIMATES FROM MODELS

Although many urban travel demand models have been developed to analyze policy alternatives, none explicitly deal with the response to gasoline shortages. Hence, a planner must find a way to adapt an existing model to treat a shortage situation. One approach used is the concept of a shadow price (5). This is a penalty cost added to the operating cost of automobiles. Its level is set by iterating the model with incrementally higher prices until the estimated fuel used is equal to the shortage or rationed level. This modeling approach assumes that travelers will all respond to shortages as if they were price increases.

By using the shadow-price approach, Atherton, Suhrbier, and Jessiman (5) found that, for Washington, D.C., a 20 percent reduction in fuel use would cause only 2 percent of commuters to switch to carpooling. This would result in a reduction in the number of cars used for commuting of only 1 percent. In this analysis, more than 14 percent of commuters took transit before the fuel reduction and this increased to more than 16 percent.

In an area without good transit service, the switch to carpools would likely be greater. For example, planners in the Dallas-Fort Worth area, who used a similar model, found that a 25 percent shortage would cause 8 percent of suburban commuters to switch to carpooling (8). This would bring about a 4.5 percent decrease in automobiles used. This estimate was made on the assumption that no carpool-matching programs were available. With such a program, another 6 percent of commuters would switch, which would result in an 8 percent reduction in vehicles used.

An alternative approach to the shadow-price approach discussed here would be to penalize travel time or automobile availability. In the case of very large shortages (e.g., 50 percent), it would be likely that many households would not have enough fuel available to use their vehicles for single-occupant commuting. If the model of Atherton, Suhrbier, and Jessiman (5) is used at an aggregate level and if the average automobile availability is assumed to drop to one-half the original level, the model for Washington, D.C., would show 6 percent of commuters switching to carpools, 27 percent switching to transit, and 20 percent staying as single drivers. This estimate would depend on sufficient capacity in the transit system to absorb this extensive increase.

A further use of the automobile-availability reduction approach can be made with a model developed with data from eight large metropolitan areas (9). In this model, land use variables are used to indicate how travel choices would differ in different locations. A 50 percent reduction in automobile availability per household would result in a 10 percent increase in the number of commuters carpooling. This is on the same order of magnitude as the shadow-price model, which estimated a 6 percent increase.

A different type of model from those above estimates a maximum potential for carpooling, given the realities of the distribution of residences and job sites, the differences in working hours, and the fact that carpooling adds some detours and travel time to the trip. Two studies (1,10) have examined the potential for carpooling based on various assumptions.

Kendall (1) studied the carpool potential in the Boston standard metropolitan statistical area (SMSA) by using the 1963 trip patterns as a base. By varying assumptions about the maximum pickup area (0.25 or 1 mile²), maximum delivery area (0.25 or 1 mile²), and the maximum difference in current arrival times (15-30 min), he found potentials of 28-90 percent of commuters originating trips between 6:00 and 9:00 a.m. At a maximum time difference of 30 min and average origin-destination areas of 1 mile, 90 percent would commute, with an average increase in travel time of 10 min. Some travelers would have double or triple this value. In addition, the average change in departure time would be another 10 min.

Kendall suggests that a realistic maximum level of carpool participation would be 60 percent of all automobile commute trips in Boston. "At this level, carpool travel times would be 40-50 percent higher, on the average, than the time required for commuters who drive alone" (1). In arriving at this level, Kendall has subtracted out the single drivers who need an automobile at work or who have irregular work schedules. He has omitted considerations of non-peak-period commuters, carpoolers who might be matched with en route origins or destinations, and drivers who need their automobile at work but who could drive other commuters as passengers. Hence, he considers the 60 percent figure a conservative one. He also suggests that the national limit is within 20 percent of this level. At the time of the survey, 27 percent of Boston's commuters already carpooled; hence, Kendall's model indicates that 33 percent of the area's commuters could switch to carpooling. This would bring about at least a 21 percent decrease in automobile use, depending on the average carpool size attained.

Another study of carpooling potential was carried out by Lee and Glover who used data about Michigan drivers in 1976 (10). They considered the maximum level of carpooling to have been reached when every vehicle has at least three commuters. However, they assumed that trips of less than 10 min would not be considered nor trips that began outside the periods of 6:00-9:00 a.m. and 3:00-9:00 p.m. Also, commuters living outside of SMSAs and towns were not included.

Lee and Glover found that, at the maximum potential, 10 percent of annual gasoline consumption would be eliminated. This corresponds to about 25-35 percent of the gasoline used for commuting. At the median of this range, the corresponding level of new carpoolers would be about 36 percent. In this situation, the average size of all carpools would probably be at least 3 persons/automobile.

In the analyses (1,10) discussed here, there are no considerations of commuters switching to transit. Their calculations are made primarily to show what carpooling could accommodate rather than the maximum number of people who would switch to it. Although Lee and Glover do not indicate the current level of carpooling (e.g., it could be 23 percent), about 60 percent of the state's commuters could carpool. This would be similar to Kendall's estimate for the Boston area.

CARPOOL SATURATION LEVELS ESTIMATED FROM CURRENT MARKETS

Kendall (1) and Lee and Glover (10) estimated the potential for carpooling by calculating the maximum number who could use this mode. Another approach to calculating the carpool potential compares the pooling levels of certain market segments that use the mode extensively with those of average travelers. This approach assumes that the maximum use, or saturation level, of carpooling already has been reached by those market segments with extensive use. These users have chosen the mode because their special circumstances have made it necessary or desirable not to drive alone. They either have low incomes, long and expensive commute trips, or fewer vehicles available than the household might desire. All of these characteristics might describe the average household in the case of an

Table 1. Influence of number of workers and vehicles per household on ridesharing.

No. of Workers	No. of Vehicles	Modal Share (%) Drive Alone	Shared Ride	Transit	Other
1	1	70	16	9	5
2	2	77	17	2	2
>2	1	49	27	21	17

Table 2. Influence of automobile availability on other members of households, excluding heads of households.

No. of Workers	No. of Vehicles	Modal Share (%) Drive Alone	Shared Ride	Transit	Other
1	1	44	28	25	2
2	2	79	17	1	3
>2	1	22	46	18	4
>3	2	48	39	7	6

Table 3. Relation between carpooling behavior of working heads of households and nonworking drivers in same household.

Other Household Members	No. of Vehicles	Modal Choice of Household Head (%) Drive Alone	Shared Ride	Transit	Other
>1 nonworking driver	1	53	23	13	11
	>2	80	12	5	3
>2 workers	1	49	27	12	12
	2	77	17	4	2

energy shortage. The potential shift to carpooling is then calculated by assuming that all commuters would carpool at the same rate as the maximum market segment.

There are two types of limitations to this approach. The first is that the pooling levels of the currently high market segment may not be the maximum attainable if a shortage existed. The income and automobile availability problems of this market segment might not represent the difficulties in a national shortage. On the other hand, this approach examines what these segments actually do rather than what they might do. Therefore, such an approach has some advantage over other approaches.

A second limitation is that the high carpooling market segments differ from the average population in ways that are not related to the effects of a fuel shortage. They live in different locations and have different household sizes than the average household. Hence, the average population may not be able to totally merge in behavior with the high carpooling market segment. These limitations are not really worse than the limitations in using the other estimation techniques discussed above.

The saturation approach can be applied to a 1978 national survey of travel behavior that collected extensive data on the use of various modes of commuting (11). Although a special analysis of the computer tape from this survey could determine the market segments that use carpooling most extensively, the following discussion will be limited to segments that can be identified in the printed report. The use of the tape would find markets with higher levels of pooling than noted in this report.

One way to consider a limit to the level of carpooling by commuters is to examine the amount of ridesharing during noncommute trips. Presumably, these shared rides are with friends or relatives who enjoy traveling together. The occupancy levels in these situations might set a limit on how much travelers are willing to ride together due to comfort considerations if nothing else.

For social and recreational travel, 78 percent of personal travel consists of rides with someone else. The average size of the groups that share rides is 2.8 persons. These values compare with those for commute trips of 23 percent and 2.3 persons/vehicle. This high level of ridesharing corresponds to the limits estimated by Kendall (1) and Lee and Glover (10); it makes their estimates seem reachable, at least on the grounds of physical comfort.

Of course, social and recreational travel must include a great deal of travel with children; hence, the occupancy levels if adults only were considered must be lower. But even the other nonwork trips in this survey are made with other persons by 66 percent of the travelers, with an average occupancy in the group travel of 2.55 persons/vehicle. If carpoolers used this level of ridesharing, 43 percent would switch to carpooling and the number of vehicles used for commuting would decrease by 31 percent.

The survey analyzes the work-trip modal choice of household heads and other family members separately. In general, the household head drives alone to work more often than the other commuters in the household. About 71 percent of the household heads versus 66 percent of others are single drivers, with most of this difference associated with shared-ride rather than transit use.

The relation of the number of vehicles owned and the number of workers influences the amount of ridesharing. Having more workers than automobiles increases the use of carpooling for household heads (Table 1).

Reducing the automobile availability to commuters could cause an 8-11 percent shift by household heads to carpooling. However, a much larger percentage could change to other modes. Not surprisingly, the effect of reducing automobile availability has a greater effect on other household members (Table 2).

The fraction of nonhousehold heads who carpool is very similar to that of the household heads when the number of vehicles matches the number of workers. But, when the number of workers exceeds the available vehicles, the choice of carpooling for the other household members jumps. For this group, reducing automobile availability could cause 18-29 percent of the commuters to shift from driving alone to carpooling.

These comparisons of market segments indicate that the effect of eliminating an automobile in a two-worker household would be to cause about 10 percent of household heads and about 25 percent of other commuters to switch to carpools. Because household heads represent 56 percent of all commuters, this analysis indicates that an additional 16 percent of all commuters could become carpoolers. This change is somewhat larger than those changes calculated by using the two mathematical models noted earlier—i.e., when automobile availability is reduced by one-half. However, all other factors are not equal. For example, other household characteristics may be different between the segments. Income, especially, may differ as may the number of nonworking drivers.

Reducing automobile availability to households because of extensive fuel shortages would apparently affect the nonhousehold heads who now drive alone more than the household heads who do. The difference in the effect of automobile availability between household heads and other household members is one of the largest shown in the survey.

The existence of nonworking drivers in a household can also affect the carpooling behavior of working household heads. The effect appears to be similar to that of having additional workers (Table 3).

Hence, reducing vehicle availability to a household with two or more drivers might have the same effect on the carpooling behavior of household heads whether or not there were another worker in the same household.

This analysis of the difference in carpooling by various market segments estimates the possible level of carpooling. But this level is based on the somewhat mechanical assumption of reducing vehicle ownership in certain

Table 4. Summary of estimates of shifts to carpooling during periods of energy shortages.

Estimation Approach	Applicable Area	Fuel Shortage Level (%)	Shift to Carpool[a] (%)	Reduction in Commuter Vehicle Miles of Travel (%)
Actual				
1973	National (6)	10	<2	1.0
1979	New York State (7)	10	14	8.0
Travelers' estimate	Southeastern Wisconsin (4)	25	19	11.0
	New York State (7)	20	17	10.0
Model				
Shadow price	Washington, DC (5)	20	6	3.5
	Dallas and suburbs (8)	25	8	4.5
Automobile availability	Washington, DC (5, adapted)	–	6	3.5
	8 SMSAs (9, adapted)	–	10	5.5
Potential	Boston (1)	–	33	21.0
	Michigan (10)	–	36	30.0
Saturation				
Noncommute	National (11)	–	43	31.0
Automobile availability	National (11, adapted)	–	16	9.0

[a]The various potential and saturation estimates cannot be rigorously associated with any particular shortage level.

households. (Workers in households with no automobiles carpool 35 percent of the time. This is less than the level for nonheads of households without available automobiles in households with automobiles.) The fact that the potentials estimated here are much lower than those calculated by Kendall (1) or Lee and Glover (10) may indicate that their estimates are too optimistic. The probable explanation for their results is that some level of shortage would force households to carpool more than the most favorable segments now do.

SUMMARY AND CONCLUSIONS

Several approaches to estimating the level of carpooling that might be attained in a period of fuel shortage were reviewed. The range of estimates—from a shift of 2 percent of commuters up to 40 percent—is wide. However, these estimates vary with respect to the level of shortage, the area considered, and the amount of transit likely to be available as an alternative.

A summary of the various shift-to-carpooling estimates is presented in Table 4. In attempting to discern some consistency in the conclusions from these estimates, one must be willing to make some judgment about the possible errors that may be attached to each estimate. Several views about these errors are presented here, followed by estimates of the national level of carpooling that might occur for different shortage levels.

The carpooling level in 1973 was very low but is probably the most-believable estimate. The 1979 estimate from the survey of New York State residents seems high, given the 1973 response and the survey and modeling estimates for a 20 percent shortage. Two surveys of what travelers would do in a future shortage seem to be reasonable, but these kinds of surveys often have respondents claiming that they would make more changes in behavior than they actually are willing to do. The models based on shadow prices probably underestimate traveler response; it appears that travelers are more troubled by shortages than by higher prices and, more important, high-income commuters may not be able to alleviate a shortage any more than those from lower-income households. (Of course, a white market for ration coupons might allow high-income households to buy their way out of a shortage.) The estimates made with both models and saturation levels by using reductions in automobile availability seem to produce low results, intuitively, for such a large-scale reduction in automobiles. Perhaps the households with only one vehicle will make much larger modal shifts than these estimates indicate. Lastly, the two high potential estimates and the high saturation-level estimate probably do set upper limits to the use of carpooling.

Given the above observations on the reliability of the estimates, the following tentative conclusion can be made for the national response to fuel shortages:

Fuel Shortage Level (%)	Shift to Carpool (%)	Reduction in Commuter Vehicle Miles of Travel (%)
8-10	1-7	1-4
20-25	8-14	5-8
30-50	10-25	6-15
Maximum	25-35	15-30

To make an estimate for a particular state or urban area, the planner must assess each of the approaches discussed here for its applicability to the local situation. The planner should decide between using surveys or models, or both. Any carpooling programs in the area, as well as the capacity and level of service of the transit system, must also be considered. Finally, the planner should realize that travelers will make a large number of responses to a fuel shortage, changing their travel patterns in many ways. If the planner does not take into account the many possible changes, an overestimation of the response due to carpooling alone is likely to result.

REFERENCES

1. D.C. Kendall. Carpooling: Status and Potential. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, Rept. DOT-TSC-OST-75-23, June 1975.
2. C. Phillips and J.K. Pollard. Transportation Energy Conservation: Current Status and Future Prospects. Transportation Systems Center, U.S. Department of Transportation, Staff Study 321-6-8, Cambridge, MA, 1978.
3. F.A. Wagner; JHK Associates. Evaluation of Carpool Demonstration Projects. U.S. Department of Transportation, Oct. 1978.
4. T.M. Corsi and M.E. Harvey. Energy-Crisis Travel Behavior and the Transportation Planning Process. TRB, Transportation Research Record 648, 1977, pp. 30-36.
5. T. Atherton, J.H. Suhrbier, and W.A. Jessiman. Use of Disaggregate Travel Demand Models to Analyze Carpooling Policy Incentives. TRB, Transportation Research Record 599, 1976, pp. 35-40.
6. M.D. Stearns. The Behavioral Impacts of the Energy Shortage: Shifts in Trip-Making Characteristics. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, Rept. DOT-TSC-OST-75-36, 1975.
7. D.T. Hartgen, A.J. Neveu, J. Brunso, J.S. Banas, and J. Miller. Changes in Travel in Response to the 1979

Energy Crisis. New York State Department of Transportation, Albany, Prelim. Res. Rept. 170, Dec. 1979.
8. A Metropolitan Transportation Plan for National Energy Contingencies. North Central Texas Council of Governments, Arlington, Aug. 1977.
9. K. Neels, M. D. Cheslow, R. F. Kirby, and G. E. Peterson. An Empirical Investigation of the Effects of Land Use on Urban Travel. The Urban Institute, Washington, DC, Working Paper 5049-17-1, Aug. 1977.
10. M. E. H. Lee and M. F. Glover. Use of Disaggregate Data to Evaluate Gasoline Conservation Policies: Smaller Cars and Carpooling. Michigan Department of State, Lansing, Dec. 1979.
11. Cambridge Systematics, Inc. Analysis of Motor Vehicle Ownership and Household Travel Patterns. Cambridge, MA, Vol. 1, June 1979.

Capacity of Urban Transit Systems to Respond to Energy Constraints

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If gasoline for private automobiles suddenly were no longer available in the quantities to which we have become accustomed, could mass transit systems in the United States absorb the great ridership increases that would inevitably result from such energy shortages?

In order to answer such a question, it is necessary to first examine the problem, its source, and its potential solutions.

The sources and origins of this potential crisis situation are almost too obvious to mention. The U.S. love affair with the automobile has been in full swing for more than 60 years and has become a near obsession over the past three decades. As recently as 1950, there was an average of less than 1.0 automobile/U.S. household. Today, in most parts of the country, that figure is in the range of 1.8-2.0 automobiles/household unit. In many of the more recently developed parts of the country, particularly in the Far West, it is not uncommon for entire communities to average well in excess of 2.0 automobiles/household. Consequently, people have been consuming fossil fuels at a furious rate, while domestic energy reserves have dwindled to alarming levels.

Accompanying this even greater reliance on the automobile has been a series of related results that have had equally detrimental effects on the U.S. energy situation. With the close of World War II, the purchase of a new automobile and a new home became the primary goals of the average U.S. family. Consequently, as housing developments boomed to accommodate this increased demand, residential development was designed with the automobile in mind. Access to public transportation became a secondary consideration as suburban sprawl attacked virtually every major metropolitan area in the country.

The pattern of U.S. growth had changed dramatically. During the first half of this century, it was not uncommon for public transit systems, streetcars, trolleys, and bus lines to be the driving forces behind the residential and commercial development of new communities across the country. In some cases, such as most of Los Angeles County, the mass transit system actually preceded much of the development by several years and, in fact, provided the impetus behind such growth patterns. Accessibility to a mass transit system became a primary consideration when people looked for places to live. Consequently, U.S. use of mass transit actually peaked in 1945 when the systems carried more than 23 billion passengers. From that point on, a steady decrease began in transit ridership that was inversely proportional to the steady increase in the number of private automobiles. Transit patronage finally bottomed out in 1972 when only about 6.5 billion passengers used the service.

Fortunately, since 1972, improved transit services—made possible by the conversion of floundering private bus companies to publicly subsidized operations and the increased availability of federal operating and capital funds—have substantially reversed the trends in transit ridership as significant patronage increases have been experienced in each of the last eight years. Still, mass transit looks forward to achieving the 10-billion passenger mark to which it still has yet to return.

Concurrent with the dramatic fall in transit ridership was an equally dramatic deterioration in the size and condition of the mass transit systems provided across the country. In 1945, almost 250 000 people were employed in the transit industry. By 1972, that figure had fallen to about 138 000; today, it is about 175 000. Of even greater concern is the overall number of transit vehicles available for the provision of transit service. Mass transit systems operate with a total of about 54 000 vehicles. That compares to about 88 000 vehicles that were in service during the late 1940s. Of even greater cause for alarm is the status of new bus construction for transit service. In the 1940s, there were nine major manufacturers of full-sized transit vehicles in the United States. Construction of new buses peaked at more than 12 000 in 1947. Today, the United States can claim only two active manufacturers of full-sized transit vehicles plus a handful of builders of mid- to small-sized buses. Construction of new vehicles in the United States in 1979 totaled less than 6000. Admittedly, that is a significant improvement over 1970 when only 1750 transit vehicles were constructed. However, that is still a long way from the 1940s.

Of equal significance, and perhaps of even greater concern, is the long wait encountered by public transportation systems desiring to buy new transit vehicles. Because of the limited construction capacities of today's manufacturers, coupled with the extensive federal requirements and procedures that must be complied with, it is not unusual for delivery dates to be in excess of 18-24 months after placement of a purchase order. The total procurement process today for a public transit system desiring to expand or improve the performance of its service could well exceed three years.

In order to fully understand the potential severity of the current situation, it is enlightening to look back on the only two experiences that the United States has had with energy-shortage situations that have created conditions severe enough to tax the performance of its mass transit services. From a transportation point of view, this century's first energy crisis was the result of the special resource demands of World War II. With military needs and long-term supplies largely unpredictable, the United States instituted a gasoline-rationing plan on a nationwide basis. Needless to say, use of mass transportation increased dramatically and steadily throughout the war years. The imposition of the rationing plan at that time, however, did not create extreme hardship situations for most citizens. After all, there were still more households without an automobile than with one. Nevertheless, use of private automobiles in those years declined dramatically as the number of transit-dependent individuals increased in direct proportion.

Fortunately, during the two decades prior to World War

II, the United States had built and operated large, efficient, privately run transit systems in most metropolitan areas. Although experiencing their most dramatic increase in ridership ever (48 percent between 1940 and 1945, representing 7.7 billion more riders per year), U.S. mass transit services became extremely crowded but were equal to the task.

In contrast to the apparent adequacy of mass transit to react to increased demands during World War II, the Middle East oil embargo in 1974 presented mass transit with a new challenge. When gasoline lines began to appear in early February of that year, millions of U.S. citizens turned to the much-neglected mass transit system as an alternative to waiting in lines for gasoline. At first, the increased transit patronage was an extremely welcome sight to most of the previously ignored public transit systems across the country. However, as the lines lengthened, near-panic conditions broke out in many parts of the country, and mild transit increases turned into a full-scale transit stampede. With their automobiles rendered useless, people reluctantly turned to the transit alternative for the first time. Mass transit systems were quickly overwhelmed. During February 1974, most urban operations experienced 30-50 percent increases over February 1973 ridership totals. On many routes, particularly suburban commuter services, ridership increases in excess of 100 percent were not uncommon. Transit systems began using every available vehicle to supplement regularly scheduled service. Nevertheless, the general public cried in outrage at not having enough transit seats available to meet their commuting needs. Clearly, mass transportation was not prepared to cope with such a situation. However, after 20 years of public neglect and general apathy, such conditions should not have been totally unexpected.

Almost as quickly as it came, the 1974 gasoline crisis subsided, and transportation habits across the country quickly returned to near normal. Some people attracted to mass transit during the crisis would, in fact, remain as regular transit riders. However, U.S. reliance on the automobile returned to its original intensity. Since 1974, many public transit systems have been greatly improved. The overall capacity of such systems, however, has not greatly increased. Therefore, the possibility of a repeat performance of the 1974 situation remains a distinct possibility (similar situations did in fact occur in April 1979 in selected portions of the country, particularly in southern California). Of greatest concern is the possible consequence of such a shortage--multiplied many times over in both severity and duration. In order to cope with such a possibility, it is important to take a look at the specific elements of the problem that must be addressed and the conditions and capabilities of various public transportation systems across the country to deal with an energy-crisis situation.

KEY ELEMENTS IN SOLVING THE PROBLEM

Perhaps the most important element in the solution to the problem of mass transit is the overall availability of vehicles. Past domestic production rates, particularly through the 1960s and early 1970s, have been clearly inadequate, if urban areas in the United States are to build mass transit services that can be reasonably expected to provide an acceptable alternative to the use of private automobiles during energy-crisis situations. Overall, it should also be remembered that reliance on the automobile must inevitably decrease in direct proportion to dwindling petroleum supplies worldwide. A current plan by the Urban Mass Transportation Administration to increase domestic new bus production to more than 10 000/year would appear to be a good start toward solving this problem. However, the two remaining domestic full-sized coach builders would appear to be unable to meet this goal with existing facilities, and current federal procedures and regulations on bus construction have served as a deterrent to the establishment of new manufacturers or to any expansion of existing providers. Realistically, the most optimistic estimate of 1980-1981 domestic bus production points to 7000-8000 units/year. This will clearly fall well below national demand as is evident from the 18- to 24-month delay in delivery experienced by transit systems that have recently placed orders for new vehicles.

Also, the cost of new buses has proven to be a severe deterrent of massive expansion of transportation systems. Although federal funding can now absorb 80 percent of the cost of a new bus, local authorities are still faced with heavy capital requirements, if substantial increases in fleet size are desired. A full-sized transit coach (47-51 passengers), as recently as 1974, could cost in the area of \$45 000 -\$48 000/unit. A full-sized advanced design transit bus today (with seating capacity normally reduced to 39-45 passengers because of federally mandated wheelchair provisions and new structural design features) could be expected to cost \$120 000-\$125 000/unit, if appropriately equipped to meet all federal guidelines. Manufacturers claim this 160 percent increase in price in just six years is justified by spiraling production costs, extensive research and development efforts, and a myriad of federal requirements, restrictions, and guidelines that have been imposed in recent years. Nevertheless, a capital burden of this magnitude has proven to be difficult for many local municipalities to absorb within recently strained budgets.

In order to cope with the vehicle-availability problem, many transit systems, which had previously planned on retiring substantial numbers of old deteriorating vehicles on delivery of newly purchased ones, have decided to retain the old relics for possible emergency use should an energy-crisis situation occur. Several systems have even begun an ambitious program of vehicle rehabilitation designed to restore many older vehicles to more acceptable working condition. Such programs have proven to be an effective means of increasing fleet size and potential system passenger capacity without undertaking extremely costly new bus purchase capital programs.

It should also be remembered that, even if additional vehicles become available, many systems do not have adequate maintenance and storage facilities to accommodate substantially greater numbers of vehicles. Consequently, expanded garage and facility programs must always be considered whenever substantial fleet expansion is contemplated.

Even if more buses are obtained and storage and maintenance facilities are expanded or modified to accommodate them, in order to provide the additional service needed to meet the increased demand, substantial increases in operating subsidies will be required. The cost of providing transit service today far outstrips the ability of the transit rider to pay for it through the farebox. Nationally, only about 40 percent of the costs of transit service is returned through the farebox. Increasing fares may be one solution to this problem. However, transit service has traditionally been most-heavily patronized by those elements of the population who can least afford high payments for such service. Therefore, other sources of local, state, and federal financing appear to be necessary. Current and future operating subsidies available through the Urban Mass Transportation Act appear to be an adequate start; however, such funding still leaves much of the cost to local and state bodies. Recent antitax movements across the country have not helped the situation. Sales, real estate, income, and gasoline taxes have all been levied by local and state authorities to generate enough revenue to maintain effective transit systems. These sources, however, have recently fallen short of the funding levels required to expand and improve transit services. Unfortunately, several referendums in the past year, designed to increase tax support for transit services, have been defeated by local citizens. If additional transit service is to become a reality, new sources of funding the operation must be found.

Finally, even if more buses are obtained, garages expanded, and additional operating subsidies secured, mass transit still may not solve the problems of an energy-crisis situation unless the attitudes and travel traditions of the U.S. public change significantly. It now seems clear that, until people decide to conform with the travel habits of the

rest of the world, a mass transit problem will continue to exist. In the future, public transportation systems must be perceived as public services, the same as police and fire protection, garbage collection, and other services that must be supported by the entire community.

CURRENT CASE STUDIES

To analyze the potential ability of public transportation systems to respond to energy-constraint situations, several case studies of transit systems of varying sizes across the country are reviewed in this section.

Long Beach, California

Long Beach Transit (LBT) operates a fleet of 150 urban transit buses and attracts about 15 million patrons annually. LBT recently completed development of a comprehensive emergency energy contingency plan that outlines step-by-step procedures to follow should either a gasoline shortage dramatically increase ridership or the availability of diesel fuel require a cutback in the amount of transit service that can be provided. Development of the emergency plan was felt to be essential to LBT in light of its experiences in April 1979, when gasoline shortages suddenly produced dramatic ridership increases throughout the LBT system. Long Beach Transit has experienced a ridership increase in excess of 40 percent since 1978. Part of this increase can be attributed to energy concerns and related gasoline price increases. LBT has managed to accommodate ridership increases without dramatically increasing the size of its operating fleet by instituting a series of route and schedule modifications. The availability of previously unused seating capacity also permitted absorption of these additional riders.

Only a few years ago, it was LBT policy to try to guarantee a seat for every transit patron during both peak-hour and midday periods. This policy has now reluctantly been abandoned, inasmuch as LBT is now faced with the reality of transit demand in excess of seating capacity during several periods of the day. Unlike many systems, LBT does not experience substantial decreases in ridership during midday hours. Heavy patronage by senior citizens and downtown-bound shoppers traditionally has kept midday ridership at 70-80 percent of peak-hour level. LBT, consequently, has not had great numbers of vehicles available during midday hours that could be used in emergency situations to accommodate higher volumes of riders. The recent gasoline shortage quickly taxed LBT vehicles far beyond their capacity during rush-hour periods. Efforts by LBT at that time to encourage major employers in the area to stagger work hours met with only limited success. As a result, LBT now perceives across-the-board fleet expansion as its only viable means to accommodate increased ridership in the future. Toward that end, the recent purchase of 40 new advanced-design transit coaches, originally destined to serve as replacement vehicles, may well serve as a means of expanding the fleet instead. Several older coaches, originally destined for retirement and eventual sale, are now being placed in mothballs and might be reconditioned in order to improve the ability of LBT to accommodate substantial future increases in ridership.

A more severe problem than vehicle availability for LBT is garage-maintenance capacity. Currently, LBT is operating from a maintenance facility that has been declared wholly inadequate for the existing fleet. Fortunately, plans are well under way for the expansion of the existing facility and the creation of a new satellite maintenance operation. Even so, the new maintenance plans will be based on accommodation of up to 225 vehicles that may or may not be sufficient for future transit demands in the Long Beach area.

Overall, LBT currently appears to accommodate modest ridership increases (5-10 percent) over the next few years by adjusting schedules and routings and encouraging use during less-active periods of the day. However, peak-hour capacity seems to be nearing its maximum, and substantial increases (i.e., 20 percent over an extended period) could clearly not be accommodated.

Memphis, Tennessee

The Memphis Area Transit Authority (MATA) provides local and some regional transit service with an operating fleet of 285 vehicles. The MATA system attracts more than 20 million riders/year. MATA has recently completed the development of its own emergency energy plan designed to accommodate substantial increases in ridership with only moderate increases in vehicle requirement.

The plan outlined by MATA envisions the capability to accommodate ridership increases of 51-52 percent, if standees could be attracted on every route. This additional ridership could be accommodated through the use of a total fleet of about 300 vehicles, only a modest increase over the existing number of vehicles available. MATA officials admit, however, that their available capacity levels (up to 52 percent during peak periods) are somewhat misleading, primarily because of the current distribution of ridership on the MATA route system. The majority of the MATA patronage is currently concentrated on only eight local routes, while much of the remaining system is largely unused. This suggests that some of the less-popular routes are currently displaying capacity use of only 20-30 percent, while the more-popular routes are clearly in the area of 90-100 percent during peak periods. It is more logical to assume that, during an energy crisis situation, several portions of the MATA system could be pressured well beyond its operating capability. It is also important to note that the apparent MATA peak-hour seating availability also includes return-trip service on commuter routes that are difficult or impossible to use to their fullest potential. In a heavily commuter-oriented transit system, such as MATA, it is difficult to generate contraflow travel demand that would be necessary in order to improve trip use.

In order to best accommodate additional riders during emergency situations, MATA has assumed the use of staggered work hours in order to extend the peak-hour demand for transit service. Overall, MATA assumes the expansion of the rush-hour period to 3 h during both morning and afternoon periods.

Under an ultimate-demand situation, with all elements of the emergency energy plan in operation, MATA assumes that it would be able to accommodate a 62 percent increase in ridership during morning peak-hour periods and a 65 percent increase during afternoon peak-hour periods. Substantially greater percentage increases could be absorbed during midday and evening service hours. One problem that has not been confronted, however, is how to and who would pay for these additional hours of operation that would be required in order to accommodate the additional ridership. No emergency local funding provisions have as yet been developed.

Minneapolis-St. Paul

The Metropolitan Transit Commission (MTC) of the Twin-City area serves a population of about 1.5 million with a transit fleet of more than 1000 vehicles. In 1979, MTC attracted more than 63 million riders, the vast majority of them using the service during peak-hour periods for commuting purposes. Transit service has become very popular in the Twin-City area for home-to-work trips, but other trip purposes seem to be still generally reserved for the private automobile. Consequently, MTC peak-hour vehicle demands are almost four times as great as those during midday hours. This presents critical problems for transit providers during emergency situations when ridership may increase dramatically. Inevitably, during a true energy-crunch situation, demand for peak-hour transit service for commuting purposes will show the greatest

increases. Consequently, during such a crisis, MTC would be forced to rely on staggered work hours in order to increase capacity to any degree at all.

An emergency energy plan was developed for the Twin-City area several years ago but has not been updated for quite some time. Recent overall ridership increases suggest that problems noted in the original energy plan may become more severe than originally anticipated. Currently, 12 percent of the MTC buses are already severely overcrowded or are filled beyond acceptable service standards during the peak hours. An overall ridership increase of only 5 percent could push another 15 percent of peak-hour trips beyond the maximum-capacity service standard level.

MTC has also considered retaining and rehabilitating some of the older vehicles in its fleet that had been scheduled for retirement and eventual sale; however, no extensive expansion of the operating fleet is contemplated at this time because of limited resources now available to subsidize the operating costs of the system. MTC hopes that, if an emergency situation occurs and ridership increases substantially, additional funding would become available from federal and/or local sources to accommodate the need for additional service. Again, however, no such plan for additional funding now exists.

Nashville, Tennessee

The Metropolitan Transit Authority (MTA) in Nashville maintains an active energy plan on an annual basis. Adjustments are made to accommodate the existing changes and special needs of the system from year to year. The MTA operates a fleet of 140 transit vehicles to transport 8-9 million transit riders annually. Nashville currently is confident that it could absorb a sudden ridership increase of about 36 percent during peak hours through the provision of additional service and the encouragement of staggered work hours by major employers in the area. No massive fleet expansion programs or facility improvements (which were just expanded and modernized a few years ago) are planned for the immediate future.

Although Nashville has experienced consistent ridership increases in recent years, it still feels comfortable with its ability to meet any demands that it can now foresee in the immediate future. Good cooperation from political leaders and the local population is an asset that Nashville will be able to rely on in making the necessary adjustments to accommodate future energy-crisis situations.

Baltimore, Maryland

The Mass Transit Administration (MTA) of Maryland operates what can best be described as a typical large eastern transit system in the Baltimore metropolitan area. The MTA operates a fleet of about 1030 transit vehicles and expects to carry almost 100 million passengers in 1980. This extremely heavy ridership creates considerable and, at times, severe overcrowding during peak-hour periods, as well as fairly heavy patronage on many routes throughout the entire day. Several of the more heavily traveled MTA routes may attract between 25 000 and 30 000 passengers during a typical weekday. Patronage is so heavy that several routes operate with 2- and 3-min headways (including one crosstown route).

Because of the heavy patronage now being experienced by the MTA, its planning department has devoted substantial time and effort to the development of an emergency energy contingency plan. The plan was deemed a necessity by the MTA following the near-crisis situation that developed during the 1974 oil embargo. At that time, the dramatic ridership increases experienced by the system (at one point 30 percent in one month) pushed the already-crowded peak-hour trips near the breaking point. Extra service was hurriedly implemented in a stop-gap fashion to try and alleviate some of the most difficult situations. Fortunately, the additional crowds subsided after a few weeks, and the system gradually returned to normal. Because of that experience, however, the MTA felt that it was imperative to develop a plan to most effectively accommodate an energy-crisis situation by using existing available resources.

Despite all their planning efforts, the MTA admits that its ability to provide for substantially greater numbers of riders with its existing fleet is limited at best. The current system is already so heavily used that an increase in ridership of only 1 percent during peak hours of operation would require almost 30 additional vehicles in order to maintain existing operating standards. With no massive fleet expansion contemplated in the immediate future, alternative means of providing for such additional ridership must be developed.

The Baltimore MTA is now in the process of constructing a rapid transit fixed-rail system for the heavily traveled northwest corridor of the city. Service is projected to begin in 1982, and it is hoped that much of the heavy peak-hour demand on the bus system there will be somewhat alleviated by the operation of the new rail system. However, an extensive feeder-bus network to provide service to the transit stations may well create an overall increase in the demand for transit vehicles rather than a net reduction. The new rapid transit system could eventually serve as a valuable tool in combating the effects of future energy-crisis conditions in that area of Baltimore.

In the short term, the MTA has developed several other measures in its emergency plan that are designed to help cope with future crises. Most are designed to improve vehicle use, such as encouraging staggered work hours, reducing the acceptable level of vehicle spares, and minimizing out-of-service time for each vehicle. Plans have been developed to provide for the additional hours of operating service that would be expected and for a recruitment and training program for additional transit operators.

No specific financial arrangements have been developed yet to accommodate the additional needs of an energy-crisis situation. However, as a department of the State of Maryland, it is anticipated that such future emergency needs could be met by emergency funds allocated through the state's general fund.

Missoula, Montana

In sharp contrast to the transit system operated by the MTA in Baltimore is the bus service provided by Missoula, Montana. The Mountain Line, as the service has been named, operates with a fleet of only 14 vehicles and is expected to carry between 400 000 and 500 000 passengers in 1980. Patronage has tripled since the service was begun less than three years ago. The Mountain Line serves a population of about 40 000.

Despite the difference in operating characteristics, Missoula exhibits similar problems to those of the Baltimore operation. Severe overcrowding is now experienced during certain portions of the day, especially during the winter months when driving in this area can become very difficult. Mountain Line officials report that the service is already operating well above capacity during peak periods of the day and project that any substantial increase in the demand for transit service in the Missoula area could probably not be fully met with existing Mountain Line resources.

Missoula has not developed an emergency energy plan for the transit system largely because they perceive that little could be done to cope with such problems. Because it has a population of less than 50 000, Missoula is not eligible for additional Urban Mass Transportation Administration funding through Sections 3, 5, or 8 of the Urban Mass Transportation Act, which would normally provide for capital, operating, and planning funds for urban transit systems. Missoula's only source of federal funding is Section 18 rural transit funds, allocated on a statewide basis and generally insufficient to meet even the existing transit financial needs of the state. For instance, should Missoula desire to purchase four new transit coaches to expand its

fleet capacity, the cost of such vehicles (about $400 000) would almost exceed the entire Section 18 funding allotment for all of Montana for 1980. Consequently, with local funding support already at a comparatively high level, fleet expansion and/or service improvements cannot be contemplated because of financial limitations.

Duluth, Minnesota

Duluth has traditionally been known as a transit-oriented community. Its number of transit rides per capita annually exceeds that of just about every other city of comparable size in the country. Duluth is a city of about 100 000 people and occupies the banks of Lake Superior. Public transportation is provided by the Duluth Transit Authority (DTA), which operates a fleet of 98 transit coaches and attracts about 6 million transit riders annually. DTA also provides service for the adjoining city of Superior, Wisconsin.

DTA has developed an energy contingency plan primarily concerned with providing for fuel needs during shortage situations. It has not given much attention to assessing potential vehicle needs to accommodate substantial ridership increases. DTA currently has a very limited number of vehicles and maintains a very low spare ratio during peak hours of service. Peak-hour demand for commuter operations is extremely heavy and requires all serviceable vehicles now available to DTA to meet that demand. An assessment by DTA personnel noted that little or no additional ridership increase could be accommodated during peak hours of service. However, midday and evening operations have considerable available capacity. DTA could potentially encourage staggered work shifts in order to provide some additional overall system capacity.

Although currently receiving federal, state, and local funding for both capital and operating needs, DTA foresees little additional funding that could be used in emergency situations in order to supplement existing service. Additionally, no massive vehicle expansion is projected in the immediate future. In conclusion, DTA points out that additional service to be provided to accommodate substantial ridership increases would have to be operated with existing vehicles and paid for by additional farebox revenues.

Louisville, Kentucky

Louisville could well represent the typical mid-sized midwestern city. Serving a metropolitan area of about 750 000, the Transit Authority of River City (TARC) operates a fleet of 242 transit vehicles and expects to attract about 15 million riders in 1980. Although TARC has enjoyed steady ridership increases in the past several years, the system still appears capable of absorbing considerably greater numbers of riders in the future. Several years ago, civil disturbances in many portions of the community had a negative effect on transit ridership from which it is only now beginning to fully recover. Consequently, additional capacity does seem to be available on many of the more-popular TARC routes.

TARC has developed an emergency energy contingency plan in which it states that the current system could accommodate an additional 48 percent increase in ridership during peak hours and considerably greater numbers during non-peak hours by using existing resources. Consequently, TARC feels comfortable with the size of its existing service and feels capable of handling future emergency needs, at least during the early stages of such a crisis. TARC also appears capable of implementing new service, should it be necessary, and of financing such service expansion through a trust fund that is available to TARC.

Overall, TARC appears to be one of the more-capable transit systems in the country, given its ability to respond to substantial increases in demand that could result in an energy-crisis situation.

OVERALL ASSESSMENT

In reviewing conditions in the eight cities examined in this report, as well as in examining the literature concerning several dozen other metropolitan areas across the country, it would appear that the least-prepared mass transportation systems and those least able to cope with the demands of an energy problem situation are those operations in either very large metropolitan areas or in very small cities—but for very different reasons.

Large transit systems (those operating 500 vehicles or more) normally assume the responsibility for the provision of public transit service for extremely large masses of people. These systems often serve areas with populations of 1 million or more. The systems in such communities are, more often than not, already fine-tuned to operate at maximum efficiency and, therefore, minimize operating and capital expenditures. Most of these systems have little or no leverage as far as additional available vehicles and other resources needed to dramatically expand transit service operations are concerned. Available seating capacity during peak hours for such systems is almost universally nonexistent. Of even greater signficance, however, is the assessment of the overall potential demand that could be imposed on these transit operations. In some cases, a switch from the private automobile to reliance on public transportation by only 5 percent of the commuting population could mean a daily increase in ridership of 80 000 to 100 000 passengers, or more. Accommodation of such increases appears clearly beyond the existing capabilities of transit services in these communities. Massive increases in the number of vehicles available for service would have to be realized. Unfortunately, procurement and operation of these vehicles seem unlikely.

The very small transit systems serving the smaller communities across the country also appear to be faced with severe problems in dealing with energy-shortage-inspired ridership increases. Their problems, however, are more related to available facilities and the absolute size of the operation rather than to the absolute number of additional patrons. Although an energy-crisis situation in cities (e.g., Missoula, Montana; Columbus, Georgia; or Lima, Ohio) may actually result in an absolute daily increase in ridership of only 1500-2500 new riders, even these small volumes of passengers could not be accommodated because of the extremely limited capacity of existing transit services. Such systems often have less than 30 available vehicles with which to provide transit service for the entire community. Also, maintenance and servicing facilities are usually barely acceptable or already inadequate to meet the needs of the current service levels. These limited physical resources greatly restrict the amount of flexibility that would be needed to accommodate this additional ridership.

Those cities and transit systems that appear to be best able to cope with potential energy crisis situations are cities with populations of 250 000 to 750 000 that have built adequate comprehensive transit systems over the past 10 years. Such systems usually have between 100 and 400 transit vehicles available for service and, more often than not, seem to require only about 80 percent of their total fleet for the provision of current peak-hour service. Increases in ridership during emergency situations in such communities seem to be calculable on a percentage basis of existing ridership that could potentially be accommodated; however, in many cases, this could only be done with substantial difficulty through revision and supplementation of the existing service. Additional daily ridership increases of 10 000 to 20 000 passengers would appear to be a manageable situation for these communities. That, coupled with the apparent availability of federal and state funding (in contrast to many of the smaller operations noted above), also suggests that financing for additional service needed to meet this demand would also be more readily available.

Geographically, the West and Midwest appear to be in a generally better position to accommodate large numbers of new riders than the transit systems operated in the East, Northeast, and Deep South. The traditional poor response to mass transit services found throughout the Far West has permitted the development of several urban transit systems

that have previously not been well patronized. Consequently, additional passenger capacity seems to exist on most Western systems. The general exception to this appears to be peak-hour service provided in Los Angeles and San Francisco. The problems associated with eastern, northeastern, and southern transit operations seem to relate to the extremely large numbers of transit-dependent riders that have dominated the operation of these services for several years. Because of these large numbers of transit-dependent riders, many services operating in communities in these parts of the country have been tailored to adequately meet those needs. However, during energy-crisis situations, the greatest increases in ridership would not come from these same well-served communities. Most probably, the greatest increases would be realized by the suburban commuter services. The 1974 gasoline-shortage experience seems to verify that conclusion.

WORKING TOWARD A SOLUTION

It can now be said that, in answer to the question posed at the beginning of this paper, current public transportation systems in the United States would not be able to adequately meet the demands imposed on it by possible future energy-crisis situations. Thus, we must look to what can be done to alleviate this problem.

Clearly, the development of an emergency energy contingency plan for every mass transit provider in the country is a necessity. All systems must be aware of the steps that can be taken to maximize use of their existing resources and to provide for the maximum number of riders possible. Fortunately, many systems across the country have already developed or are in the process of developing such plans. Hopefully, by the end of 1981, energy plans will be a standard part of the planning process of all mass transit systems.

Effective short- and long-range planning will also be a key element toward solving this potential problem. Short-range planning should be directed toward fine-tuning existing routes and schedules so as to meet existing demand in the most efficient and effective manner. Long-range planning should have the foresight to develop appropriate capital programs capable of expanding and maintaining operating fleets in a manner that will most effectively provide for additional service to meet future energy-crisis situations. Long-range plans should also include activities designed to encourage a smoother transition from the private automobile to public transportation so as to alleviate the impact of future energy shortages.

Finally, public awareness of this potential problem must be greatly enhanced. People must realize that their traditional travel patterns and habits may well not be compatible with the availability of future resources. Therefore, an overall program to educate the public more effectively in the area of energy consciousness would appear to be a key element in lessening or ultimately sidestepping future crisis situations.

OUTLOOK FOR THE FUTURE

Despite efforts now under way by urban transit systems to plan for the inevitable problems that will arise from future energy shortages, the overall impact of these situations, nevertheless, will be quite severe and, most likely, will cause extremely difficult times for the average U.S. commuter. Decades of personalized transportation provided by the private automobile have conditioned the United States into thinking that such ease and flexibility in transportation are inalienable rights. The realization that such convenience may no longer be feasible may be difficult for the average citizen to accept. The impact can be substantially lessened, however, if the transportation alternative—represented by the mass transit systems—is substantially upgraded and expanded to an appropriate level capable of absorbing these transition riders with only a minimum of growing pains. In order to accomplish this, planning, growth, and spending must be undertaken now at an unprecedented pace.

Our confrontation with this problem may actually be much closer than anyone expects. Surely, an interruption—even for a limited time—of the petroleum supplies from the Persian Gulf could trigger an energy-related chain reaction that could confront us with the problem in a matter of weeks. Hopefully, this confrontation will materialize more gradually, over a period of several years, which may permit us to adequately prepare for this inevitable occurrence. In either case, the fact remains that public transportation in the United States is not what it used to be and certainly not what it should be. Its overall ability to respond to major energy-constraint situations is only very limited at best and, more likely, wholly inadequate.

The transportation problems experienced by visitors to the 1980 Winter Olympics in Lake Placid, New York, may well have been a sneak preview of what may be experienced on a nationwide basis not too many years from now. If the United States cannot plan or provide for transportation services any more adequately than was done by the Olympic Committee, the same inconvenient and, at times, chaotic conditions that were experienced at the Olympic games may be imposed on an equally transit-dependent U.S. citizenry. To avoid such a situation, adequate measures should have begun yesterday.

Potential Roles for Auxiliary-Paratransit Services in an Energy Shortage

Charles Carlson and Mary P. McShane

There is a variety of specialized transportation services that can and should play an important role both in energy conservation and in the nation's response to future fuel shortages. Described here as auxiliary-paratransit services, these service types include dial-a-ride (DAR), subscription bus, jitney service, shared-ride taxi (SRT), vehicle rental-lease operations, school bus service, privately owned intercity bus operations, and limousine services.

Auxiliary-paratransit services may be open to the general public or they may be restricted to certain user groups (e.g., the elderly, the handicapped, and company employees). Fares and funding approaches vary; public subsidies may or may not be used to cover operating costs.

Auxiliary-paratransit services use a variety of vehicles that may be owned and operated by either public- or private-sector organizations (with or without union labor). These vehicles may include transit buses, over-the-road intercity coaches, school buses, taxis, vans, and regular passenger sedans and station wagons.

Finally, auxiliary-paratransit services may be subject to public regulation. Such regulation may encompass fares, service areas, routes, schedules, and market-entry requirements.

Paratransit modes have tended to be viewed as secondary services, modest in scale but with rather specialized application. The growth of paratransit has been hindered also by the existence of institutional and regulatory barriers, some of them explicitly intended to

protect conventional transit operations from competition. In the event of a major fuel emergency, however, it is virtually certain that conventional transit capacity will be heavily overburdened, even on routes that are well served in normal times. At that point, it will be necessary to seek out and press into service all available auxiliary and paratransit capacity in order to retain a tolerable level of citizen mobility. Even if an acute fuel emergency does not develop, energy prices will continue to rise and chronic supply shortages are likely to become the rule rather than the exception. When this happens, the need for additional services will be equally critical. However, the position of such services will be precarious unless they are recognized immediately as potential coping mechanisms and are given particular planning attention.

There are four primary reasons for focusing on the augmentation of such services. First, there are large numbers of auxiliary-paratransit vehicles already in operation in the United States. These vehicles include intercity coaches, school buses, minibuses, vans, and automobiles. Transit systems have limited capital available to them, and the acquisition of new equipment requires a long lead time. Few transit systems have additional vehicles on hand for emergency expansion of service. Auxiliary-paratransit vehicles, therefore, could be an extremely important resource. Particularly during a fuel shortage, these vehicles could help to absorb the excess demand for public transportation that results from reduced fuel availability for automobiles.

Second, rising fuel prices and sporadic fuel shortages will generate demands by the public for new transportation services that can help them to preserve their mobility. Auxiliary-paratransit services should form a major element of the public- and private-sector response to these demands. Under many circumstances, such services may be less expensive to operate than new fixed-route transportation services and less difficult to establish administratively.

New auxiliary-paratransit services can also be effective in encouraging permanent reductions in the nation's energy consumption. By providing people with the means to fulfill their travel needs without an automobile, auxiliary-paratransit services can discourage automobile travel. More than that, they may persuade some people to sell or not purchase a second car.

Third, fuel supplies for auxiliary-paratransit services may be threatened by fuel shortages during the next decade. If such shortages occur, localities and individual auxiliary-paratransit service operators would do well to have contingency plans ready in order to maintain current operations. Even without severe fuel shortages, existing auxiliary-paratransit services will face increasingly more difficult struggles in the coming years to maintain current levels of operation in a climate of rapid inflation, rising fuel costs, and tight government budgets. Attention needs to be directed now to the identification of methods to ensure that existing services are operated at maximum productivity during both normal and fuel-short periods.

Finally, existing private operators constitute a reservoir of expertise and experience that should not go unnoticed as the nation moves to reduce energy consumption and to prepare for sporadic energy shortages. Indeed, these operators may be essential to the creation of comprehensive and productive transportation energy conservation and contingency plans at the local level.

This paper focuses on six types of services (rental-lease vehicles, shared-ride taxi, dial-a-ride, jitney services, school buses, and intercity bus operations) that may be particularly important during future fuel shortages. The potential value of each service and obstacles to expanded operations are discussed. A number of issues that seem to be of general concern with respect to all of these service types are highlighted for special consideration in the next section. Finally, general recommendations regarding each service type are presented.

EXPANDED USE OF RENTAL-LEASE VEHICLES

It is difficult to determine with great accuracy the size of the vehicle rental-leasing industry because data are so limited. However, estimates from several sources suggest that the size of the rental-car fleet was approximately 450-490 000 cars in 1978 (1). The lease-car fleet is estimated to be nearly 10 times as large as the daily rental fleet; it numbered more than 4.2 million vehicles in 1978 (1). Both sides of the industry have traditionally experienced rapid growth, with rental-car growth averaging about 12.6 percent/year between 1964 and 1972 (2).

Both rented and leased cars are heavily used by business people. The Urban Institute's paratransit study estimated that 80 percent of the daily revenue from rental cars is for business-related travel, primarily on weekdays (2). Rental-lease cars have tended to be full-sized models with automatic transmissions and are generally held by the rental-leasing agency for 6-18 months.

Tourists also make up a large portion of the daily rental-car market in cities and recreation areas, but these persons do not figure largely in car leasing. Finally, there are several cities, notably New York, in which city residents represent a substantial fraction of the daily rental-car market because they prefer renting to owning.

Because of the needs of their customers, daily rental-car agencies are heavily concentrated near transportation terminals, downtown business districts, major travel corridors, and tourist or convention centers. Car-leasing agencies, on the other hand, are more evenly distributed throughout population centers. Some agencies, in fact, are located within suburban residential areas as part of car dealerships.

The car rental-lease industry is not regulated as a utility; instead, government has viewed the industry as a form of private enterprise and generally has left it free of any regulations except those that pertain to all private businesses.

Strategies

Four possible strategies for involving the vehicle rental-leasing industry in national energy conservation programs are proposed here for further study.

Employer Van Leasing Through Standard Car-Leasing Companies

Many employers now lease cars for their sales people, executives, and other employees. Indeed, many companies own no cars; instead, they prefer to lease vehicles as they are needed. Some of the largest companies spend more than $1 million/year for this purpose.

Given the size and scope of the corporate vehicle-leasing business, it is quite conceivable that vans could be fully integrated into the leasing industry. Employers could lease vans and use them to establish a vanpool program. Leases could be written for several months or more than a year, depending on the desires of employers (which may be greatly affected by the state of the nation's energy supplies).

This concept would provide employers with an opportunity to try a vanpool program without making a substantial capital investment. Indeed, some companies currently involved in vanpooling started their programs by using leased vans and, subsequently, became purchasers. Many employers might be attracted to the concept because vehicle rental-lease companies are already knowledgeable about and prepared to undertake the responsibility for maintaining and insuring the vehicles. Van leasing would also enable employers to institute vanpool programs quickly in the event of a fuel shortage. If the vanpool program were successful, employers might be able to purchase the vans they had been leasing and to apply lease payments toward purchase—a practice that many car-leasing organizations follow today.

Of course, the normal financial and administrative requirements of operating a vanpool program would not disappear as a result of van leasing. State regulations vis-a-vis insurance and taxes, for example, would have to be followed. Employers would have to spend some operating funds to administer vanpooling programs and to pay for the lease cost of the vehicles. A marketing program would be needed to sell the vanpooling concept to employees.

Crucial to the success of the van-lease concept, however, would be extensive marketing efforts by vehicle rental-lease organizations. By aggressively contacting employers and publicizing existing employer van-lease programs and the benefits of the lease-purchase option, vehicle rental-lease organizations might be able to add a substantial new dimension to their businesses. Ultimately, a large commitment to vanpooling by employers could lead to a substantial and permanent reduction in the nation's consumption of energy for commutation.

Integrated Vanpool and Car-Leasing Arrangements

This idea would involve mixed leasing of vans and cars by a single group of commuters. In brief, a van would be leased by the commuter group for work-trip travel Monday through Friday. Friday night or Saturday morning, the commuter group would travel to the lease site, drop off the van, and pick up separate cars for weekend use. Alternatively, one member of the vanpool could keep the van during the weekend. The cost of the weekend rental cars would be lower than normal because of the van lease Monday through Friday. The cost of the van lease would, as usual, be shared among the commuter group members and would be at prevailing rates.

This concept appears attractive for several reasons. First, rental cars are generally easy to obtain on weekends because most use occurs Monday through Friday. Second, such a practice might eliminate a family's need for a second car to be used for commuting. Third, though it requires some analysis regarding relative costs, this practice might prove to be less expensive than individual vehicle ownership. Finally, the total vehicle miles traveled (VMT) of the commuter group would be reduced, thereby reducing both energy consumption and pollution.

Several of the largest car-rental firms have indicated that the van- and car-lease concept may be feasible and attractive to them. However, several factors can affect the implementation of such programs.

First, insurance might prove to be a problem if insurance companies determine that the van leased by a group of commuters constitutes for-hire use of the vehicle. If insurance companies did make such a determination, insurance costs would escalate substantially, with consequent increases in the cost of leasing a van.

Second, the companies noted the need to positively identify vanpoolers if weekend car rentals are to be provided to these persons at a lower-than-normal price. Membership in a formal organization that could certify participation in a vanpool would be necessary. An employer or a state agency might be an acceptable certifying agent. Membership cards that would be renewed every few months would most likely be necessary to eliminate use of low-cost rentals by persons who had dropped out of pools.

Third, it may prove necessary for the commuter group to lease the van on a weekly basis rather than on a Monday-through-Friday basis. Under a five-day lease, weekend rental of the vehicle would be impossible. Rental of the van for Saturday or Sunday would leave open the possibility that the weekend renter would keep the vehicle for an extra day or two or would return it to another outlet of the leasing company. Controlling such problems would be nearly impossible. Thus, only a seven-day lease would be feasible for the leasing company. If this is the case, one of the members of the vanpool would have to keep the van on weekends and use that vehicle (rather than a car) for personal travel.

Despite these concerns, the van- and car-lease concept does appear to have some promise as an energy conservation device. It remains to be seen whether rental-lease vehicle companies will be willing to test the implementation of the concept.

Carpool-Vanpool Brokerage by Car Rental-Leasing Companies

Brokerage might be feasible if interest by the car rental and leasing companies was generated by the first two strategies noted above. The rental-lease company would take the lead in marketing a variety of carpool and vanpool options to employers. Such options might include (a) matching service for employees; (b) van leases for vanpools after large group matches are made; (c) car ("rabbit" pool) leases for small-group carpools that may encourage users to sell or not purchase a second commuting car; (d) van-car lease arrangements as described above; and (e) administration, maintenance, and insurance of carpools and vanpool programs.

At least two major ingredients would be required to ensure the success of such programs. Vehicle rental-lease companies would have to make a major internal commitment to these programs (i.e., staff, financial, resources, and top management involvement). In addition, these companies would have to undertake vigorous marketing programs to sell their services to employers.

State governments might be able to stimulate private-sector interest in these programs by committing a block of their ridesharing funds to rental-lease program operations. One approach would have the state establish a list of rental-lease agencies that are prepared to offer (at varying prices) some or all of the services described above. An employer would be able to contact the state for information about available services; then, employers could select one of the listed agencies to establish a high-occupancy-vehicle program to meet the specific needs of employees. The state might then contribute a portion of the cost to establish the program.

Several benefits would result from this approach. It would very likely result in an expanded number of vendors offering such services, thereby relieving state and local governments of the burden of direct provision of ridesharing, marketing, and matching activities. This increase in the number of willing vendors would also make it easier for larger numbers of employers to obtain timely professional assistance at a competitive price. Also, the approach offers flexibility in that market needs would determine the overall level of ridesharing services offered, with providers entering the market according to demand.

Ad Hoc Public Transportation by Using Rented Vehicles

During a fuel shortage, rental-lease vehicles, particularly vans, could be used in rural areas to create public transportation services, particularly if school buses are unavailable and there is no local taxi company. Such services might be sponsored (financially or otherwise) by local governments or they might be operated as private enterprises by individual entrepreneurs. The implementation of these services, however, would undoubtedly require an extensive period of time, leading to the conclusion that extensive preshortage planning would be necessary.

EXPANDED USE OF PRIVATELY OWNED INTERCITY BUSES

There are approximately 1100 private companies that provide intercity bus service in the United States (3). These companies service about 15 000 communities with a fleet of 20 200 buses—usually over-the-road coaches rather than urban transit buses (3). In 1978, intercity bus companies transported 335 million passengers, compared to 260 million for airlines, 280 million for rail, including the National

Railroad Passenger Corporation (Amtrak), and 7.6 billion for mass transit services.

Two companies—Greyhound and Trailways—dominate the industry. In 1976, they provided 56 percent of the industry's total bus miles of service, while accounting for 24 percent of the industry's total revenue passengers and 62 percent of total industry operating revenues. After Greyhound and Trailways stand 46 so-called class 1 operators whose annual gross revenues exceed $3 million/year. There are also approximately 1000 class 2 and class 3 carriers that have annual revenues of less than $3 million. In 1976, class 1 carriers (including Greyhound and Trailways) accounted for 75 percent of the industry's total bus miles of services, 43 percent of the total number of revenue passengers for the industry, and 77 percent of total industry operating revenues (4).

Regular-route intercity passenger operations are not the only services provided by the intercity bus industry. Indeed, other services provide a substantial portion of the industry's revenues (3)—regular-route passenger service, 50 percent; charter service, 30 percent; package express service, 15 percent; and other services, 3 percent.

The market for intercity bus services in the United States is unique among the major transportation modes. Users of intercity bus services who make trips of more than 100 miles tend to have lower incomes and more-limited educations than users of other modes. Students, members of the military, and retired persons are heavy users. Unlike any other mode, the majority of intercity bus passengers is female (5). Long-haul intercity buses are most heavily used for sightseeing, entertainment, and visiting friends and relatives. Business use of long-haul intercity bus services is relatively low. Short-haul intercity bus services have not been studied extensively. Insufficient data are available, therefore, on the market for and users of these services. It appears safe to assume, however, that commuters make up quite a substantial portion of the ridership of these services. Elderly, poor, and young persons who are dependent on public transportation probably constitute the majority of other types of riders.

Fares for intercity bus service are still low relative to those for other modes. In 1976, trips on class 1 intercity bus carriers cost an average of 5.14 cents/passenger mile. Other per passenger mile costs were Amtrak, 5.56 cents; domestic airlines, 7.63 cents; and cars, 17.9 cents (4).

Intercity buses are extremely fuel efficient. An intercity bus in scheduled route service can achieve 113 passenger miles of service/gal of fuel; the figures for trains, airplanes, and cars are 38, 22, and 41, respectively.

Labor patterns in the industry vary considerably. The vast majority of class 1 intercity bus companies is unionized; many of the smaller carriers are not. Wage and salary rates in the intercity bus industry are generally higher than those for the taxi industry, but they are usually lower than the wage and salary rates of personnel who work for railroads, mass transit enterprises, and airlines.

Intercity bus services, if they travel across state boundaries, are regulated at the federal level by the U.S. Interstate Commerce Commission (ICC). Intrastate services are regulated by state public utilities commissions (PUCs), which vary widely in their powers and activities. In general, however, the ICC and most PUCs regulate safety, fares, market entry, service characteristics, and mergers. The major difference between PUCs and the ICC is that the latter does not regulate the service frequencies of interstate carriers.

Since World War II, the services and financial condition of the intercity bus industry have been slowly deteriorating. The most pronounced decline, however, occurred during the 1970s. Competition from the private car has been the most important cause of this decline, but federal assistance to mass transit, intercity rail, airline enterprises, and human service agencies has also played a role. Finally, poor management has been cited as a source of the industry's fall from prominence. Clear evidence of the industry's problems can be seen in the rising operating ratios (i.e., total operating expenses divided by total operating revenues times 100) for class 1 carriers. Between 1968 and 1978, the national operating ratio for these carriers rose from 88.9 to 96.0 (3). According to George Snyder of the Greyhound Corporation, the fact that Greyhound was operating with an average load factor of only 53 percent during the height of the 1979 gasoline shortage is an indication of the excess capacity that exists on intercity bus services.

Despite these problems, there have been only piecemeal moves to provide public-sector financial assistance to the intercity bus industry. Limited financial assistance theoretically is available from the federal government through DOT's Section 3 and 18 programs, although few funds have been expended for this purpose to date. (It should be noted that the Surface Transportation Assistance Act of 1978 authorized specific capital and operating assistance programs for the intercity bus industry. No funds, however, were appropriated for these programs.) In the absence of large-scale federal assistance, several states have taken action to provide funding to the industry. Michigan has the most extensive program and provides both capital (for vehicles and terminals) and operating assistance to carriers who wish to operate new or expanded services. New Jersey provides substantial amounts of operating assistance funds to private carriers who operate local and/or intercity service (most funds to date have been provided for commuter services). New York, Pennsylvania, West Virginia, Iowa, and Oregon also provide capital and/or operating subsidies, but their financial assistance programs are small compared to those of Michigan and New Jersey.

The energy crisis and related factors should stimulate other states and the federal government to pay more attention to the intercity bus industry. Short-haul intercity bus services, in particular, should be perceived as major actors in local transportation networks. They provide essential commuter and recreational transportation services in many rural areas. Intercity bus companies have vehicle, labor, management, and other resources that could be invaluable in regional responses to future fuel shortages.

Strategies and Problems

It may be feasible for intercity bus services to initiate new services designed to encourage energy conservation and to help maintain individual mobility during fuel shortages. Such services could include (a) expansion of existing services, (b) new routes linking rural and metropolitan areas, (c) new routes between suburbs and central-city areas (including park-and-ride services), (d) supplemental fixed-route transit service within cities, and (e) contract service to employers.

Increasing existing short-haul intercity bus services by reducing headway spacing would be most valuable to commuters and would relieve the strain caused by sudden influxes of peak-period demand. New routes linking rural and metropolitan areas would aid in maintaining the economic stability of rural tourist and recreation areas and could also serve to maintain personal mobility for some rural residents who do not have access to other public transportation services. Likewise, new routes between suburbs and central-city areas would provide an alternative to car travel for many users, while the use of intercity buses as supplements to fixed-route mass transit could allow excess demand on these routes to be accommodated quickly. Finally, employer-sponsored subscription or park-and-ride services provided by intercity bus companies could play a significant role in ensuring that employees can get to and from work during a shortage. If these services were introduced during times of plentiful fuel supplies, coupled with a campaign of service promotion and car disincentives, employer-sponsored bus services could make a contribution to energy conservation.

However, decisions regarding the implementation of one

or more of these services will require consideration of a variety of issues, including fuel availability, regulatory requirements, funding and fare questions, vehicle design problems, labor conflicts, and vehicle availability.

Fuel Availability

DOE's Special Rule 9 (6) provides that intercity bus operators who have bulk storage facilities and whose vehicles use diesel fuel (as virtually all intercity buses do) may acquire as much fuel as they need, whether or not a fuel shortage exists. The only problem that might arise for these operators is locating suppliers who have fuel for sale at a reasonable price (7). Carriers who cannot locate fuel must apply for fuel from state set-asides. (The state set-aside program allows states to reserve up to 4 percent of total state diesel fuel supplies. The state may distribute allotments from this reserve to fuel users who are experiencing hardship.)

At the moment, these procedures appear to be working reasonably well. However, DOE's petroleum-allocation regulations are scheduled to expire in September 1981. If these regulations are not extended, fuel supplies will henceforth be allocated only by price—a potential disaster to intercity bus operators who are constrained by limited operating funds, fixed-cost contracts, and public regulation of fares. As prices rise sharply during a shortage, some operators just may not be able to finance their fuel purchases.

Regulatory Requirements

This paper noted earlier that interstate bus services are regulated by the ICC and intrastate services by state PUCs. Implementation of new bus services or expansion of existing intrastate services will require regulatory approvals at the state or federal level. Street licenses will have to be obtained from local authorities. If the new services are to operate within any part of a transit authority's service district, the transit authority may have to approve these operations.

All of these regulatory processes will take time, particularly if the regulatory agencies are hesitant to use their emergency powers to authorize new or expanded intercity bus services. Regulatory requirements, therefore, may pose a significant obstacle to prompt expansion of intercity bus services in the event of a fuel shortage.

Funding and Fare Questions

If new bus services are introduced without public subsidy when fuel supplies are plentiful, fares are likely to be high (relative to the out-of-pocket cost of car travel) and the demand for service most likely will be low. Stimulating use of new intercity bus services in order to reduce energy consumption, therefore, may require some amount of public subsidy to reduce fares to attractive levels. Finding funding sources for such subsidies, on the other hand, may be quite difficult due to the lack of "fat" in current federal and state assistance programs.

If new intercity bus services are introduced in response to a serious fuel shortage, many members of the public may be quite willing to pay full-cost fares in order to abandon their cars. In this case, a major financial issue facing regulatory authorities will be the degree of profit that they will allow intercity bus operators to earn.

Other members of the public (e.g., elderly, handicapped, and poor persons), however, may be unable to afford the full-cost fares of new intercity bus services. A second financial issue, therefore, may be the development of mechanisms to ensure that disadvantaged persons can afford to use these services.

Vehicle Design Problems

Intercity buses are built for high-speed service over highways rather than stop-and-go operations on city streets. Their transmissions are geared for express service; they have high-backed upholstered seats, narrow aisles, no room for standees, a single door in the front, and, in most cases, no fare box. Due to these problems, use of intercity buses in main-line transit service (except for park-and-ride or express services) may prove to be extremely difficult.

Labor Conflicts

Existing Section 13c agreements between management and the labor unions of most transit authorities probably represent the most insuperable barrier to the use of intercity buses and other services discussed later in this paper. Such agreements specify that all services provided by the transit authority must be operated by members of the authority's labor union. Without union approval, therefore, it may be impossible for transit authorities to contract for service provided by the buses and drivers of private operators. In addition, it appears that the U.S. Department of Labor may require that a service contract between a transit authority and a private bus company be accompanied by the extension of 13c protections to the company's employees. Wishing to avoid further entanglements with Section 13c, transit authorities may decide not to write contracts with private operators. Finally, a transit authority might wish to lease intercity buses and operate them with transit union labor for the duration of an energy emergency. Yet, because the authority probably would have to acquire new funding in order to pay for the operating costs of these vehicles, the authority's labor union might be able to demand a new or supplemental 13c agreement to cover these new funds. The writing of such an agreement could take months; the buses and the new funding probably could not be used during the negotiation period. Moreover, the writing of a new or supplemental 13c agreement might open up a whole range of old labor issues for new negotiations. In brief, Section 13c requirements may act as a powerful barrier to transit authority use of privately owned intercity buses.

Vehicle Availability

Most intercity bus companies operate charter as well as fixed-route services. Many other operators provide only charter service. The vast majority of charter trips is for sightseeing and recreational purposes. These trips generate a major portion of the patronage, revenues, and employment in the tourist and sports industries, particularly those that are situated in rural areas.

Intercity buses that are used for charter purposes do constitute a reservoir of vehicles that could be used to expand existing services and/or introduce new routes between cities, suburbs, and rural areas. On the other hand, reducing or eliminating charter services would mean a serious loss in revenue and employment for important industries and regions. It should also be noted that employers, resorts, and other elements of the private sector are likely to contract for use of intercity buses during a fuel shortage in order to maintain their own operations. Few buses, therefore, may be available for publicly sponsored services. (Privately sponsored services, in fact, may be most desirable because they can be implemented quickly, thus avoiding difficult federal, state, and local laws, regulations, and procedures. They may also be more efficient in that they respond directly to market forces.)

Purchases or leases of new vehicles may be perceived as an alternative means of acquiring vehicles for expanded or new intercity bus operations. Long lead times for vehicle procurement, however, will preclude use of this option unless it is exercised in advance of a shortage and intercity bus companies are certain that these vehicles will produce revenues for them. The shortage of capital in the intercity bus industry is a further deterrent to new vehicle acquisitions.

EXPANDED USE OF SCHOOL BUSES

According to the National School Transportation Association (NSTA), there are approximately 390 000 school buses in use in the United States (including spares, equal to about 10 percent of the total). This fleet is more than five times larger than the nation's total stock of mass transit buses and rail vehicles (8). There are nearly twice as many school buses as there are taxis in this country (9). According to NSTA, the fleet is growing—most recently at a rate of about 4 percent/year. This growth is attributed, in part, to school desegregation and continued suburbanization.

Some 85-90 percent of the school bus fleet is composed of large vehicles, while the other 10-15 percent includes vehicles that carry less than 16 passengers (e.g., vans and station wagons). Further, approximately 60 percent of the fleet is owned by public-sector organizations, including school systems and the military. The remaining 40 percent is owned by private and parochial schools, private companies, and other organizations.

To date, successful demonstrations of the feasibility of using school buses in public transportation service have been conducted in Morehead, Kentucky; Newton and Boston, Massachusetts; Dade County, Florida; Arlington, Virginia; Klamath Falls, Oregon; Wilkes-Barre, Pennsylvania; and Rhode Island. School buses have been used to provide fixed-route, DAR, and subscription (prearranged group) service. Also, these demonstrations have focused on different populations, including the elderly, poor, children, and, in several cases, the general public.

It is notable that only one of these demonstrations (Dade County) involved changes in school hours due to a fuel shortage. Two other demonstrations (Boston and Wilkes-Barre) included changes in school hours as a result of natural disasters. None of the demonstrations mixed school children with adults.

Strategies and Obstacles

Studies investigating the potential for greater public use of school buses generally agree that such use is a good idea (10-13). What is more important is that several of these studies suggest that school buses could play a valuable role in energy conservation and in local responses to future energy emergencies. For example, school buses could be used for the following purposes:

1. To reduce headways or crowding on buses and rail vehicles on existing transit routes;
2. To create new transit routes in urban areas;
3. To provide feeder service to line-haul transit routes, either through DAR or fixed-route operations;
4. To provide park-and-ride service to major employment sites;
5. To ensure that necessary transportation services are provided to elderly, handicapped, and other disadvantaged persons; and
6. To provide community transit services that respond to the short-distance travel demands of persons traveling during off-peak hours.

Studies and service demonstrations undertaken thus far indicate, however, that there are significant obstacles to widespread use of school buses to transport the general public. In some cases, these obstacles overlap with those discussed in relation to intercity buses. They include fuel availability, regulatory requirements and prohibitions, cost and funding questions, school bus design problems, labor problems, and vehicle availability.

Fuel Availability

Under DOE's gasoline-allocation program (which is activated during shortages), school bus operators who have bulk storage facilities may receive 100 percent of the fuel that they used from November 1977 through October 1978. (Diesel-powered buses, on the other hand, are eligible for unlimited fuel supplies under DOE's Special Rule 9 of the allocation program. This issue, therefore, does not concern the operation of diesel-powered school buses.) If they require additional fuel, they must request it from state emergency set-asides or they must apply to DOE's Office of Hearings and Appeals (OHA) for an increased allotment. However, most operators have gotten fuel from state set-asides rather than OHA during past shortages.

Small school bus operators who do not have bulk storage facilities do not have guaranteed access to fuel supplies. They must compete at retail pumps or they must make arrangements to acquire fuel from other users of gasoline who have bulk storage and fuel priority under DOE's allocation program. Purchasing fuel at retail pumps is time-consuming and the availability of fuel may be uncertain. New arrangements with other bulk purchasers of gasoline may be difficult to make because of industry competition within localities.

In addition, school bus operators, like intercity bus operators, would be severely affected if DOE allowed its petroleum-allocation regulations to expire in September 1981. Failure to extend these regulations would result in sharp price increases when fuel is in short supply and would severely limit the capability of school bus operators to expand service or even continue their existing operations.

Regulatory Requirements and Prohibitions

State laws and regulations pertaining to school bus use vary considerably. Although nearly half the states allow school buses to be used for nonschool purposes, the other half either restricts such use to certain groups and segments of the populations (e.g., the elderly) or totally prohibits nonschool use.

Several states (e.g., Virginia, New Mexico, and Oregon) have already responded to this problem by passing laws that allow nonschool use during emergencies. On the other hand, there are at least a dozen states that do not have such laws and whose governors do not possess emergency powers to suspend existing laws and regulations. This problem, therefore, remains a serious one.

Most states, as well as the federal government, have other laws or regulations about the equipment that must be used in school bus operation. For example, school buses must operate flashing lights when they stop to pick up or drop off school children. These lights must be disconnected if the vehicles are operated in nonschool use. Such laws and regulations discourage use of school buses to transport the general public.

Franchising requirements at the federal, state, and local levels may slow the introduction of school buses into mass transportation service. Currently, the ICC, virtually all state PUCs, and most local licensing authorities do have emergency powers that enable them to authorize immediate introduction of new fixed-route transportation services in advance of normal (and lengthy) franchising processes. These agencies must determine, however, that a true emergency exists before they issue emergency operating rights (i.e., franchises) to operators. Without a severe fuel shortage, it is unclear if regulatory authorities will use their emergency powers to permit school bus operators to provide new transportation services for the general public.

Finally, there is some question as to whether DOT's Section 504 regulations would be applied to school buses in public service supported with federal funds during a fuel shortage. If these regulations were applied, the fact that school buses are generally not accessible to the handicapped might prove to be a significant barrier to expanded school bus operations.

Costing and Funding

It will not be inexpensive to operate school buses for the transportation of persons other than school children. A 1978 study estimated these costs to range between $0.68 and

$1.78/vehicle-mile. However, in 1977, the average operating cost was $2.15/vehicle-mile for all transit modes (10).

Depending on the type of service in which school buses are used, fares may or may not be an appropriate method of fully funding vehicle operating costs. If, for example, school buses are used to provide park-and-ride express service from neighborhoods to major employment sites, fares could be set at a level that would fully cover operating costs. If, on the other hand, school buses are used to supplement existing transit vehicles on main-line routes, it seems likely that fares would have to be set at the usual below-break-even level. Additional operating subsidies, therefore, would be required.

School Bus Design Problems

Most school buses are designed for school children and for school-related service; they are not designed to transport adults. Standard school buses have low ceilings, small seats, little knee room, no hand rails for standees, narrow aisles, a single door in the front, and high steps. Some of these problems, in fact, are the result of federal regulations (e.g., the distance between seats and the size of the seats). Further, standard school buses are light-duty vehicles that are not built for transit service. Extensive use of these vehicles in line-haul transit operations would probably lead to substantial maintenance problems, more rapid deterioration of the national school bus fleet, and a need for capital dollars to replace vehicles that wear out because of expanded operations.

It should be noted that there is an alternative to the standard school bus. Several companies are now manufacturing a type of heavy-duty school bus that is quite durable and appropriate for nonschool use; it is also somewhat more expensive than a standard school bus. Relatively few of these vehicles are in service at this time.

Labor Problems

Section 13c agreements are likely to pose a significant obstacle to the use of school buses in mass transportation service, just as they will to the use of intercity buses. Without union approval, it may be impossible for most transit authorities to contract for use of school bus vehicles and drivers. Even if transit authorities do win the right to contract for such services, it may be required that 13c protection be extended to the employees of the contractor as part of such agreements. Negotiations over agreements could take months, with the desired services not provided in the meantime.

Vehicle Availability

The availability of school buses is a major issue standing in the way of general public use of these vehicles. During the school year, the morning peak period for school transportation closely resembles the morning peak period of transit demand in most cities. Conflict between school transportation demand and transit demand is only slightly reduced during afternoon hours.

Evidence of these problems was obtained in Illinois and Virginia, where it was found that, depending on the county studied, between 75 and 95 percent of the school bus fleet was in use during the morning and afternoon travel periods (generally 6:00-9:00 a.m. and 3:00-6:00 p.m.). About 20-30 percent of the fleet was being operated between 9:00 a.m. and 2:00 p.m. In addition, a changing percentage of the school fleet was unavailable during morning, midday, evening, and weekend hours because of maintenance work, legally mandated bus inspections, and extracurricular school activities (11).

School bus hours, then, present a major problem during the school year. School hours may need to be changed or shortened in many areas if it becomes necessary in an energy emergency to make school buses available for supplementary peak-period transit services. Continuing increases in the number of working mothers, however, may act as a powerful counterforce to school-hour changes (due to disruptions in work schedules that would result if children were to be home at different hours), unless a fuel shortage is judged severe. Therefore, in lesser-shortfall situations, it may be feasible to consider using school buses only for off-peak services. Fuel shortages during the summer months may pose less of a problem in terms of vehicle availability than shortages during the school year, provided sufficient preplanning is done and mechanisms are in place to allow rapid deployment of such vehicles.

EXPANSION OF DAR, SRT, AND JITNEY SERVICES

DAR, SRT, and jitney services are considered together because they fall within the hail-or-phone category defined by Kirby (2). They are not strictly fixed-route, fixed-schedule services but are at least somewhat demand responsive, thus providing a degree of service somewhat more personalized than traditional transit services using large vehicles.

DAR refers to the wide range of demand-responsive services that are generally provided by public agencies (usually transit authorities) and private nonprofit organizations with vans and small buses. SRT operations frequently provide the same services but are generally controlled by private taxi companies that operate regular passenger sedans, often under the direction of a public agency. In a real sense, DAR and SRT services frequently are very similar, differing only in their ownership and vehicle types.

A variety of demand-responsive services can be and has been provided by DAR and SRT operators. These services include (a) basic DAR service, (b) feeder to fixed-route bus service, (c) fixed-route bus replacement service, and (d) subscription service. These services may operate on an immediate- or advance-request basis or may serve only particular trip purposes or destinations.

As part of a recent DOT-sponsored study, Systan, Inc., verified the existence of 308 U.S. DAR and SRT services. Systan also produced the following inventory of U.S. paratransit systems (14), which distinguishes between DAR and SRT services on the basis of service type and market, i.e., the availability of the services to the general public (general market) or only special user groups, such as the elderly and handicapped (target market).

	Market			
Service	General	Target	Unclassified	Total
DAR	74	135		209
SRT	42	27		69
Integrated	3	-		3
Mixed (DAR and SRT)	1	5		6
Unclassified	2	11	8	21
Total	122	178	8	308

The above table does not include DAR and SRT services that are provided only to the clients of human service agencies. There are at least 200 of these services in the United States. Given that there are 969 transit systems in the United States, it is clear that DAR and SRT services have not achieved broad distribution throughout the United States. They appear primarily in small cities, many of which do not have other mass transit systems. Moreover, Michigan and California claim 147 of the 308 DAR and SRT systems identified by Systan. No aggregate data exist regarding the total number of vehicles used in DAR and SRT services. The Systan study, however, indicated that the median number of vehicles in DAR and SRT operations is about 5. Given this median number, there are probably at least a few thousand vehicles providing DAR and SRT service in the United States. This number is minuscule

compared to the number of taxis (193 000), transit buses (52 900), and intercity buses (20 200) currently operating in this country, according to the American Public Transit Association and others (3, 15).

Although DAR and SRT services exist only to a limited extent in the United States, these operations seem quite substantial when compared to the distribution of jitney services. To date, there are only nine legal and formally organized jitney services in the United States. The two oldest legal jitney services operate in Atlantic City and San Francisco. Illegal but operative jitney services exist in four other cities.

Jitney services are available for use by all members of the general public. They usually operate hail- or flag-stop service along fixed or semifixed routes with vans or passenger sedans. Individual ownership and operation of vehicles are the norms rather than the exceptions. Fixed schedules are rare.

DAR, SRT, and jitney services generally are regulated at the local level by public service commissions. (Some DAR and SRT services are not regulated by such commissions. Instead, the local transit authority determines the operating characteristics of the service.) These commissions set fares and determine vehicle and service characteristics. In the case of some jitney services, the local commissions also set vehicle routes. Finally, because they control entry into the market, these commissions have also been largely responsible for the lack of growth of DAR, SRT, and jitney services. Faced with strong opposition from existing transportation providers (and, quite often, their labor unions), the commissions historically have acquiesced and voted to maintain the status quo (i.e., premium-ride taxi service only).

Recent developments indicate that the situation may be changing. Section 505 of the Surface Transportation Assistance Act provides that a taxi company may receive a 100 percent rebate of its gasoline and other fuel taxes if the company is not prohibited from furnishing (with consent of the passengers) shared transportation. This development may stimulate local operators to push for regulatory changes that will permit them to offer SRT service. Further, in November 1979, the International Taxicab Association (ITA) announced its endorsement of SRT service and stated its support for expansion of these services. In addition, several cities—notably San Diego and Seattle—have recently (a) eliminated barriers to market entry by new operators, (b) allowed competitive pricing to determine fares, and/or (c) eliminated regulations prohibiting the introduction of both SRT and jitney operations. Finally, increasing federal interest in these services is indicated by DOT's funding of 17 SRT and DAR demonstration projects and a study of an extant jitney service during the past seven years.

Five other factors argue that public- and private-sector interest in DAR, SRT, and jitney services may increase substantially during the next several years. First, rapid inflation and sharply rising fuel prices should stimulate taxi operators to seek new means of maximizing their revenues. SRT and jitney services may be perceived as a way of gaining more passengers (and more revenue) while operators use the same amount of fuel. Second, government decision makers at the federal, state, and local levels may perceive that the broad expansion of DAR, SRT, and jitney services could discourage second-car purchases by the public, thereby assisting the long-term goal of energy conservation. Third, the probability that the United States will experience repeated fuel shortages during the next decade may stimulate local governments and regulatory authorities to explore alternative methods of retaining personal mobility during these shortages. DAR, SRT, and jitney services can assist in accomplishing this goal. Fourth, transit authorities may view SRT and jitney services as a means of reducing crush loading on their vehicles, which results from a fuel shortage. Finally, public demands for more public transportation services during a shortage may force decision makers (i.e., regulatory authorities) to encourage the introduction of shared-ride operations by reducing or eliminating regulatory obstacles.

Strategies

Several kinds of shared-ride services might be introduced in response to the need for energy conservation and local preparedness for future fuel shortages. These services include the following:

1. Simple dial-a-ride or SRT service for the general public;
2. DAR or SRT service with open market entry for the general public;
3. DAR or SRT service for elderly, handicapped, poor persons, and the clients of human service agencies;
4. Feeder service to mass transit routes and stations;
5. Supplemental service along existing transit routes;
6. Replacement service on existing transit routes; and
7. New fixed-route or semifixed-route service (particularly local operations that serve travel needs within a community).

Depending on local circumstances and needs, the last four services noted above might be permitted under a system of open market entry to keep fare levels low and the amount of service high.

A simple conversion of premium-ride taxi services to shared-ride services could have an important impact by increasing the number of passenger trips per hour that an individual taxi could make. SRT service would also help to minimize deadheading by taxis. (High demand may necessitate the use of vans or minibuses. In this event, SRT operations would become DAR services.) If DAR or SRT service was combined with a temporary or permanent suspension of market-entry restrictions, even greater amounts of service could be provided. Existing companies and new private entrepreneurs could offer as much demand-responsive, shared-ride service as they wished in order that all citizens could have access to local transportation services.

DAR or SRT service for particular segments of the population could be an invaluable means of maintaining the mobility of certain persons (e.g., the elderly, handicapped, poor, and clients of human service agencies). It is quite conceivable that these persons will have difficulty in using mass transit during a fuel shortage due to heavy crowding, while taxi services may suddenly become very popular with upper-income persons because of the unavailability of gasoline. DAR and SRT services that are reserved for certain persons could respond to these problems. (It should be noted here that the majority of existing DAR and SRT services is reserved for special populations such as the elderly and handicapped.)

Feeder services to mass transit routes and stations could increase public access to transit. Through fixed-route, semifixed-route, or DAR operations, taxi companies, new entrepreneurs, or public-agency-sponsored services could link up neighborhoods and suburban areas with main-line transit routes, thereby relieving congestion at transit stations and making transit available to persons (such as the handicapped) who cannot walk, bicycle, or drive to transit stops. St. Bernard's Parish in Louisiana, for example, has had a taxi-based feeder system in operation since 1974 and has seen ridership climb from 75 trips/month to more than 1000 trips/month (16).

Supplemental service along existing transit routes (by using a jitney-type operation) could help to relieve the problem of overloaded transit vehicles during peak hours. Such a service has been successfully provided along San Francisco's Mission Street for many years (17).

Replacement service (e.g., at night, in areas of low population density, or at the outer ends of transit routes) could free transit vehicles for use on other routes and could increase the availability of transit vehicles for needed maintenance work. Evidence of the effectiveness of this

practice can be seen in the Trans-Cab operation in Ontario. In this case, replacement of fixed-route bus service with taxi service led to a tripling of ridership and a 75 percent reduction in the operating deficit for the operation (16).

Finally, taxis, vans, minibuses, and other vehicles could be used to inaugurate new fixed or semifixed routes within localities. Vehicles operating along these routes could operate with hail-or-phone stops or could have regular routes and schedules. Westport, Connecticut, has been perhaps the most successful example of this kind of service. The Westport operation serves many travel needs within the community, including shopping trips, after-school activity transportation, commuter service to a nearby rail station, and the like. Other communities could reduce local energy consumption by replicating the Westport system.

Obstacles

While all of the above services may be useful for energy conservation and may serve as a response to energy emergencies, there is a variety of barriers that will affect the implementation of these services. These barriers include problems similar to those affecting the service types discussed earlier: (a) fuel availability, (b) legal regulatory issues, (c) funding and fare questions, (d) labor problems, (e) vehicle supply, (f) operational issues, and (g) public information and marketing needs.

Fuel Availability

Small taxi operators and other passenger transportation providers (including private entrepreneurs who use their own vehicles) who do not have bulk storage facilities do not have guaranteed access to fuel supplies. Under DOE's allocation program, they must compete at retail pumps for fuel or, if they are defined by DOE as priority users, they can make arrangements to acquire fuel from other users of gasoline who have bulk storage and fuel priority under DOE's allocation program. Purchasing fuel at retail pumps is time consuming and the availability of fuel may be uncertain. New arrangements with other bulk purchasers of gasoline may be difficult to arrange because of additional paperwork requirements and business competition at the local level.

In addition, operators of taxis, jitneys, and other such services who are bulk purchasers of fuel, like the service providers discussed earlier, would be severely affected by a DOE decision to allow the petroleum-allocation regulations to expire in September 1981.

Legal and Regulatory Issues

Local commission prohibitions on shared-ride service would have to be altered to permit or require shared-ride operations of the types described above. In addition, these commissions would have to authorize jitney-type operations to facilitate feeder service or supplemental service along fixed routes. In areas that have mass transit services, the local transit authority would probably have to provide authorization for supplemental service or new fixed routes that would be operated by private entrepreneurs. Finally, several states would have to have new services (particularly of a fixed-route nature) approved by the state PUC.

A more general question concerns whether market entry and fares for taxi services should continue to be regulated at all. As noted above, several cities, including San Diego and Seattle, have made major moves toward deregulation of their taxi industries. The results of these changes are not yet clear. If productive new SRT and jitney services with reasonable fares eventually are established, it may be worthwhile for other localities to reconsider their regulation of the taxi industry.

Funding and Fare Questions

Fares for current DAR services range from zero to $2.00/trip, with a median fare of $0.50. SRT fares range from zero to $1.00/trip and also have a median fare of $0.50. Many DAR and SRT services, however, do receive public subsidies. In some cases, these subsidies are provided only to particular persons (e.g., in Danville, Illinois, the elderly and handicapped are subsidized) through user-side subsidies. In other places, such as Merced, California, users pay a flat fare, and a public agency absorbs the difference between fare revenues and the total cost of providing service (14).

Jitney fares generally vary with distance traveled. For short-distance trips, the fare for jitney service may not be much higher than the cost of using transit service. Over long distances, however, jitney fares usually exceed transit fares. No jitney services receive public subsidies at this time.

To promote ridership during both fuel shortages and times of normal energy supplies, localities that are starting new DAR, SRT, and jitney services may wish to provide public subsidies in order to keep fares as low as possible. Finding funding sources for such subsidies, however, will not be an easy task. DOT's Section 5 and Section 18 programs appear unable to support extensive funding of shared-ride operations. Moreover, these programs carry with them Section 13c labor requirements, which often prove to be major deterrents. State and local governments, in turn, are under steady pressure to reduce taxes. In short, localities will have to grapple with a difficult funding problem in order to subsidize shared-ride operations on other than an emergency basis.

Labor Problems

Existing 13c agreements, and the possible need to negotiate new such agreements to cover new services, have been discussed in earlier sections in connection with intercity bus and school bus operations. They pose as great an obstacle to the use of taxis, jitneys, and other demand-responsive services that might be supported in part by federal funds for all the same reasons.

Vehicle Supply

Existing public and private transportation companies may not have enough vehicles to operate new shared-ride services and may not be able to afford new vehicle purchases with only their own resources. Taxi companies tend to be particularly short of capital (as are many school bus and intercity bus companies). Federally funded transit authorities cannot purchase vehicles for DAR, SRT, or jitney operations without running afoul of Section 13c. Vehicle acquisition, therefore, is likely to be a serious problem. The only recourse of existing taxi companies and other potential providers of DAR, SRT, and jitney services may be to contract for service with private individuals who are willing to operate their own vehicles in shared-ride operations.

Operational Issues

A number of technical difficulties or questions are likely to require resolution in connection with emergency establishment and operation of jitneys, SRTs, and other demand-responsive services. Such potential difficulties include (a) communications, (b) shared-ride versus exclusive-ride taxis, and (c) equity toward the service population.

Several of the shared-ride services described above require dispatching to be successful. The acquisition and installation of radios in vehicles currently unequipped will require a substantial amount of time and money, both of which are likely to be scarce in an energy emergency.

It is unclear whether taxi patrons should be given the choice of shared-ride versus exclusive-ride service with differential fares in a fuel shortage, or whether portions of the taxi fleet should be designated for shared-ride service

only in such a situation. A decision on how the shared-ride option is presented and structured should be made in advance of any such shortage.

Elderly, handicapped, and poor persons, together with the clients of human service agencies, may be squeezed out of existing taxi services due to new demand for taxi services from wealthier persons who wish to abandon their cars. Wealthier persons will pay cash (an attractive alternative to taxi companies who usually bill human service agencies for client trips). Moreover, taxi drivers may expect higher tips and fewer robberies (or other personal crimes) if they focus their operations in upper-class neighborhoods. The result may be a concentration of taxi services in certain sections of metropolitan areas and a serious decline in the availability of taxis in other sections.

These and other operational issues will need to be dealt with by areas intending to focus on such services as significant elements of their response to a fuel shortage.

GENERAL ISSUES FOR CONSIDERATION

In addition to the specific issues related to various service types, a number of more general issues are likely to arise in connection with all of the above services, or indeed with only emergency transportation services initiated in response to a major fuel shortage. These issues are briefly discussed here.

Planning

In order to marshal any of these resources in time to be of use in a short-term emergency, it is essential that sufficient time and expertise be available to plan for such contingencies and negotiate with would-be service providers. Development of new intercity bus service, formal or informal demand-responsive services, or special services that use school bus equipment cannot be done overnight. Consequently, it is advisable that designations of planning responsibility be made as soon as possible within states and localities and that likely service possibilities requiring advance coordination begin to be identified.

Marketing and Public Information

In order for emergency services to be used most productively, it will be important that they be targeted toward particular markets and be accompanied by effective public information programs. The development of such programs likewise takes a significant amount of time and resources: establishing telephone information lines, publishing schedules, providing route or service area maps to aid would-be passengers, or simply educating people about the ways in which unfamiliar service types operate.

Funding

Both rural and urban areas that could conceivably benefit most from use of the above kinds of services in energy shortages are already severely constrained in terms of available capital, operating, and planning funds to meet already-identified needs. Additional funding geared specifically to energy contingency and conservation planning is urgently needed; beyond the planning phase, states and localities should continue to press for the establishment of a special reserve of funds—free, if possible, of Section 13c restraints—to be made available for the introduction of new auxiliary-paratransit services during fuel shortages.

Fuel

The availability of sufficient fuel to operate many of the service types discussed herein will become a critical issue if the petroleum-allocation regulations are terminated after September 1981. If termination occurs, the willingness to pay the market price will be the factor determining which users will obtain available gasoline. Such action will result in severe economic consequences for providers of the services discussed in this paper (as well as all other essential fuel users). Thus, it is in the interest of special-service providers and localities likely to be dependent on such services in an emergency to argue for an extension of the allocation regulations. If such an argument fails, other ideas for ensuring fuel supplies for auxiliary-paratransit services must be considered. Among them are, for example, making grants or low-interest loans to operators so that they can continue to purchase fuel in the face of sharply rising prices during a shortage and encouraging auxiliary-paratransit operators to construct and fill emergency fuel storage facilities when supplies are relatively unconstrained so that the contents can be drawn down during periods when a shortage forces the price up.

Labor

The single most important factor inhibiting the speedy introduction of any of the above services is Section 13c of the Urban Mass Transportation Act of 1964. The need to extend existing 13c agreements to cover paratransit or auxiliary services, or to negotiate new agreements where federal support is desired, is likely to deter many local authorities from initiating planning for such services. It may be possible to override such agreements for the sake of providing urgently needed public services if a fuel emergency is severe enough. In the absence of a dramatic threatening situation, however, it is unlikely that the impetus will exist to suspend 13c. Consequently, it may not be possible to use Section 5 or Section 18 funds channeled through transit authorities to support such services. Funding obtained from other federal programs that support transportation activities may be a partial solution. Such funds, however, usually place restrictions on who may use the services provided. Alternatively, it might be appropriate for DOT to consider the possibility of asking the U.S. Congress for a special operating assistance appropriation that would be free of 13c obligations and that would be held aside for use during fuel shortages, possibly with additional support from other federal agencies.

RECOMMENDATIONS

Rental-Lease Vehicles

None of the ideas described in the rental-lease vehicle section have been explored in any depth as yet. However, as stated earlier, some level of interest has been perceived within the industry to pursue at least some of these options. Clearly, opportunities do exist for expanding the role of rental-lease vehicles in local energy conservation and contingency programs. Questions that need to be explored in pursuing these opportunities include the following:

1. The extent to which private businesses and government agencies already lease vans for vanpooling,
2. The degree to which lessees are exercising the lease-purchase option,
3. The potential market for vanpooling through vehicle leases by employers,
4. The need for and cost of marketing programs to convince employers to lease vans for vanpooling,
5. The feasibility of the van- and car-lease concept,
6. The interest of rental-lease agencies in simultaneously marketing a wide range of high-occupancy-vehicle programs to employers,
7. The relative operating costs and administrative requirements involved in using rental-lease vehicles instead of taxis and/or school buses for local public transportation services in rural areas; and
8. The interest of states in any or all of the programs described herein.

Intercity Buses

Section 13c requirements and limited vehicle availability are the most serious obstacles to expansion of intercity bus services. These constraints, together with the currently depressed state of the intercity bus industry, argue that the first priority should be to increase the load factors on existing routes. Average load factors were 45 percent in 1978. The industry has argued that these load factors could be increased to between 61 and 70 percent with no change in services. Moreover, an industry report claims that an increase to 65 percent would reduce the nation's fuel consumption by 1.4 million bbl/year (7).

Obviously, these load factors may be impossible to achieve in every intercity bus operation. The industry's estimates of fuel saving, therefore, may be overstated. These estimates do indicate, however, that there is enormous potential for expanded ridership without the introduction of new services.

As a second priority, public agencies should cooperate with elements of the private sector in the planning of new services that will be needed in the event of future fuel shortages. To the extent that buses are available (and are not needed for charter services), park-and-ride or commuter express services sponsored by the private sector and fixed-route operations sponsored by recreation areas may be the best use of available vehicles.

After the preceding options have been explored, contingency planners should examine the need for publicly sponsored intercity bus services. If intercity buses are needed to provide new fixed-route services in areas that are served by federally funded transit systems, local government bodies should contract for and/or administer these services. Through this process, conflicts with transit labor unions can be kept to a minimum. Federal funds, however, will not be available to support these services unless local 13c agreements are revised or federal 13c requirements are changed.

To the extent that public funds are used to support new or expanded intercity bus services, user-side subsidies may be the most appropriate means of providing this support. User-side subsidies can help to minimize costs to the public sector because, unlike producer-side subsidies, user-side subsidies do not obligate the subsidy provider to absorb whatever level of deficit an operator incurs in service. Instead, subsidy is paid on a per-trip basis (sometimes only for trips by particular persons, such as the poor or the elderly), and the operator is encouraged to seek riders who are eligible for subsidy payments. User-side subsidies also permit experimentation. Instead of locking government into long-term relations with operators and their labor forces, user-side subsidies can be instituted and withdrawn with relative ease. This flexibility may be invaluable if localities want to provide subsidies during shortages and not as an ongoing energy conservation incentive.

School Buses

The most intractable obstacles to expanded school bus use are

1. Section 13c requirements that will prevent federally funded transit authorities from contracting for service with school bus operators,
2. A lack of public money to pay for the operating costs of school buses,
3. The unavailability of large numbers of school buses during the hours when they are needed most (assuming, of course, that school hours are not changed), and
4. Vehicle design problems.

If these problems are not remedied, school buses will be able to play only a limited role in providing transportation to the general public. It is true, however, that school buses may be the only public transportation resource that is available in many communities (particularly in rural areas). School bus operators also represent a considerable reservoir of private-sector expertise in transportation operations. This expertise should be tapped as much as possible.

In metropolitan areas, the few school buses that are available when school is in session might best be used in park-and-ride express services during peak hours. (Employer adoption of variable-work-hour programs could expand the usefulness of school buses in providing park-and-ride service after these vehicles complete their school transportation routes.) Such services could be financially self-supporting, although subsidies from local and state governments and from employers would be beneficial to keep fares as low as possible in order to attract riders. Employers or local governments could assume responsibility for the administration of these services, thereby eliminating potential conflicts with transit labor unions. Park-and-ride services would have few operating difficulties (except for a lack of fare boxes) because vehicles would not be continually boarding and discharging passengers. Vehicle deterioration would be kept to a minimum.

School buses could also provide feeder services from outside the boundaries of transit authorities to the ends of transit routes. Community transit service within transit authority districts and suburban areas could serve populations that currently have no access to transit service (e.g., school children, the elderly, and parents who need to travel short distances for shopping, health, or work-related reasons). In both cases, however, school bus service for the public would have to be administered by local governments rather than the transit authority in order to eliminate labor problems. Further, federal funds could not be used to support these services. Local and state funds could be used, however. Problems with the operation of school buses in community transit services might be significant due to simultaneous loading and unloading of passengers. Because large numbers of school buses will not be available during peak hours, these services might be best provided during midday hours and evenings.

Currently, few rural areas have transit systems or receive federal funds for public transportation. In most rural areas, therefore, problems with Section 13c will not prevent the implementation of school bus services for the general public. (The exception to this argument will be rural areas that receive Section 18 funds. These areas must provide 13c protections to local employees of public transportation services.)

Because school hours are unlikely to be changed except in the event of a severe shortage, general public use of school buses may be possible only during midday or evening hours. Services that might be provided include DAR operations and subscription services to regional employment sites and health centers (although taxis and vans, if available, might provide this service less expensively and more efficiently in low-density areas). In all probability, however, some amount of subsidy from state and/or local governments will be needed to finance these operations.

DAR, SRT, and Jitney Services

The presence of a fuel shortage may not provide any impetus to change existing 13c agreements. If this is the case, the following actions may be most desirable and most feasible:

1. Conversion of existing premium-ride taxi services to shared-ride operations, with or without open market entry—Such action would require only that local fare structures for taxi service be altered.
2. Alteration of local and/or state regulations to permit private companies to introduce jitney services where these operations would not compete with existing transit operations—Jitney services might act as feeders to existing transit routes or they might serve wholly new geographical areas and/or trip purposes.
3. State and local government subsidization of new DAR, SRT, and jitney services—These services probably would

have to be administered by a local government agency other than the transit authority in order to avoid conflicts with 13c constraints. Under these arrangements, localities could stimulate the development of all types of DAR, SRT, and jitney services except those that compete with the services of a transit authority. User-side subsidies might be the most cost-effective and flexible means of providing public-sector financial support for new services.

4. Concentration of new service development on segments of the population that will be most affected by a fuel shortage (i.e., elderly, handicapped, poor persons, and clients of human service agencies).

REFERENCES

1. Motor Vehicle Facts and Figures. Motor Vehicle Manufacturers Association, Washington, DC, 1978.
2. R. Kirby and others. Paratransit: Neglected Options for Urban Mobility. Urban Institute, Washington, DC, 1974.
3. America's Most Fuel-Efficient Passenger Transportation Service. American Bus Association, Washington, DC, 1979.
4. The Intercity Bus Industry: A Preliminary Study. U.S. Interstate Commerce Commission, 1978.
5. 1973 Census of Transportation. U.S. Bureau of the Census, 1973.
6. Energy. 10 Code of Federal Registers, Parts 200 to 499. U.S. Government Printing Office, 1980, pp. 149-150.
7. Energy—Domestic Passenger Transport Modes: Facts and Opinions. American Bus Association, Washington, DC, 1979.
8. Transit Fact Book—1978. American Public Transit Association, Washington, DC, 1978.
9. Transportation Energy Conservation Data Book. Oak Ridge National Laboratory, Oak Ridge, TN, 1979.
10. The Use of School Buses for Public Transportation. North Central Texas Council of Governments, Arlington, 1978.
11. The School Bus: A Transportation Resource for Northern Illinois. W.C. Gilman and Company, 1975.
12. Feasibility Study: School Bus Utilization for Non-Pupil Transportation Programs. Wilbur Smith and Associates, New Haven, CT, 1974.
13. L. Harris. The Use of School Buses During an Emergency. Federal Highway Administration, 1979.
14. Paratransit Handbook: A Guide to Paratransit System Implementation, Volume 1. Systan, Inc., Los Altos, CA, 1979.
15. Control Data Corporation; Wells Research Company. Taxi Operating Characteristics. U.S. Department of Transportation, March 1977.
16. The Feasibility of Late Evening Taxi-Transit Coordination. Multisystems, Inc., Cambridge, MA, 1979.
17. Interplan Corporation. The Potential for Flexicab Services: Innovative Uses of Taxis and Jitneys for Public Transportation. U.S. Department of Transportation, 1975.

Energy Contingency Planning for the U.S. School Transportation Industry, 1979-1980

National School Transportation Association Energy Committee

Barring some unforeseen solution to the world's current energy situation, such as the discovery of vast fossil-fuel deposits or the development of a cheap synthetic energy source, it appears clear that the United States will have to modify its transportation systems. A primary factor in such modification will be the sharply curtailed use of and dependence on the private automobile.

Based on the best information available today, the world's energy picture presents a problem of a very long-lasting nature. Whether the United States will adapt to this situation voluntarily or involuntarily remains to be seen, but it seems indisputable that implementing energy-conservation measures and maximizing the use of available transportation modalities are inevitable steps.

As the nation adjusts to these new transportation circumstances, it will be necessary for each locality to provide for the mobility of its citizens. The development of energy contingency plans is an essential first step in this direction.

The first obligation of the school transportation industry is the safe transportation of children to and from school and school activities. But, due to the shortage of fuel, school buses will be necessary for broader community service.

It is imperative to realize that planning for future transportation needs cannot be addressed in a compartmentalized fashion. It is assumed at the outset that comprehensive solutions—the only sort acceptable for such a pervasive problem—must involve many elements of society in general and the transportation community in particular. Therefore, only an approach that integrates all transportation providers can deal adequately with the problem.

ENERGY CONTINGENCY PLANS

Energy contingency plans are designed to prepare for both immediate and long-range dependence on multipassenger vehicles, which should result in an overall petroleum saving. Most often, energy contingency planning addresses the need to increase the capacity of local bus transportation systems. At the same time, it prescribes methods of apportioning travel demand in a more uniform way and over a longer time period and encourages greater acceptance and use of taxis, vans, and informal multipassenger travel modes.

The chief elements in such planning are the process and the end product. The process describes the way in which plans are developed, identifies the participants, and assigns responsibilities. The product is a list of actions to be implemented. Moreover, energy contingency plans are generally keyed to levels of crisis and suggest which actions are most appropriate at given levels of fuel shortage.

In developing this document, the National School Transportation Association recognized that, although most communities have no transit systems and many have no rail or intercity bus systems, virtually all have school transportation systems. The existence of such systems means that school buses are available for use. Therefore, faced with increasingly scarce and expensive fuel, energy contingency planning that takes the presence of these vehicles into account can assure the community of the continued mobility of its population in order to maintain public welfare, support economic vitality, deliver public services, maintain the quality of life, and be prepared for emergencies.

The school bus operator may find that energy contingency planning presents additional opportunities. The curtailment of private automobile travel, whether as a matter of personal choice, economic necessity, or

government intervention, is likely to result in an increased demand for public transportation. This situation will provide the transit operator with a means to market the convenience of bus services to new passengers. It is probable that this will lead to the retention of that new ridership, if or when conditions ease.

Contingency planning can be expected to relieve the stress on the public of a crisis mentality and help to build support for bus service among local officials and citizens. Should such support materialize, there would be a residual opportunity for continued use of school transportation vehicles in an ancillary capacity to other transit systems long after the crisis—of whatever degree and duration—has waned. This would also bring the adult, nonschool population into immediate contact with the school transportation industry—a contact that would provide the opportunity to make the public aware of the skills of school bus operators and the safety, design, and maintenance of school buses.

As suggested above, energy contingency planning may become the cornerstone of an integrated transportation management system that links urban development and air quality into one comprehensive local transportation response.

ROLE OF THE BUS OPERATOR

For bus operators, three categories of action are important. First, through the redeployment of resources and revisions in traditional concepts about the school bus enterprise, there are those actions that can be planned and implemented by the operator without outside assistance. Second, there are actions that involve the cooperation of other agencies. The third category includes actions, such as parking bans, staggered work hours, and governmental intervention, that do not directly involve the bus operator but will have an important impact on operations.

Energy contingency planning challenges the local community to adjust its transportation components so that the entire system performs at its maximum level of efficiency. This goal also challenges transportation providers to see themselves as parts of a total transportation team rather than isolated systems operating in a vacuum.

Consistent with this goal and the need for cooperation, bus operators may find themselves taking on several or all of the following specific task-oriented roles.

1. The bus operator is a service provider, managing the network to accommodate increased demand and attempting to attract those who travel on less-fuel-efficient modes. The school bus operator provides a specific transportation service. However, the operator—as a transportation professional--must also provide expertise and nonschool transportation services to enhance economic growth and to aid the community during periods of special need.
2. The bus operator needs to be a fuel conserver. A fuel-management plan is essential to maximum fuel economy standards and must deal with storage and supply issues.
3. In some cases, the bus operator may be a service coordinator, linking conventional school bus operations with those of other service providers in the area.
4. The bus operator has taken, and must continue to take, the responsibility of a planning catalyst. In this role, the operator alerts public agencies, other transportation providers, the local business community, and the general public to the seriousness of the local energy situation and suggests ways of coping with it.

ORIGINATING THE LOCAL PLAN

In 1973-1974, the country was shocked by the so-called oil crisis. After decades of apparently abundant fuel at what now are viewed as unrealistically low prices, most cities were unprepared to deal with the sudden and dramatic demand for mass transportation services in the wake of soaring fuel prices. The oil embargo also was turning people away from the private automobile.

Based on that experience, many localities developed contingency plans for dealing with future supply and price problems. In many cases, those plans, which probably surfaced in the 1975 period, were updated in 1979. Should a community have no contingency plan, or one that has not been reevaluated for several years, it is time to originate such a plan or modify an existing one. The school bus operator should take a leading role in this process.

Chief elements of a local energy plan ought to include the following:

1. Analysis of current local energy situations and provisions for the continued monitoring of supply levels, storage provisions, and related factors;
2. Analysis of existing services, vehicles, and ridership, as well as factors affecting ridership;
3. Analysis of current capacity of all available fleets of multipassenger vehicles;
4. Projections of demand for transportation services that take into account both the magnitude of the demand and the location of such demand at various levels of a petroleum shortage (e.g., seasonal demand changes such as school vacations, holidays, and summer school closings);
5. Analysis of actions that may be taken to increase capacity, both with and without new capital investment;
6. Recommendation of operational actions to increase service;
7. Financial analysis of actions and newly proposed program changes;
8. Recommendation of support actions that involve personnel, planning, public information, marketing, and the interface of private and public entities;
9. Analysis of actions along a time line—those to be taken at once, those of an intermediate nature, and those that are long term;
10. Plan for fuel management that includes conservation measures within existing and projected operations, as well as provisions for additional fuel procurement and storage;
11. Analysis of actions that require public cooperation, such as staggered work hours, high-occupancy-vehicle lanes, ridesharing, vanpooling, park-and-ride lots, and prohibitions on students driving to school;
12. Implementation strategy that includes the designation of responsibilities for and timing of actions; and
13. Identification and procurement of funding needs and sources.

COMMUNITY ROLE IN PREPARING AND IMPLEMENTING THE PLAN

In a great majority of communities, the school bus operator or local transit operator working with the local MPO has been responsible for developing energy contingency plans. Routinely, the MPO has provided information by collecting and analyzing statistics for the operator. Local government and the business community have acted as consultants by offering comments and suggestions on the feasibility of various travel alternatives. By using this information, transit administrators and operators have been responsible for implementing transit improvements. Because most plans are heavily transit oriented, this puts the operator in the position of being a major resource. In those communities with no transit system, however, the school bus operator may also be the primary service provider. This situation means a new look must be taken at school bus use. The school bus operator must take the initiative in making the necessary contacts with and providing intelligent data to the proper local and state governmental bodies.

The role of local government varies from cities where it has the major responsibility of assuring that most phases of the transportation planning are carried out to other communities where policy guidance is the sole function of government related to energy planning. Local governments

are also being called on by transit systems to support, coordinate, and accelerate transportation system management actions that are consistent with the regional plan and to seek and provide funding opportunities.

In general, the private sector has been asked by transit operators, local government, and planning agencies to facilitate carpooling and variable work hours among its employees and to provide transit service information. Just as this means a broader service and use for many school vehicles, it also requires that a wider range of governmental and community groups be involved in the planning process.

SCHOOL BUS OPERATOR ACTIONS

Plans routinely call for various classes of actions. One category sets forth those efforts that can be achieved by the bus operator with little or no outside assistance. The most common are summarized here.

Operations and Scheduling

1. Increase the number of buses available by retaining vehicles that are replaced by new purchases.
2. Rehabilitate older vehicle where feasible.
3. Set up emergency vehicle-use agreements with other operators (e.g., school buses, charter services, transit operations, and intercity and private commuter services).
4. Monitor daily demand to ensure that resources are allocated to be most effective.
5. Increase purchase and use of larger-capacity buses.
6. Initiate line-haul feeder services with other publicly sponsored services.
7. Develop reverse-commute runs in cooperation with isolated employers.
8. Develop park-and-ride or express services, possibly by using high school parking lots so that, as students are brought to school, workers are picked up for transport to employment sites.

Maintenance

1. Plan for increased employee training and the addition of new mechanics.
2. Contract for the loan of maintenance personnel from other vehicle operators.
3. Reschedule routine maintenance to nonpeak hours, which might require more than one maintenance shift or split shifts.
4. Recognize that increased service requires increased maintenance.

Personnel

1. Provide for emergency expansion of personnel (e.g., drivers, mechanics, dispatchers, and supervisors).
2. Maintain a list of satisfactory former drivers and mechanics for possible temporary reemployment.
3. Increase personnel recruitment, selection, and training.
4. Investigate ways to bring bus drivers, mechanics, and other employees to work, such as a special bus run for employees, during an extreme gasoline shortage.

Facilities

1. Determine current bus storage capacity and where additional space exists.
2. Accelerate programming of new buses and fuel storage facilities.
3. Establish alternative arrangements for midday parking of buses to avoid extra deadhead miles.

Fuel Management

1. Lease additional fuel storage space, such as vacant service stations, and bulk tanks on farms and in-city locations.
2. Develop a list of operating actions to reduce fuel use.
3. Purchase bulk amounts of fuel on the open market as well as from regular suppliers.

Customer Information and Marketing

1. Develop a telephone information staff.
2. Develop and share information on other ridesharing and paratransit services with providers.
3. If the bus services are subject to changes, develop means of communicating with passengers via brochures, radio, television, newspapers, newsletters, and bulletins.

Planning

1. Determine where additional bus requirements will most likely occur during crises of varying severity and duration.
2. Identify appropriate park-and-ride locations that should include those to be used on a temporary emergency basis, as well as those to be used on a permanent basis such as schools, shopping centers, municipal parking lots, and post-secondary school campuses.

LOCAL GOVERNMENTAL ACTIONS

The following kinds of actions have been identified as appropriate to the roles of local government.

1. Develop an overall energy plan for the municipality and region.
2. Mandate variable work hours for public employees.
3. Request (or where the power to do so exists, mandate) private employers to institute variable-work-hour programs and to encourage their employees to use buses and other multipassenger vehicles.
4. Develop emergency coordination networks among public agencies and private transportation providers to share supplies, vehicles, fuel, and personnel.
5. Expedite the implementation of the local transportation system management element, with special attention to the provision of preferential treatment for high-occupancy vehicles.
6. Assist in the development of additional park-and-ride locations.
7. Establish emergency transportation information centers and simplify the exchange of ridesharing information and the use of referral systems.

STATE AND FEDERAL ROLES

It is imperative that government at the state and federal levels advise and support appropriate aspects of the local energy contingency plan and planning efforts. Most plans will assume state and federal financial assistance. In addition, state and federal employers are expected to implement variable work schedules as well as to encourage the use of bus and ridesharing transportation modes.

The following are specific requests that can be made of appropriate state and federal agencies.

1. State departments of education and school boards should allow or approve added school bus use.
2. Such levels of government should develop an emergency procedure to marshal all publicly and privately owned transportation services during a crisis.
3. Appropriate agencies should establish contacts with fuel suppliers to ensure that adequate amounts of product are refined and available to the whole system.
4. DOE should assure bus operators that they will have the highest priority for diesel fuel and gasoline allocation.

ROLE OF LOCAL BUSINESS

In general, the local business community is asked to cooperate by setting up variable work-hour schedules, disseminating information about bus services, encouraging their use, and facilitating the formation of ridesharing arrangements. Where feasible, business enterprises with large parking areas are asked to dedicate a portion of such space for park-and-ride use.

Depending on the resources and technology available to the school bus operator, transit operator, or local government, certain businesses—especially those of a highly technological type—may provide commuter services to maximize efficiency in coordinating the overall transportation system in return for the obvious public relations value. These operators may also provide planning and administrative personnel to assist in the design and execution of the plan. Moreover, business and industry may be sources of additional funding.

ROLE OF LABOR

Where labor unions for school employees, workers, or drivers exist, energy contingency plans need to address labor issues that call for additional personnel. Constraints imposed by labor contracts and work rules incompatible with aspects of an energy contingency plan must be changed through consultation with involved unions. The importance of being able to hire part-time and contract personnel must be negotiated and resolved in advance with the appropriate unions.

ROLE OF LOCAL PLANNERS

If the community has adopted a plan that does not currently involve the local school bus operator, this should be remedied. If no plan exists, one should be devised by the various responsible participants, especially in order to secure funding and fuel. It may be necessary for the school bus operator to encourage the formation of such a group with the support of the local governmental structure that encompasses all transportation modes. In any event, it seems clear that there can be no realistic, comprehensive transportation policy that does not involve the school bus operator as one of the primary planners and providers of services.

OTHER CONSIDERATIONS

As with any business transaction, funding arrangements to implement local energy contingency plans will vary widely. Although many cities, counties, and states have crisis contingency funds, the local contingency planning committee will need to know the sources of money other than from bus fares.

Some identifiable sources of financial assistance include the following:

1. Transportation funds budgeted by the city, county, and state;
2. City, county, or state contingency funds;
3. Factory or agency-contracted rates of subsidies;
4. Passenger fares;
5. Revenue-sharing, welfare, social security, and other federal transportation funds for which the agency that contracts for bus service applies; and
6. UMTA funds.

If school buses are used for other purposes between the hours of 10:00 a.m. and 2:00 p.m., after school, and on weekends, then school officials need to know these schedules so that they can plan activities and athletic trips in advance. Businesses can have more flexible shopping times if needed, and community events can be planned within workable timetables. All of these ideas are to allow the same bus to make the maximum number of trips daily that are reasonable and needed in the community. Special-education vehicles can be used by adult, as well as school, passengers through flexible scheduling.

Any vehicle that can carry many people to similar destinations or the same destination will save fuel. Deadheading and empty runs must be recognized as contrary to the goal of energy conservation.

IMPLEMENTING THE CONTINGENCY PLAN

Each area should determine its own needs and shortfall problems and be ready to act when the shortage is at the 15 or 20 percent level. This means that the groundwork with local suppliers, schools, city, state, and county should be ready and in place.

Further, it would be helpful to begin now to effect even small changes in each locality. Such changes might include a limitation on the use of student-owned cars, the establishment of park-and-ride lots, and the use of school buses to accommodate revised factory work schedules. In fact, pilot operations would help prepare the community and the transportation providers to cope with the changes. The less sudden the "shock", the more smoothly the community can accept and work with long-range energy plans.

The media can be key factors in helping the community develop an awareness of the need for transportation changes and encourage the public to cooperate. For example, the media could highlight the amount of fuel saved through the maximum use of school buses.

The energy shortfall is a long-range national problem. Therefore, school staff and pupils should be involved in analyzing local problems and developing solutions. Research and experience show that persons who are involved in the development of solutions work diligently to make them succeed.

Although future energy shortfalls may not seriously affect a given area as much as another, it is likely that no location will be immune. Regardless of current situations, the time to prepare for an energy shortfall is now.

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Can the Intercity Transportation System Accommodate the Demand During an Energy Shortage?

Gibson W. Fairman

What is an energy shortage? In this paper, it is defined as a short-term emergency interruption of the supply of transportation fuel similar to that created during the 1973-1974 oil embargo by OPEC. Such a short-term shortage is characterized by its suddenness, its severity (percentage of supplies cut off), the curtailment of normal travel, and the likelihood of government intervention (fuel allocation, rationing, etc.), as well as its adverse long-term economic and social impacts.

Individual efforts by private citizens and government-initiated programs to reduce travel would be aimed primarily at the automobile and light-truck user. Together, they account for more than 88 percent of the total person miles of travel in the United States and consume about 63 percent of all petroleum used for transportation, or nearly 33 percent of all petroleum consumed in the United States. (All data in this report are for 1977.) The other forms of passenger transportation consume an additional 6.3 percent of the petroleum used for transportation. Freight movement by truck, rail, water, pipeline, and air accounts for the remaining 3 percent of transportation fuel use. Transportation used 53.7 percent of the total U.S. petroleum consumed (1-3).

Petroleum accounts for approximately 49 percent of the total U.S. energy resource. Nearly 48 percent of the petroleum consumed in the United States is imported. A sudden one-third reduction in oil imports could mean a 16 percent reduction in fuel available for transportation. Similarly, a two-thirds cutoff of imported oil could result in a 32 percent reduction. These percentages are based on the assumption that available oil would be distributed in proportion to past consumption patterns. Undoubtedly, reallocation would deviate from past trends but to what extent is beyond the scope of this paper.

Aside from the uncertainties of emergency shortages, we are also faced with the long-term problem of diminishing world oil supplies. Responses to the long-term problem call for different and more deliberate actions than those we would take in an emergency. Nevertheless, consideration of the long-range implications should be a factor in evaluating potential short-range solutions.

Before attempting to determine the amount of excess capacity that may exist in the public intercity modes, it would be useful to summarize the basic assumptions of this paper. All data are for 1977. Intercity trips by automobile and truck are defined as one-way trips of 100 miles or more and 50 miles or more. Automobile and light-truck travel data are taken from the 1977 U.S. Census of Transportation for one-way trips of more than 100 miles. A light truck is a pickup or van. Additional automobile and truck travel to account for trips of 50 miles or more was determined from output from the California Statewide Travel Model (trip-length frequency distribution). Reductions in available fuel are applied across the board, except for total decreases in intercity travel that are applied to automobile and truck travel only—i.e., the modal shift is from automobile and truck to the three public modes (bus, rail, and air). No change in existing (1977) oil distribution patterns is assumed as a result of reductions, except as noted above. Automobile and truck occupancy for total travel is 2.2

persons/vehicle, while occupancy for intercity travel is 2.4 persons/vehicle. A barrel is considered equivalent to 42 U.S. gallons. The table below on 1977 imports of petroleum used for transportation (2,3) and Table 1 are based on reconciling fuel consumption (gallons) with amount of travel (person miles):

Factor	Gallons (000 000s)
Total U.S. consumption	282 550
Imports	135 002
One-third of imports	45 001
Transportation use	151 729
One-third of imports for transportation	24 169

The petroleum use data indicate 151.729 billion gal for all transportation. Travel data converted to fuel consumption by using energy-intensity factors show an estimate of 145.284 billion gal for all transportation in Table 1 and the table below on freight movement and petroleum consumption:

Mode	Gallons (000 000s)
Truck (excluding pickups)	26 534
Rail	4 115
Water	7 598
Pipeline	4 320
Air and other	1 896
Total	44 463

The small difference could be due to variations in the energy-intensity factors. The lower figure is used for most of the remaining calculations in this paper. [Whenever possible, the energy-intensity factors (person miles per gallon) are synthesized from actual use data published in generally accepted references, keyed to each mode in the tables presented in this paper.] There is considerable potential for improving these factors—and good incentives to do so for reasons of fuel conservation and economics. In fact, the load factors (person miles divided by seat miles) for public modes have increased since 1977, with resulting increases in fuel efficiencies (person miles per gallon). Improved efficiencies have also occurred due to such changes as those in operating procedures, engine modifications, and lighter vehicles.

In order to assess the amount of excess capacity in the intercity transportation system, we need to know what the system consists of, how it is being used, what its capacity is under existing (1977) service levels, and what its capacity could be if it were used more intensively. Some of these data appear in Table 2. The first three systems in Table 2 are public, common carriers subject to a wide range of government regulations that affect service levels, fares, schedules, labor management, safety, and so forth. The last two are privately owned and operated. The movement of freight is not within the scope of this paper, except to note the potential for passenger and freight interference (especially for passenger rail service).

ECONOMIC IMPACTS OF REDUCED INTERCITY TRAVEL

A relatively convenient method of estimating the potential economic impact of a period of vehicle fuel shortage is to look back at the impact of the two shortage periods already experienced in 1973-1974 and in 1979. During these two shortages the economic indicators did not reveal any significant change or shift in the level of economic activity for several reasons. First, the shortage period was not long enough to cause any serious economic impacts. After a brief period of shortage, fuel became available—even though at a higher price—and things returned to normal. Second, in spite of the fuel shortage, the public managed to make all essential trips, thus averting many adverse economic impacts. In comparison to the total trips taken, the number of cancelled trips that created some adverse impacts was so insignificant that such trips did not appear in the aggregate statistics. Also, compared to total economic activity, trip-related activities were small enough not to appear in any aggregate data. Whatever impact was detected was highly localized and in specific sectors. However, given a longer and deeper period of shortage, the impacts could become detectable, even though they would still be highly localized in specific sectors.

In case of a fuel shortage, major urban centers are going to be the most resilient and immune to adverse economic impacts. The reasons are that these centers usually have a diversified industrial mix and a larger economic base.

The most vulnerable economies are the nonmetropolitan area economic centers, especially recreation areas and vacation resorts, to and from which the automobile serves as the major travel mode. In many of these areas, resident businesses depend on a short, seasonal peak period for about 80 percent of their annual income. Adverse impacts in these areas would hurt the private sector by a loss of income and the public sector by loss of tax revenues. In large or small communities, when a few major businesses suffer for one reason or another, the whole community suffers. However, there are certain businesses that stand to lose more than others in a period of motor fuel shortage—manufacturers of recreation vehicles and boats; hotels, motels, and their suppliers; restaurants, resorts, and amusement parks; camping and skiing areas; convention centers; vehicle sales and repairs; and service stations.

The potential impacts of a severe cutback in travel on these businesses would take the form of employee layoffs; reduced wages, salaries, and other forms of income (e.g., proprietor's income); business closures; and loss of tax revenue for essential public services. A relatively healthy reaction to the fuel shortage that might take place in many affected areas, where possible, would be the relocation of some of these businesses closer to their clients.

EXISTING USE OF THE SYSTEM AND CALCULATION OF EXCESS CAPACITY

The year 1977 was chosen for this research effort because all the necessary data were available from government and private-industry publications. In 1977, the three public modes of intercity person transportation handled a total of 193.1 billion person miles of travel in the United States. In addition, the two major private modes carried another 260.8 billion person miles of travel. Table 3 summarizes the number of person miles traveled (about 14.9 percent of total travel) and the gallons of fuel consumed (about 10 percent of petroleum used for transportation) for intercity travel in 1977.

Informal inquiries to the air, bus, and rail passenger industries resulted in a set of load factors considered to be the maximum practical under current service levels. These are air carrier, 70 percent; intercity bus, 90 percent; and Amtrak, 80 percent. Attaining these load factors would require extensive managerial effort, intramodal and intermodal coordination, streamlined maintenance, improved operating procedures, and probably some changes in government regulations. For instance, under current deregulation, the airlines are precluded from closer coordination because of antitrust laws. Government's role may be to provide a mechanism for coordination that is workable or to seek regulatory and administrative changes that foster coordination both within and between modes of intercity travel. Data obtained from these travel modes in relation to load factors are summarized briefly below.

Amtrak

These statistics (14,16-18) concern Amtrak's load factor: revenue passenger miles, 4.204 billion; seat miles, 15.680 billion; average load factor, 26.82 percent; revenue passengers (trips), 19.0 million; average passengers per train,

Table 1. Petroleum consumed by person-travel modes.

Mode	Person Miles (000 000s)	Person Miles per Gallon	Gallons Consumed (000 000s)
Automobile and taxi (4, 5)	2 461 028	30.67	80 242
Pickup (2, 4)	228 620	20	11 431
Motorcycle (4)	24 823	55	451
Air carrier (6-8)	163 219	25	6 529
General aviation (9, 10)	33 830	34	995
Intercity bus (11)	25 700	140	184
School bus (2, 12)	70 257[a]	175	402
Transit bus (13)	19 730	50	395
Heavy rail transit (13)	9 682	160	60
Commuter rail (13)	5 478	160	34
Amtrak autotrain (14-16)	4 204	43	98
Total	3 046 571		100 821

[a]Estimated figure.

Table 2. Equipment and use data for intercity transportation systems.

System	Item	Use Data
Amtrak (6, 14, 15, 17-19)	System miles	25 811
	Locations served	524
	Number of locomotives	369
	Number of cars	2154
	Average seats per car	60
	Number of trains per day	262
	Average cars per train	7.9
	Average locomotives per train	2.1
	Daily average cars out of service (%)	24.3
	Daily average locomotives out of service (%)	19.5
Intercity bus (6, 11, 17, 20)	System miles	277 000
	Locations served	15 000
	Number of buses	
	Classes 1-3	20 200
	Class 1	8360
	Average seats per bus	43
	Daily average buses out of service (%)	7.0
Domestic air carrier (7, 8, 17)	System miles	
	Total	327 969
	Jet routes	151 848
	Locations served, certificated	
	Total	629
	Air traffic hubs[a]	158
	Airports	2153
	Number of aircraft	2231
	Average seats per aircraft	136.9
	Daily average aircraft out of service (%)	3.0
General aviation (9, 10, 17)	Total system miles	_[b]
	Locations served	15 000
	Airports	14 117
	Number of active aircraft	184 294
	Average seats per aircraft	
	Local	3.5
	Itinerant	5.0
Automobile, truck, and motorcycle (4, 12, 17, 21)	System miles	686 329
	Locations served	All
	Registered vehicles (total U.S.)	
	Passenger automobiles	113 696 100
	Motorcycles	5 014 600
	Single-unit trucks	28 298 400
	Average seats per vehicle	
	Passenger automobiles	4.5
	Motorcycles	1.5
	Single-unit trucks	2.0

[a]These hubs handle 96.8 percent of all enplanements.
[b]Data are not available.

126.63; average trip length, 221.26 miles; and average speed (station-to-station), 46.40 mph. If the load factor for Amtrak were increased to 80 percent, based on existing schedules, it would provide for 12.54 billion total passenger miles—an increase of 8.34 billion or 198.3 percent. In terms of person trips, it would add 37.675 million—assuming an average trip length of 221.26 miles. The number of passengers per train mile would increase to 378.

Table 3. Intercity travel and fuel consumption in the United States, 1977.

Mode	Person Miles (000 000s)	Person Miles per Gallon	Gallons Consumed (000 000s)
Air carrier (7)	163 200	25	6 500
Intercity bus (11, 17)	25 700	140	200
Amtrak (14, 17)	4 200	43	100
Automobile and truck[a] (5)	230 700	33.46	6 900
General aviation[b] (9, 10)	30 100	34	900
Total	453 900		14 600

[a]Data, taken from 1977 Census of Transportation, include person miles of travel from one-way trips of 100 miles or more. If trips of 50-100 miles are included, total intercity travel would increase to 671.3 billion person-miles (22 percent of total) and consume 21.1 billion gal of fuel (14.5 percent of total).
[b]General aviation includes itinerant (city-to-city) person miles only.

An additional increment of capacity could also be added by scheduling the trains to run during as many of the 24 hours in a day as possible. Given the average consist of 7.9 cars and 2.1 locomotives per train, it appears that the availability of locomotives becomes the limiting factor. This assumes that there is no pool of unused locomotives to press into service and that none would be shifted from hauling freight. It is also assumed that there is not a large pool of passenger rail cars suitable for service on short notice.

By running the trains as much as possible, using locomotives as the constraint, and assuming an 80 percent load factor, the total person miles of travel by rail would be 5.165 times the existing figure. This would amount to a total of 21.714 billion person miles, or an increase of 17.510 billion.

It is acknowledged that the use of systemwide averages is no way to run a railroad—nor a bus line, nor an airline. However, such use is probably sufficient to establish the order of magnitude regarding how much excess capacity could be made available if needed.

Intercity Bus (Classes 1-3)

The following statistics (11,17,20) concern the load factor for intercity bus systems (classes 1, 2, and 3): revenue passenger miles, 25.700 billion; seat miles, 47.386 billion; average load factor, 54.24 percent; revenue passengers (trips), 332.0 million; average passengers per bus, 23.32; average trip length (one-way), 77.41 miles; and average speed (station-to-station), 39.29 mph. If the load factor for intercity bus were increased to a practical maximum of 90 percent, the total passenger miles carried would be 42.644 billion, or an increase of 16.944 billion (65 percent). This would mean an additional 218.89 million person trips. The average length of such trips would be 77.41 miles.

Combining class 1, 2, and 3 buses shows that, on average, and allowing for 10 percent downtime, each bus is used only 4.23 h/day. By running the buses as much as possible with a 90 percent load factor, the total passenger miles of travel by bus could be 9.42 times the current figure. This would be a total of 242.17 billion passenger miles—an increase of 199.526 billion.

Intercity Bus (Class 1 Only)

It should be understood that 8360 buses of the total intercity bus fleet of 20 200 are engaged in class 1 service (11), which handles the bulk of regular-route intercity service in addition to package express, some charter, and special services. Class 1 buses represent 41 percent of the fleet but account for 66 percent of the passenger miles. These buses are used about 6.9 h/day on average, while class 2 and 3 buses are used only 2 h/day.

If the class 1 buses ran on existing schedules with a 90 percent load factor, they would account for 29.644 billion passenger miles—an increase of 12.714 billion, or 75 percent of the total increase in passenger miles in classes 1, 2, and

3. Since the average trip length on class 1 buses is 135.33 miles, compared to 42.39 miles on class 2 and 3 buses, the increase would account for 93.95 million passenger trips, or 42.92 percent of the additional passenger trips carried by all three classes.

If the class 1 buses were used during as many of the 24 hours in a day as possible at 90 percent load factor, an additional increase of 73.946 billion passenger miles would result, as well as a total increase of 86.66 billion over current passenger miles. This represents 40 percent of total additional capacity in all three classes.

Commercial Air Carrier (Scheduled Domestic)

The statistics concerning the load factor for commercial air carriers (scheduled domestic) include the following (7,8): revenue passenger miles, 156.609 billion; seat miles, 280.619 billion; average load factor, 55.81 percent; revenue passenger enplanement, 222.283 million; passengers per plane, 76.4; average passenger trip length, 704.5 miles; and average airborne speed, 408.1 mph. Discussion with representatives of the commercial air carrier industry revealed these constraints on excess capacity for this mode of travel. The practical maximum load factor was estimated to be 75 percent. This means that many flight legs would be operating at 100 percent, with standbys. There is very little downtime (3-4 percent) to interfere with flight service because most maintenance is performed in nonscheduled hours. The availability of pilots appears to be a limiting factor to increasing capacity. Official air-carrier traffic statistics indicate that the 24 900 pilots employed by the airlines are being used at least 90 percent. Federal regulations and labor contracts are major factors limiting the allowable flight time for pilots. A large number of qualified pilots to be drawn on for greatly expanded service on short notice does not exist. This means that the excess capacity of the air carriers would be based on using pilots (and aircraft) about 10 percent more and on increasing the load factor up to 75 percent.

Revenue passenger miles would be increased from 163.2 billion to 219.3 billion, an increase of 34.38 percent. This would result in 79.77 billion additional passenger enplanements, assuming an average trip length of 704.5 miles.

For purposes of comparison, assume that there are sufficient pilots and airport capacity to operate the air-carrier fleet around the clock. A 10 percent downtime factor is used because aircraft could no longer be maintained during nonscheduled time. Given these assumptions, a total of 753.9 billion passenger miles could be handled, an increase of 362 percent over the existing figure. This would result in an additional 838.5 million passenger trips of 704.5 miles in average length. These figures have little meaning in the real world because it is unlikely that an increase in air travel of 350 percent would be accommodated during a severe energy shortage even if the demand were there and pilots and airport capacity were available.

Tables 4 and 5 list the excess capacities in terms of person miles of travel that would theoretically exist (a) if the three public modes were operated on existing schedules at maximum practical load factors and (b) if the three public modes were operated at the maximum practical load factors with around-the-clock use of equipment and with maintenance downtime. These tables show that Amtrak is underused compared to intercity bus and air carriers. Also, its excess capacity is limited by the availability of locomotives. On the other hand, the excess capacity of air carriers is limited to increasing the load factor to 75 percent. The lack of pilots precludes more-intensive use of aircraft. It is also doubtful that there is a real demand for the excess 56.1 billion person miles of air travel with an average trip length of 704.5 miles. Intercity bus appears to offer the most-readily accessible resource for handling the short- and medium-length trips that characterize the automobile and truck travel shifting to public modes.

Relation of Capacity to Cutoff

How do these excess capacities relate to a one-third, two-thirds, or complete cutoff of imported oil? Assume that a cut in imported oil is distributed across all uses of petroleum in proportion to existing consumption patterns. However, also assume that the reduction in fuel for intercity travel applies only to automobile and truck and that supplies to the three public modes would not be cut.

Table 3, which lists intercity travel and fuel consumption, shows a total of 14.6 billion gal for all intercity travel. A one-third cut in imports would result in a reduction of $1/3 \times 0.4778 \times 14.6 = 2.324$ billion gal. This amount of fuel would be 33.71 percent of automobile and truck fuel--77.77 billion person miles of travel or 32.40 billion automobile and truck vehicle miles. Can the intercity transportation system accommodate this modal-shift demand?

Table 4 shows a potential excess capacity of 81.4 billion person miles. However, 56.1 billion is air carrier person miles, which cannot substitute for most of the automobile and truck person miles. Assuming that the percentage reduction in automobile and truck travel is constant for all trip-length categories (based on the 1977 Census of Transportation) and that trips of 500 miles or more are candidates for shifting from automobile and truck to air, then 23.343 billion person miles of automobile and truck travel could shift to air travel. This would increase the load factor on airplanes to 63.8 percent.

The remaining 54.430 billion person miles, with shorter average trip lengths, could be split between Amtrak and intercity bus. One way to do this would be to use Amtrak to the maximum; this would accommodate 17.510 billion person miles, with the remaining 36.920 billion assigned to intercity bus. The buses would run at a 90 percent load factor for 6.2 h/day instead of 4.2 h. Or, if only class 1 buses were used, they would operate at a 90 percent load factor for 12.5 h/day versus the existing 6.9 h. This example of one way to absorb a one-third cut in oil imports is summarized in Table 6. The additional fuel needed to run Amtrak and buses more frequently would be more than compensated for by automobile and truck trips that would be cancelled, especially those recreational sightseeing trips made by automobiles and trucks carrying camping gear.

If Amtrak merely increased its load factor to 80 percent by using existing schedules, it could handle an increase of 8.336 billion person miles. Intercity buses (classes 1, 2, and 3) would then handle 46.094 billion person miles by operating an average of 7.1 h/day. If only class 1 buses were used, they would operate 14.6 h/day.

If a two-thirds cut in imported oil were treated in similar fashion, air carriers would be operating on existing schedules with a 71.8 percent load factor, Amtrak would be running 24 h/day at an 80 percent load factor, and every intercity bus would be running at a 90 percent load factor for 11.6 h/day. Class 1 buses only would have to operate at a 90 percent load factor 24 h/day.

All of these examples are probably unrealistic, however, because they are based on shifting person travel from automobile and truck to the three public modes. It seems more likely that higher priorities would be placed on energy requirements for agriculture, freight movement, heating and cooling, and industrial uses.

If a complete cutoff of imported oil occurred, all intercity travel by automobile and truck would theoretically cease. The remaining transportation fuel would be sufficient to keep the public modes operating as they do now, except that the load factors could increase. With these increases, the three public modes could handle about 50 percent of intercity travel. This would probably entail prioritizing trips on the basis of necessity, with business and important family matters ranked higher than vacations and sightseeing.

It could be argued that, during a severe energy shortage, air travel should be curtailed because it is the least energy efficient of the intercity modes. On the other

Table 4. 1977 excess annual capacity, by mode and based on existing schedules.

Mode	Existing Person Miles of Travel (000 000s)	Existing Load Factor (%)	Maximum Load Factor (%)	Person Miles per Gallon	Potential Person Miles of Travel (000 000s)	Excess Person Miles (000 000s)
Amtrak	4 204	26.82	80	128	12 540	8 336
Bus						
Classes 1, 2, and 3	25 700	54.24	90	232	42 644	16 944
Class 1	16 930[a]	51.39	90	245	29 644[a]	12 714[a]
Air carrier	163 219	55.81	75	34	219 341	56 122
Total	193 123				274 525	81 402

[a]Not included in total.

Table 5. 1977 excess annual capacity, by mode, if equipment is used 24 h/day.

Mode	Existing Person Miles of Travel (000 000s)	Existing Load Factor (%)	Maximum Load Factor (%)	Potential Person Miles of Travel (000 000s)	Excess Person Miles (000 000s)
Amtrak	4 204	2.98	1.73	21 714	17 510
Bus					
Classes 1, 2, and 3	25 700	1.66	5.68	242 170	216 470
Class 1	16 930[a]	1.75	3.49	103 590[a]	86 660[a]
Air carrier	163 219	1.34	3.44	753 909	590 690
Total	193 123			1 017 793	824 670

[a]Not included in total.

Table 6. Potential for shift from automobile and truck to three public modes to absorb a one-third cut in oil imports.

Mode	Existing Load Factor (%)	New Load Factor (%)	Existing Use per Day[a] (h)	New Use per Day[a] (h)	Excess Person Miles of Capacity (000 000s)
Amtrak	26.82	80	13.86	24.00	17 510
Bus					
Classes 1, 2, and 3	54.24	90	4.23	6.20	36 920
Class 1	51.39	90	6.87	12.48	36 920[b]
Air carrier	55.81	63.79	6.28	6.28	23 343
Total					77 773

[a]With allowance for equipment downtime. [b]Not included in total.

hand, the 1977 U.S. Census of Transportation shows that probably one-half of all air travel could be classified as necessary because it involved business or important family affairs requiring prompt personal attention at great distances. It could also be argued that a large amount of pleasure travel or discretionary travel between cities would simply not occur.

For instance, in California—where automobile use is the most extensive in the United States—motorists have voluntarily reduced their driving so that 1979 showed a net annual decrease in vehicle miles of travel of 0.9 percent. Normally, travel on the state highway system would have increased 5 percent/year. The point is that a one-third cut in oil imports, which theoretically translates to a 33.71 percent reduction in automobile and truck person miles of travel, may in fact turn out to be much less of a drop. The most significant problems would undoubtedly occur within urban areas where trip making is generally less energy efficient.

ROLE OF THE INTERCITY TRANSPORTATION SYSTEM IN MEETING A FUEL SHORTAGE CONTINGENCY

Intercity travel in the United States accounts for approximately 14.9 percent of the total 3 trillion person miles of travel. Because intercity travel is more energy efficient than intraurban travel due to higher vehicle occupancy and better operating conditions, it probably consumes no more than 10 percent of the total energy for transportation. In the example of a one-third cut in imported oil, intercity travel would accommodate a saving of about 1.6 percent of the total energy used for transportation.

Given that intercity travel's role in the total transportation picture and its important economic and social values are known, curtailment of travel brought on by a sudden fuel shortage should be handled as equitably as possible with some sense of priorities. These priorities should be based on necessity and the extent that other transportation modes and nontravel forms of communication can be substitutes for automobile travel.

The 1977 U.S. Census of Transportation provides some insights into the nature of intercity travel that may be useful. The reader is cautioned, however, to be aware that the data presented here on the three public modes from this census will differ from the summary figures given previously because the 1977 census reported only on one-way trips of 100 miles or more. Data from automobile and truck travel will agree because they were taken from the 1977 census. This is illustrated in the following table, which compares average trip lengths:

Mode	Average Trip Length, Including Trips < 100 Miles	1977 Census Average Trip Length in Miles
Amtrak	221	473
Bus	77	298
Air	704	961
Automobile and truck	-	261

By using 500 miles as a breakpoint, the 1977 census shows that 45 percent of total person miles resulted from trips under 500 miles. Automobile and truck modes accounted for 90 percent of that travel. Air carriers accounted for 60 percent of the person miles of travel for trips of more than 500 miles. Automobile and truck modes accounted for 35 percent of travel for trips of more than 500 miles.

In terms of person trips, 83 percent was less than 500 miles in length. Three-quarters of these trips were by automobile and truck. For trips greater than 500 miles in

Table 7. Percentage of person miles of travel, by mode and purpose, based on 1977 U.S. Census of Transportation.

Trip Purpose	Automobile and Truck Without Camping Gear	Automobile and Truck with Camping Gear	Bus	Train	Air	Other	Use of Different Mode Going and Coming	Total
Visit to relatives or friends	23.59	1.42	0.69	0.49	9.13	0.09	1.25	36.66
Business	6.76	0.23	0.11	0.25	11.75	0.19	0.44	19.66
Convention	0.99	0.09	0.10	0.02	1.83	–	–	3.11
Outdoor recreation	5.80	1.85	0.23	0.04	1.22	0.07	0.11	9.32
Entertainment	4.03	0.64	0.33	0.05	2.74	0.11	0.24	7.98
Sightseeing	3.43	1.06	0.34	0.05	2.29	–	–	7.31
Personal, family, medical reasons	7.17	0.34	0.20	0.11	2.87	0.07	0.79	11.35
Shopping	0.24	0.01	0.01	0.00	0.00	–	–	0.26
Other	2.38	0.28	0.33	0.01	1.15	–	–	4.35
Total	54.39	5.92	2.34	1.02	32.98	0.46	2.83	

Table 8. Percentage of person trips, by mode and purpose, based on 1977 U.S. Census of Transportation.

Trip Purpose	Automobile and Truck without Camping Gear	Automobile and Truck with Camping Gear	Bus	Train	Air	Other	Use of Different Mode Going and Coming	Total
Visit to relatives or friends	30.79	1.16	0.66	0.29	3.07	0.11	0.73	36.80
Business	11.35	0.24	0.13	0.25	5.19	0.20	0.28	17.58
Convention	1.21	0.06	0.10	0.02	0.53	–	–	1.97
Outdoor recreation	9.54	2.62	0.30	0.02	0.41	0.12	0.09	13.09
Entertainment	5.67	0.51	0.50	0.05	0.85	0.17	0.11	7.75
Sightseeing	3.37	0.57	0.39	0.05	0.74	–	–	5.24
Personal, family, medical reasons	10.53	0.32	0.20	0.08	0.95	0.10	0.43	12.45
Shopping	0.63	0.01	0.02	0.00	0.01	–	–	0.68
Other	3.12	0.27	0.47	0.01	0.42	–	–	4.44
Total	76.21	5.76	2.77	0.77	12.17	0.69	1.64	

length, automobile and truck modes, along with air carriers, accounted for 51 and 46 percent of these trips, respectively. Only 13 percent of the bus trips and 29 percent of train trips were more than 500 miles in length. The average number of persons per trip by mode was automobile and truck, 2.5; Amtrak, 1.6; bus, 1.5; and air carrier, 1.5.

Tables 7 and 8 give the percentage breakdown of intercity person miles of travel and trips by purpose and mode of travel. Automobile and truck modes dominate for all trip purposes, except for business and convention travel, where air is the preferred mode. For person trips, automobile and truck dominate for all trip purposes.

The 1977 census also reported intercity travel as vacation or nonvacation travel and weekend or nonweekend travel. Person miles of travel were about evenly split between vacation and nonvacation. Automobile and truck modes accounted for 60 percent and air carriers for 33 percent of vacation and nonvacation travel. About 37 percent of the person trips was for vacation; automobile and truck modes carried about 80 percent and air carriers, 13.5 percent. The share of nonvacation travel by automobile and truck and air carriers was 83 percent and 11.5 percent, respectively.

Person miles for weekend and nonweekend travel split 26 percent and 74 percent, respectively. Automobile and truck carried 53 percent, while air carriers handled 40 percent.

Person trips split 41 and 59 percent between weekend and nonweekend travel. Automobile and truck carried 92 percent of the weekend trips and 75 percent of the nonweekend trips. Comparable percentages for air carriers were 4 percent and 18 percent.

In prioritizing intercity travel, one can surmise from Tables 6 and 7 that business, personal family affairs, or medical reasons are the trip purposes most likely to be considered as high priority on a scale of necessity. Such purposes account for about one-third of the person miles of travel and of person trips. Because a 100 percent cutoff of foreign oil would result in a 50 percent reduction in intercity travel, we can conclude that all necessary trips would continue to be made unless fuel for the public modes of intercity travel was also preempted for higher-priority purposes.

It seems fair to say that there is enough potential excess capacity within the intercity transportation system to absorb a one-third shift from automobile and truck to the three public modes. A two-thirds shift would require almost maximum use of the three public modes. Only intercity bus would have much excess capacity remaining. With a complete cutoff of foreign oil, the three public modes would be able to meet about 50 percent of the intercity travel demand. These statements are based on the foregoing analysis, which rests, admittedly, on fairly simplified assumptions. For instance, the use of nationwide annual averages implies that travel is evenly distributed in time and space. Nothing could be further from the truth.

Travel demand comes in bunches and spreads out along major population corridors. There are peak hours, peak days of the week, peak months of the year, special holiday peaks, and special-event peaks. During many of these periods, various intercity modes are operating at full capacity or are unable to handle all who wish to travel. Moreover, much intercity travel flows along congested corridors where one worries about airspace, ground-side capacity, passenger train-freight train conflicts, overcrowded highways, and teeming terminals. Any meaningful planning for a fuel-shortage contingency must be conducted at the corridor level for intercity travel and at an even finer level for intraurban travel.

Marshaling the potential excess capacities to handle a sudden increase in demand caused by a fuel shortage could present major logistic problems. Examples include government rules and regulations, labor contracts, service area disputes, maintenance, modal interface, and the

average person's desire to travel during daylight hours. There are personal phobias and biases to overcome in any major shift from the automobile.

CONCLUSION

In summary, we can say that considerable excess capacity is available, but it may be difficult to use unless we can focus sufficient managerial and logistic talent in the transportation area to develop plans to use that capacity. Also, in recent months, evidence that we can handle these problems has increased, as U.S. citizens responded to a realistic awareness of diminishing fuel supplies, to the prodding of rapidly rising fuel prices, and to their desires to reduce U.S. dependence on foreign energy.

REFERENCES

1. W.J. Hoffman. Energy and Transportation. California Transportation Plan Task Force, Issue Paper 12, Sacramento, June 1976.
2. D.B. Shonka, ed. Transportation Energy Conservation Data Book: Edition 3. Oak Ridge National Laboratory, Oak Ridge, TN, Feb. 1979.
3. Basic Petroleum Data Book. American Petroleum Institute, Washington, DC, Oct. 1975.
4. Highway Statistics. Federal Highway Administration, 1977.
5. Travel During 1977: 1977 Census of Transportation, National Travel Survey. U.S. Department of Commerce, Bureau of the Census, Oct. 1979.
6. West Coast Corridor Study: California Subcorridor. California Department of Transportation; Federal Railroad Administration, June 1978.
7. Air Carrier Traffic Statistics. U.S. Civil Aeronautics Board, Dec. 1978.
8. FAA Statistical Handbook of Aviation. U.S. Department of Transportation, 1978.
9. 1977 General Aviation Activity and Avionics Survey. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, April 1979.
10. 1975 General Aviation Activity Survey. Federal Aviation Administration, Sept. 1976.
11. A Report from the American Bus Association. American Bus Association, Washington, DC, 1979.
12. Motor Vehicle Facts and Figures. Motor Vehicle Manufacturers Association, Detroit, 1979.
13. Transit Fact Book, 1977-1978. American Public Transit Association, Washington, DC, 1978.
14. Amtrak Annual Report. National Railroad Passenger Corporation, Washington, DC, Feb. 15, 1980.
15. Amtrak National Train Timetables. National Railroad Passenger Corporation, Washington, DC, June 22, 1977.
16. A Reexamination of the Amtrak Route Structure. U.S. Department of Transportation, May 1978.
17. Summary of National Transportation Statistics. U.S. Department of Transportation, Aug. 1979.
18. Yearbook of Railroad Facts. Association of American Railroads, Washington, DC, 1979.
19. Report to Congress: The Rail Passenger Service Act of 1970. U.S. Department of Transportation, March 1973.
20. Greyhound Lines Handy Reference Guide. Greyhound Corporation, Los Angeles, April 30, 1978.
21. Transportation Facts and Trends. Transportation Association of America, Washington, DC, July 1979.

Energy and the Airline Industry

K. William Horn

The most critical problem facing the airline industry today concerns fuel--its availability, price, and supply. This report (a) presents background information on jet fuel availability and prices, (b) discusses fuel efficiency and conservation, and (c) describes the impact of the 1973-1974 fuel shortage and possible future actions resulting from shortages.

FUEL AVAILABILITY

Adequate fuel supplies are necessary to ensure the reliability and availability of air transportation. The following are a few basic facts about jet fuel.

1. Scheduled air carriers use kerosene-based jet fuel (kerojet). It is a middle-distillate product, and only about 10 percent of the crude oil barrel can be used to produce jet fuel. Currently, however, only about 4.5 percent is processed and sold as kerosene-based jet fuel.
2. In addition to its use by scheduled airlines, kerojet is used by the military, general aviation (including business aircraft and commuters), and electric utilities that rely on kerojet as an alternative fuel.
3. Kerojet, as a middle distillate, can be diverted into other comparable products, such as heating oil. In winter months, however, such diversion has an adverse potential for kerojet supplies.
4. Kerojet is sold directly by refiners to air carriers in the United States. Middlemen are seldom involved in its distribution.

U.S. airlines supported the removal of price and allocation controls from kerosene-based jet fuel, which occurred in February 1979. But, since March 1979 and the upheaval in Iran, suppliers that have contracts with carriers have allocated jet fuel supplies. Most of these allocations, which refer to different base volumes, are tied to corresponding 1978 monthly increases and do not reflect current levels of carrier operations or the continuing surge in air transportation.

The difference between the allocated volumes and the volumes needed to maintain adequate service has been made up with purchases in the spot market, contracts with new suppliers, and, to some very limited extent over the past year or so, cancelled flights.

FUEL PRICE

The recent sharp increases in the price of jet fuel began in the early months of 1979. By December 1979, the average price of jet fuel was $0.75/gal, compared to $0.40/gal in 1978 and $0.12/gal prior to the OPEC embargo in 1973.

Currently, the average price is more than $0.80/gal. The December 1980 price may well reach $1.10/gal based on trends over the past year. Every increase of $0.01/gal adds more than $110 million annually to the operating costs of U.S. airlines.

The airline industry's total 1980 fuel bill is estimated at $10.6 billion, with $4.1 billion added in 1980 due to price increases alone. At this level, fuel accounts for more than 30 percent of total operating expenses. By comparison, fuel accounted for 25 percent of operating expenses in 1979, based on a total fuel bill of $6.5 billion, and about 12

percent of operating expenses prior to the 1973 oil embargo.

FUEL EFFICIENCY AND CONSERVATION

In the past five years, the airlines have become increasingly more efficient in conserving their use of petroleum resources with the purchase of more fuel-efficient aircraft and with operational improvements. Passenger load factors have increased from 52 percent to 63 percent. Also, the average number of seats per aircraft and stage lengths have increased. Other improvements have included (a) reducing cruise speed, (b) expanding use of flight simulators, (c) increasing the use of computerized flight planning, (d) developing sophisticated monitoring systems to identify aircraft that may be using excess fuel, and (e) shutting down one or more engines for taxiing maneuvers before takeoff and after landing.

Since 1973, the number of airline passengers has increased by about 100 million, or 49 percent, while airline fuel consumption has increased by only 5 percent. For 1980, total airline fuel consumption is expected to remain at the 1979 level of 11.2 billion gal. During the period 1973-1979, passenger miles per gallon, the best efficiency measure for jet fuel use, increased by 43 percent—from 17.5 passenger-miles/gal in 1973 to an estimated 25 passenger-miles/gal in 1979.

1973-1974 SHORTAGE—IMPACT AND ACTIONS

The OPEC oil embargo during the latter part of 1973 had a serious impact on the airlines and the travel industry. Relative to airline traffic, there was a certain amount of diversion from the automobile to the airplane as a result of the gasoline shortage. Domestic airline passenger traffic increased 7 percent in the first quarter of 1974, largely as a result of this diversion from automobile use. Domestic intercity travel by all modes of transportation was down about 4 percent in early 1974. For all of 1974, domestic air travel was up about 3 percent, compared to a decline of about 2 percent for all transportation modes.

As a result of the jet fuel shortage, the airlines dropped nearly 2000 flights/day in early 1974. These flight reductions averaged 1100/day for all of 1974. During that year, the airlines averaged about 13 000 flights/day, compared to 14 000 flights/day in 1973. With this reduction in capacity, the airlines had to furlough about 15 000 employees in 1974.

With the decrease in flights in 1974 and the increase in traffic, passenger load factors increased. The load factor in 1974 amounted to 55 percent, compared to 52 percent in 1973.

POSSIBLE FUTURE ACTION

The airlines in the future are likely to pursue increasing efficiency as part of their role in the nation's conservation efforts. The purchase of more fuel-efficient aircraft will also help in energy conservation efforts and provide operational improvements.

Airline industry capital requirements for new equipment during the 1980s are estimated at $87 billion, including passenger- and freight-carrying aircraft. During the past decade, capital investment by the airlines amounted to $17 billion and in the 1960s, $10 billion.

The industry will need an average annual corporate return on investment of 13-15 percent to meet the $87 billion in capital requirements from 1980 to 1990. In 1979, the industry's return on investment was less than 8 percent.

The airlines and other public transportation modes must receive adequate supplies of fuel during tight supply situations because they constitute the basic network of the nation's transportation system. In addition, public passenger transport accounts for only about 10 percent of total transportation-related petroleum consumption.

In the event of future major disruptions in energy supply, such as another embargo, it is hoped that ways could be found to ensure adequate jet fuel supplies to avoid curtailment of airline services. Nevertheless, we must be prepared for reductions in airline services should they prove necessary. Only through the combined cooperation and efforts of all concerned, including carriers, travelers, and shippers of all modes, can the transportation industry meet the national energy challenges of the future.

Energy Needs of the Commuter Airline Industry

Commuter Airline Association of America

The combination of airline deregulation, the uncertain availability and price of automotive fuels, and the surging public demand for air travel have spurred the growth of the commuter airline industry beyond its wildest dreams of just a few years ago. As a result, commuter airlines are gearing up to implement better service, with greater frequency to more communities than ever before.

It might appear that the Airline Deregulation Act of 1978 brought about a near revolution in U.S. air service. It has not. The role of commuter airlines in providing short-haul, hub-spoke air transportation as a replacement for departing certificated jet air-carrier service has long been established. In the 12 years prior to the Airline Deregulation Act, commuter air carriers successfully replaced service at 140 of the 172 cities that were suspended from the certificated air-carrier schedules. Since deregulation, that commuter replacement figure has increased by another 60 cities.

What the deregulation act did provide was a mechanism to allow this change in air service on a rational basis. The Airline Deregulation Act contained important provisions that (a) guaranteed the provision of minimum levels of air service for the next 10 years; (b) established a replacement mechanism that assures an orderly transition in air-carrier service; (c) allowed commuter air carriers to operate aircraft with a capacity of up to 60 seats, important because the commuter replacement service can be provided in aircraft properly matched to the size of the replacement market demand; and (d) provided key economic incentives to commuter airlines, such as equipment loan guarantees, joint fares, and subsidy where needed—provisions long available to other segments of the air-carrier industry.

Under deregulation, commuter airlines will assume an even more significant proportion of local and feeder air service than ever before. The economics of short-haul transportation make it increasingly difficult for air carriers that use large jet-transport aircraft to profitably serve such markets. On the other hand, commuter airlines with frequent schedules use aircraft matched to the market density and can continue to provide convenient replacement air service in those markets abandoned by trunk- and local-service carriers.

FUEL COSTS

The most significant new element in this changing service pattern has been the incredible rise in the cost of fuel. No one could have foreseen, even several years ago, that the enplane (i.e., to board) price of jet fuel would increase so dramatically. That increase measured some 80 percent

during 1979 alone, and this kind of price increase may continue this year. With this increase in the price of jet fuel has come the stark reality that short-haul jet transportation in those market segments of 150 miles or less simply has become uneconomic, no matter how high the average load factors. Yet those markets do not necessarily have low passenger densities. They include, for example, American Airlines suspending its flights between Dallas-Fort Worth to Oklahoma City, TWA dropping Wichita-Kansas City schedules, and United Airlines eliminating service in a number of substantial California markets, such as Bakersfield, Visalia, Fresno, Merced, Santa Barbara, and Sacramento. Nor is an end to this trend in sight. As the price of fuel increases, so do the stage lengths that continue to be profitable for jet air-carrier service.

AIRPORT SERVICE AND MARKET IMPACT

Commuter air carriers serve 819 U.S. airports. Nearly 400 of the U.S. airports receiving regularly scheduled air service are dependent on commuters for that service. One-quarter of all scheduled flights in 1979 was performed by commuter air carriers. Commuters are increasingly being relied on by the U.S. Civil Aeronautics Board (CAB) to meet the essential air transportation needs of the nation's small cities, which are guaranteed service for a period of 10 years by the Airline Deregulation Act. The CAB is mandated to guarantee continued air service at these points and, in every instance to date, is relying on commuter air carriers to provide such service. In order to meet these mandated public-service needs, it is essential that commuter air carriers have sufficient fuel to provide the increased service expected of them. Commuters, however, are not being allocated their current requirements. In fact, allocations range down to 60 percent of their 1978 allocation base. Thus, airline deregulation and the service mandated to small cities by the Airline Deregulation Act are being jeopardized by the lack of fuel.

The market impact of a special allocation of current requirements for commuter air carriers would be negligible. As a form of efficient mass transportation, the commuter air carriers offer the traveler the direct benefit of both energy and time savings. In 1979, commuter airlines carried more than 12 million passengers and 545 million pounds of cargo, up 22 percent and 35 percent, respectively, over comparable 1978 statistics. In doing so, they consumed only 0.7 percent of all aviation fuel. When compared to the other modes of transportation, this fuel translates into only 0.06 percent of all fuel used for passenger transportation purposes.

Commuters also use fuel-efficient aircraft. Given a 100-mile stage length, the average commuter aircraft attains 51.8 seat-miles/gal of fuel when all seats are occupied. The most efficient commuter aircraft, the Shorts SD 330, attains a figure of 58.3 seat-miles/gal of fuel. These figures are all the more impressive when compared to the average jet airliner, which, on average, attains a comparable figure of 31.8 seat-miles/gal over a 400-mile stage length. In comparison, the average commuter aircraft is 61 percent more efficient than the larger aircraft.

The wide geographic dispersion of the points served by commuter air carriers and the small size of aircraft used in the service make it infeasible for commuters to tanker (carry) fuel from one point to another. Thus, it is important that fuel be available at all points for commuters. The Commuter Airline Association of America estimates that commuter air carriers will need about 80 million gal of jet fuel this year, about 20 percent more than in 1979, and about 35 million gal of aviation gasoline, an increase of 15 percent over last year.

Commuter air carriers provide a mass transportation service to otherwise isolated small cities. The market impact of fuel allocation on them would be slight. Their service is provided in fuel-efficient aircraft. Unless these carriers receive sufficient fuel, the essential air transportation program mandated by the Airline Deregulation Act is in danger, as well as airline deregulation in general.

Effect of a Sudden Fuel Shortage on Freight Transport in the United States: An Overview

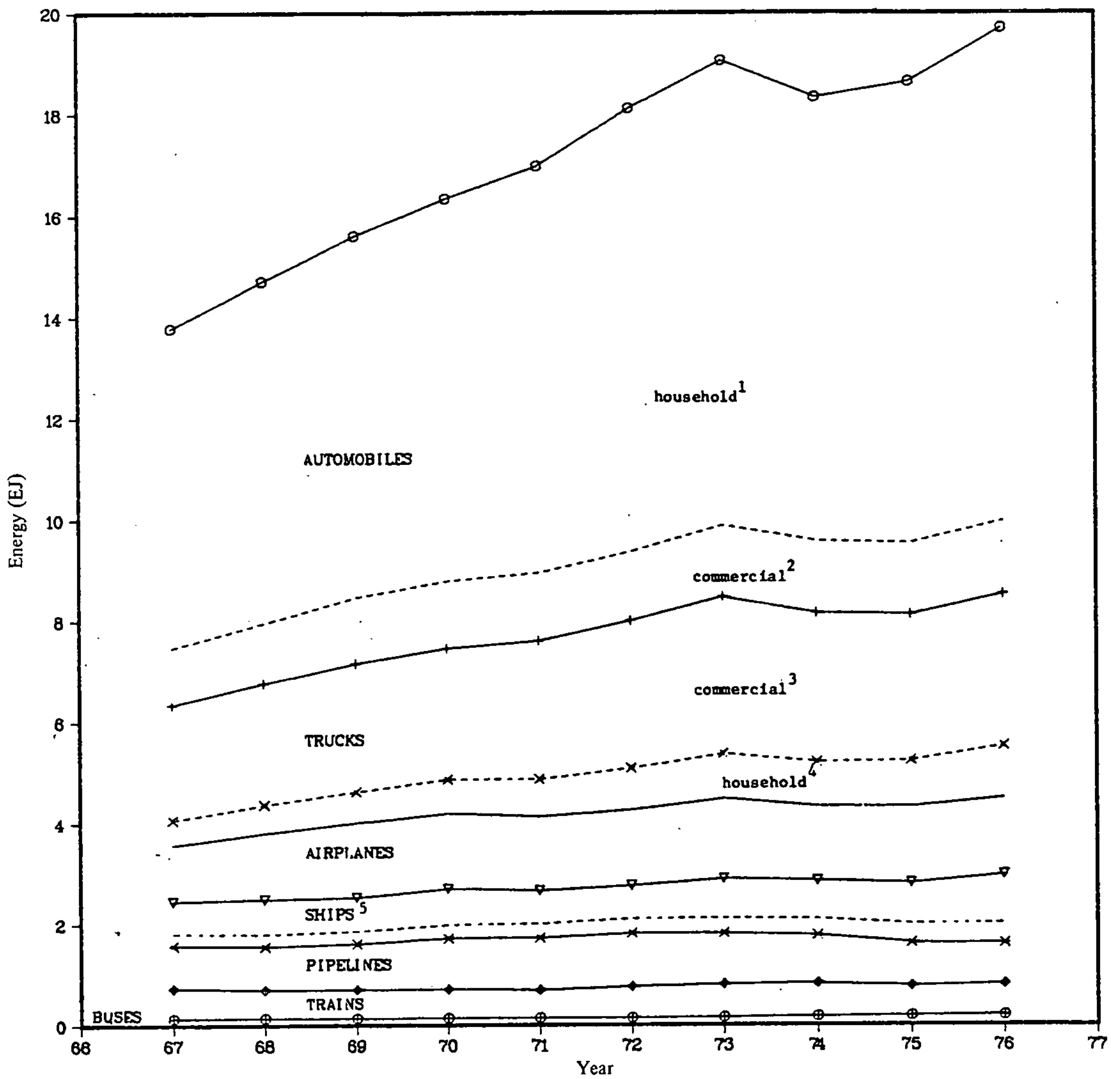
John N. Hooker

Rock oil was a curiosity in 1870—a time when the U.S. economy was powered by coal, wood, wind, water, and muscle (1). In 1977, oil and its distillates provided 49 percent of our energy and natural gas, 26 percent. During the period 1950-1975, petroleum's share rose from 40 to 46 percent, and consumption rose from 1.0 million to 2.6 million m^3/day (6.5-16.3 million bbl/day) (2).

To satisfy our thirst for oil, we have slipped into a dependence on foreign sources for which it is difficult to find a parallel in our history. The hard necessity of maintaining proper relations with some of our suppliers has become the anvil on which our foreign policy is shaped. Our vulnerability has forced us to compromise our principles in many instances. Our dependence on oil has reached the point where it would be foolish not to consider the potential effect of a sudden reduction in our foreign supply. The difficulty, of course, is that we import 45 percent of our crude oil and that 79 percent of this comes from OPEC nations (3). Some 43 percent of these imports is supplied by nations of the Middle East, a part of the world that is traditionally unstable and becoming more unstable. It is true that a cutback in foreign production would probably be mollified by the same determination to secure petroleum that got us into this predicament. But a relatively small perturbation of supply can precipitate a large disruption of distribution.

This paper will examine the potential effects of a sudden supply disruption on freight transport in particular. The paper discusses what freight transport is like, especially as it relates to the use of energy; it is important to understand where the energy goes and what affects the level of its consumption. It then sets out some of the main conservative responses transport firms might make to a shortage, with a rough indication as to their potential effectiveness. Modal shifts and opportunities within these modes are examined, and suggestions about whether and how our knowledge in these areas can be improved are made.

Figure 1. Energy used by civilian transport modes in the United States, 1967-1976.



ENERGY CHARACTERISTICS OF FREIGHT TRANSPORT

In 1976, the United States burned 895 million m^3 (5633 million bbl) of petroleum products. Transportation, which is 96 percent oil fueled, not only uses 61 percent of this fuel but favors the lighter, more-expensive distillates. All gasoline, nearly all jet fuel, and 74 percent of distillate fuel were used for transportation purposes in 1976 (4). Figure 1 (5), however, reveals that most of this fuel moved people not freight. [In Figure 1, household[1] includes fuel used by commercial automobiles not in fleets of four or more, as well as a relatively small amount of fuel used by state and local government automobiles, state and local government buses and trucks (except school buses), and vehicles not classifiable as automobiles, trucks, motorcycles, or buses (e.g., motor homes). Commercial[2] includes fuel used by commercial automobiles in fleets of four or more. Commercial[3] includes all fuel consumed by trucks used primarily for purposes other than personal transportation, plus all fuel used by federal government trucks. Household[4] includes all fuel consumed by trucks used primarily for personal transportation. In regard to ships[5], the area above the dashed line indicates fuel used by commercial vessels; the area below the dashed line indicates fuel used by pleasure boats.] Commercial freight transport in 1976 accounted for 111 million m^3 (701 million bbl) of liquid fuel, only 22 percent of the 505 million m^3 (3178 million bbl) used by civilian transportation as a whole. Freight transport is also better at operating with the heavier crude-oil fractions. In 1976, all of civilian transportation's residual oil and only 11 percent of its gasoline were used for moving freight (5). [It should be emphasized that no one knows for sure how much of each fuel is used for freight transport or for each mode of transport. The most uncertainty exists in the highway modes, where most of the fuel is burned. The Federal Highway Administration (FHWA) publishes total highway fuel-use data based on tax receipts, but any further breakdown can only be a matter of estimation. The truck fuel-use estimates provided herein are based on truck-mile data collected as part of the 1967 and 1972 Truck Inventory and Use Surveys, each of which canvassed some 100 000 trucks of all types nationwide, and on estimated fuel efficiency of trucks by fuel, by range (local or intercity), and for four weight classes (6). The resulting estimates run lower than those of certain sources. The estimated 1976 total fuel use of trucks, for instance, is 112 million m^3 (706 million bbl), compared to the FHWA estimate—most often quoted—of 136 million m^3 (857 million bbl). It has not been possible to learn, however, just how the FHWA estimate was made.]

In freight transportation, there is a well-known trade-off involving flexibility and level of service on the one hand and energy efficiency on the other. It is a fact that a vehicle

that can carry more commodities more places faster on a more accommodating schedule burns more fuel. Listed in order of flexibility and in reverse order of efficiency, the four major freight modes are trucks, rail, marine, and pipeline. (Since air freight, other than belly freight, in passenger aircraft uses less than 1 percent of freight transport energy, it is omitted from consideration here.)

Trucks are not only the least efficient of the four modes but are the predominant users of fuel and energy. In 1976, they used 69 percent of the liquid fuel and 57 percent of the energy devoted to freight movement (Table 1, 5). If intercity trucking is weighed against trains and ships, it is seen to use half the energy but to carry only 30 percent of the ton-kilometers, resulting in an average energy intensiveness of about 2000 mm/s^2 (2800 Btu/ton-mile). This compares to about 500 mm/s^2 (700 Btu/ton-mile) for rail movements (7). Tables 2 (5) and 3 (8) reflect this relation between freight movement and energy use. Table 4, which notes trends in intercity truck and rail freight energy intensiveness, is derived from data in Tables 2 and 3. The method used to calculate energy intensiveness is noted below.

[The customary unit of energy intensiveness, J/kg•km (=kJ/t•km), is equivalent to a unit of acceleration, mm/s^2. The letter "t" is used herein as an abbreviation for the metric ton. In the English system, 1000 Btu/ton-mile is equivalent to 0.07369 ft/s^2. The energy intensiveness of a vehicle in fact represents the amount of constant acceleration it would deliver to its cargo if all of its energy were used to achieve acceleration. To get the energy required for a trip, multiply this acceleration (mm/s^2) by the mass moved (kg) and the distance covered (km); the result is in joules ($mm \cdot km \cdot kg/s^2 = kg \cdot m^2/s^2 = J$). It is also possible to use another method to obtain this result. Multiply the acceleration (energy intensiveness) in ft/s^2 by the mass in slugs and the distance in feet to get the energy use in foot-pounds.]

To be sure, the comparisons in the tables, text, and other sources are unfair to trucks because trucks carry materials of relatively low density. Yet it has been estimated (7) that even when carrying high-density materials, trucks operate at about 1350 mm/s^2 (1860 Btu/ton-mile). It is clear that the flexibility and speed of truck transport exact a substantial energy premium.

A comparison of rail and truck transport illustrates how speed and flexibility can cost energy. The steel rails that limit the extent of rail service reduce rolling friction. They permit freight cars to be pulled in long consists, which reduces air drag but necessitates time-consuming switching operations. The segregation of rail traffic on its own network also reduces the energy-consumptive stopping and starting to which vehicles on the highway are subjected. The sheer size of trains, compared to trucks, provides economy of scale with respect to energy use but simultaneously makes the rail system more sluggish and less flexible. Finally, the ability to control operating conditions on the rails permits the traction engines to be designed for a fairly narrow range of conditions. Highway vehicles must negotiate a greater range of inclines and must deliver a much greater range of torques and acceleration rates. One can build this kind of flexibility into an engine only by sacrificing efficiency.

The energy characteristics of water transport depend on which of the four classes of water carriers is at issue. These classes are lakewise shipping, which carries mainly iron ore, iron, and steel; coastal traffic, dominated by tankers and tanker-barges; and river and international shipping, each of which moves a variety of products. Due to the relatively high density and viscosity of water, ships and barges are not inherently more-efficient transportation devices than trains or even trucks. They use less energy per ton-kilometer because of a substantial economy of scale and because they move slowly. Lakes, oceans, and navigable rivers are big and float the biggest transport vehicles in existence. Big ships are more efficient principally because their surface area exposed to water drag is smaller per unit of cargo volume. A ship's energy intensiveness varies roughly with the square of its speed so that, as a rule of thumb, a 10 percent reduction in speed effects a 20 percent reduction in energy use (9). It happens that the economics and engineering of shipping have resulted in operating speeds that, in combination with economy of scale, make water shipping more efficient than rail shipping. Rose (7) estimates that energy intensiveness averages about 270 mm/s^2 (380 Btu/ton-mile) for coastal shipping, 370 mm/s^2 (510 Btu/ton-mile) for lakewise shipping, and 350 mm/s^2 (480 Btu/ton-mile) for inland shipping, compared to about 500 mm/s^2 (700 Btu/ton-mile) for rail shipping. (No reliable estimates for international water movements are available.) The energy advantage of inland water transport is offset, however, by the fact that rivers are crooked. A correction for circuity can be made by comparing energy use per ton per great-circle kilometer. Measured in this way, rail's energy intensiveness (7) is about 650 mm/s^2 (900 Btu/ton-mile), whereas the corresponding number for inland water transport is 670 mm/s^2 (920 Btu/ton-mile). It should be borne in mind, of course, that these numbers are only rough averages; transport efficiency varies enormously for different commodities and over different routes.

Pipeline transport is unique in that its vehicle is stationary. This and a substantial economy of scale enjoyed by large-diameter pipelines make them the most-efficient movers of oil and oil products. No reliable data for the nation as a whole exist, but pipeline movements of oil products from the U.S. Gulf Coast to the Atlantic seaboard achieve an energy intensiveness of some 200 mm/s^2 (270 Btu/ton-mile), compared to a minimum of 350 mm/s^2 (480 Btu/ton-mile) for competing coastal tankers (10). The greater circuity of the water route compounds even this advantage. The penalty for such efficiency, of course, is the inflexibility of pipeline transport. The routes are fixed when the pipe is buried, and the flow must remain near capacity for profitable operation. Pipelines are also suitable for only a very small class of commodities, albeit the class is growing with the development of various types of slurry pipelines (11). As for gas pipelines, they are considerably less efficient than oil lines but have no serious competitor for overland transport. Gas lines consume about 3 percent of the heating value of their cargo per 1000 km of movement, compared to less than 1 percent in case of oil lines, and they consume nationwide about three times as much energy as oil pipelines. The energy intensiveness of a pipeline is highly sensitive to the flow velocity and the pipe diameter, however. It varies roughly with the square of the flow velocity, and a rule of thumb, valid at least for oil pipelines, is that energy intensiveness is more or less inversely proportional to the diameter. [This assumes that flow velocity is independent of diameter, whereas oil tends to move somewhat more rapidly in large pipes. A study whose aim is to quantify the energy use and efficiency of oil pipelines more accurately is under way at Oak Ridge National Laboratory (12).]

I will not discuss pipelines further in this paper for two reasons. One is that pipelines consume relatively little oil. Three-quarters of pipeline energy is supplied by natural gas and nearly all the rest by electricity. Since 18 percent of electricity is generated by burning oil at roughly 30 percent efficiency (13), pipelines use indirectly about 0.6 million m^3 (4 million bbl) of oil per year, or only about 0.5 percent of that consumed directly for freight transport. The other reason for neglecting pipelines is that the allocation of fuel in an emergency will require maximum flexibility on the part of pipelines. Indeed, the ability of pipelines and other transporters of energy to implement a given allocation plan is too seldom weighed. In any case, the urgency of routing fuel to where it is needed would override any desire to conserve energy in its transport.

The obvious lesson to be learned from the foregoing is that any proposed scheme for saving fuel in an emergency

Table 1. Types of fuel and energy used by commercial freight transport modes, 1976.

Mode	Gasoline (m^3 000 000s)		Diesel Fuel (m^3 000 000s)		Residual Oil (m^3 000 000s)		Liquid Propane Gas (m^3 000 000s)		Jet Fuel (m^3 000 000s)		Electricity (kW·h 000 000 000s)		Natural Gas (m^3 000 000 000s)	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
Truck[b]	47.3	100	36.3	68	0		1.0	100	0		0		0	
Marine[c]	0		4.5	8	18.7	95	0		0		0		0	
Pipeline	0		0		0		0		0		11.3	100	15.5	100
Rail	0		12.4	23	0.9	4	0		0		0		0	
Air[e]	0		0		0		0		0.6	100	0		0	
All modes	47.3	100	53.3	100	19.6	100	1.0	100	0.6	100	11.3	100	15.5	100

[a]Assumes 38.49 billion J/m^3 (138 100 Btu/gal).
[b]Excludes government-owned trucks and all trucks used primarily for personal transportation.
[c]Includes fuel purchased in the United States for both domestic and international shipping.
[d]No breakdown by fuel is available.
[e]Includes only freight aircraft operated by U.S. certificated air carriers; fuel used to transport belly freight in passenger craft is excluded.

Table 2. Trends in commercial freight transport energy use by mode, 1967-1976.

Mode	Energy Use (PJ) 1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
All modes	4251	4422	4584	4808	4914	5190	5484	5243	5066	5318	NA
Truck[a]											
Local	1398	1439	1474	1486	1513	1567	1589	1468	1434	1452	NA
Intercity	853	943	1034	1089	1201	1329	1488	1451	1424	1526	NA
Marine[b]	642	693	670	716	651	653	778	756	802	954	1061
Pipeline	840	856	901	1001	1028	1053	1006	943	846	803	791
Rail	517	491	504	515	522	588	624	625	561	584	595

Note: 1 J = 0.001 384 Btu; NA = not available.

[a]Local trucking is that mostly in the local area (in or around the city and suburbs, or within a short distance of the farm, factory, mine, or place where the vehicle is stationed). The rest is classified as intercity. Estimates are based on interpolation and extrapolation of the percentages of each fuel type used for local and for intercity trucking in 1967 and 1972.
[b]Military shipping excluded.

Table 3. Trends in commercial freight movement by mode, 1970-1977.

Item	Movements (t·km 000 000 000 000s) 1970	1971	1972	1973	1974	1975	1976	1977
Intercity trucks[a]	601	628	687	736	723	664	745	803
Rail[b]	1121	1086	1141	1255	1243	1107	1153	1199
Inland waterways[c]	465	460	496	521	517	501	546	541

Note: 1 t · km = 0.684 ton-mile.

[a]Includes movements between cities and between rural and urban areas. Rural-to-rural movements and city deliveries are omitted.
[b]Revenue movements.
[c]Excludes coastwise and intercoastal movements.

Table 4. Trends in intercity truck and rail freight energy intensiveness, 1970-1977.

Intercity Mode	Average Energy Intensiveness (kJ/t · km = mm/s^2) 1970	1971	1972	1973	1974	1975	1976	1977
Truck[a]	1810	1910	1940	2020	2010	2150	2050	NA
Rail[b]	459	481	514	497	502	507	507	496

Note: NA = not available.

[a]Calculated by dividing energy use in Table 2 by movements in Table 3. The fact that the Table 3 figures do not account for long-distance movements from one rural area to another, while the energy use estimates do, makes the above estimates of energy intensiveness slightly high. Also, the energy intensiveness of an average loaded truck would be somewhat lower because the energy-use estimates in Table 2 cover the fuel used to drive empty trucks. The above figures are appropriate, however, for assessing the efficiency of truck transport as a system. Yet they should be interpreted with caution due to the difficulty of obtaining reliable estimates of energy use and movements.
[b]Calculated by dividing energy use in Table 2 by movements in Table 3. The energy intensiveness of an average loaded train would be somewhat lower because Table 2 covers energy use for switching and hauling empty trains, and Table 3 covers only revenue ton-kilometers shipped. The above numbers are appropriate, however, for assessing the efficiency of the rail system as a whole.

should be scrutinized for a corresponding degradation in service.

MODAL SHIFTS

The greater energy efficiency of the rail and water modes described earlier suggests that a quick transfer of shipping from truck to these modes could stretch fuel supplies. This suggestion is strengthened by results of the Transportation System Center's Freight Energy Model (14), evidently the most comprehensive and detailed effort to account for the behavior of freight transport. This model incorporates a somewhat aggregated representation of the U.S. freight network, including access points and transfer points. It takes into account the cost of movement over each link, travel and transfer times, costs of loading and transfer, link capacities and congestion, the effect of congestion on energy use, the effects of long-term contracts, and a number of other factors. One particular run of the model directed each shipper to choose modes so as to minimize the energy required to deliver cargo, regardless of cost. This policy was to be in effect through 1990. During this period, no technological or system improvements were allowed. A base case run of the model set up similar conditions but directed shippers to minimize costs, and it too ran to 1990. Not surprisingly, rail and marine's share of freight movement increases substantially when shippers are directed to minimize energy use.

The model indicated that the total intercity freight energy requirement drops by one-third when shippers do their best to save energy. This can be taken as an absolute upper bound on the saving that could be achieved in an

Total Liquid Fuel (m^3 000 000s)		Total Energy (PJ)		Crude Oil Equivalent[a] (m^3 000/day)
Amount	%	Amount	%	Amount
81.8	69	2977	57	212
23.2	19	954	18	68
0.1[d]	0	726	14	52
13.3	11	584	11	42
0.6	1	23	0	1.6
119.0	100	5264	100	375

emergency through modal shifts. In other words, the available fuel could be cut 31 percent, at an absolute maximum, without a reduction in the ton-kilometers shipped. Degradation of service does occur. Bronzini's figures imply that the ton-weighted average transit time for the portion of cargo shifted from truck to train would rise from 0.8 days to 6.8 days, assuming that the shifted freight gets average rail treatment. The heavy use of expedited trailers on flatcars (TOFC) would improve service for this freight, but it should be realized that TOFC transport is not as efficient as customary rail transport.

There are several reasons why modal shifts would not obtain anything like the 31 percent maximum fuel saving. One is that those who make the choice of mode, unlike the carriers themselves, would not ordinarily have an immediate incentive to conserve fuel during a crisis. Their object is to ship their freight quickly and cheaply. Consequently, any shift away from trucking would be that occasioned either by prohibitive rates (in instances where regulations would permit tariffs to reflect exorbitant fuel costs) or simply by the unavailability of trucks with fuel in the tank. The high cost of fuel would presumably have little effect on the modal choice of firms served by their own private carriers because an idle fleet of trucks could be economically disastrous for a firm. Similarly, many patrons of common carriers would pay dearly rather than subject their freight to railroad delays. Delays not only can spoil merchandise and alienate customers, but they can necessitate more warehouse space than is available or affordable. The surest motivation for a shift would be dry fuel tanks aboard a fair portion of the nation's trucks. Demand for rail transport under such unprecedented circumstances is inextricably bound up with the way a fuel crisis would alter demand for freight transport in general. Its prediction would be a herculean task, one that to my knowledge no one has undertaken in a serious way.

Another factor limiting modal shifts away from trucks during a crisis is the capacity of railroads to absorb their share of the diverted freight. Industry sources tend to be optimistic about the ability of the railroads to accommodate sudden influxes of new business and point to the rapid escalation of coal shipping over rail in the West after the 1973 embargo. But this optimism is not universal. The only general consensus regarding rail capacity is that it would be limited much more by the availability of cars and locomotives (in the short term) than by congestion, except in such bottleneck areas as high-volume seaports. Bronzini's model in fact indicated that the increase in traffic described above would not, generally speaking, cause problems of congestion. (The increase in ton-kilometers does not fairly represent the magnitude of the demand for new rail capacity because the new cargo is relatively less dense.) It is difficult to gauge, however, the ability of rolling stock to accommodate higher demand.

The ability of new freight to find a place on the rails would depend in part on whether it happens to be so routed that it could fill some of the rolling empties. Opportunities to boost quickly the number of available cars are limited. Sources at the Association of American Railroads indicate that the railroads are retiring cars earlier than in the past and would have the option of refurbishing these old cars rather than junking them. Such a move would be cost-ineffective in the long run but would be useful for supplying cars in the short run. As for new cars, there is already a backlog of orders for them.

Even if car space were found, it would probably be more difficult to find locomotives. It is difficult to obtain firm data on this point, but it appears that locomotives are used close to their capacity now. Lead time for ordering a new locomotive is at least six months, and a rise in demand would, of course, lengthen the delay. In the event of a fuel crisis, many railroaders would undoubtedly clamor for relief from regulations requiring branchline service. Besides making things more profitable for the railroads, this would free locomotives to pull longer consists on main lines and, as a bonus, would upgrade energy efficiency. But a reduction in branchline service would not only turn away some of the business for which room is being made, but it would of course necessitate an increase in truck service to the cut-off areas, potentially defeating the purpose of expanding railroad capacity. The new truck service would not only use more fuel but, if fuel supplies are very short, it may simply be unavailable. Thus, it appears unwise to count on the ability of railroads to provide a large immediate increase in freight service. If they accommodate a massive shift from trucks, it would be at the expense of service already provided.

There are yet other obstacles to a sudden shift in modes: limited waterway capacity (at least in the short run), long-term contracts with carriers, and so on. The foregoing observations do not prove that modal shifts cannot help significantly during a fuel crisis. But they do, I maintain, shift the burden of proof to one who would contend otherwise.

TRUCKS

A glance at Table 3 reveals what is happening to intercity trucking. It is booming. Table 2 shows that the resultant increase in energy consumption by intercity trucking accounts for two-thirds of the 1967-1976 increase in total freight transport energy use. (The reader is reminded that these are not firm data, because the fraction of the annual consumption of each fuel type that is attributed to intercity trucking is an interpolation or extrapolation of fractions derived from 1967 and 1972 data. It is certain, however, that intercity truck fuel use rose substantially between 1967 and 1972, by an amount close to that indicated in Table 2.) Table 4 documents the consequences for the efficiency of freight movement. The average energy intensiveness for overload transport (except pipeline) increased from about 900 mm/s^2 in 1970 to about 1100 mm/s^2 in 1976 (1300-1550 Btu/ton-mile). The energy intensiveness of intercity trucking itself appears to have been increasing up to the time of the 1973 embargo. These facts corroborate the popular observation that our economy is tending more and more to emphasize high-value, low-density goods—goods economically suited for energy-intensive truck transport. This trend does not bode well for our ability to weather another oil shutoff, except to the extent that these light goods are inessential gadgets we can well do without for a while.

But let us first examine whether, in a pinch, the trucking industry can move the same goods with less fuel. I will first discuss three proposed ways to reduce intercity fuel consumption: (a) slow down, (b) load the empties, and (c) use mechanical devices.

Slow Down

The energy advantage of slowing down is hotly debated, but it has been firmly established to exist (8). To begin with, the resistance to a typical [i.e., gross vehicle weight (loaded) = 27 700 kg (61 000 lb); frontal area = 8.9 m^2 (96 ft^2); normal road surface] truck's motion on a straight, level road in still air falls 16 percent when its speed drops from 105 to 90 km/h (65 to 56 mph). So, if air and road resistance were the only variables, fuel use per mile would be some 16 percent less for a typical truck at 90 km/h than at 105 km/h. The fact that diesel engines generally run more efficiently at low rpm tends to increase the saving, and the fact that lower speeds often require lower gears tends to decrease the saving. On-the-road tests put the saving at about 15 percent (15,16). In the well-publicized 55-mph road tests, staged by the Voluntary Truck and Bus Fuel Economy Program, 32 randomly picked truckers used an average of 9.3 percent less fuel at 55 mph than at an average higher speed of 62.3 mph on a level track (17). After examining driver reports of rpm and gear choices, as well as manufacturers' specifications for the tractors, analysts claimed that this 9.3 percent advantage could have been 13.9 percent if the drivers had shifted correctly. Some drivers, they said, used unnaturally low gear ratios at 55 mph. If they are right, a straight-line extrapolation would put the advantage of 105 over 90 km/h at about 17 percent.

The effect of slowing down seems to show up in the national data. Table 4 shows the energy intensiveness of intercity truck transport increasing until about the time the national 55-mph limit was imposed. Although the margin of error in these figures is of the same order of magnitude as the annual variations, it is difficult to believe that this distinctive pattern in the data is the result of random error. One might argue that, since average truck speed on rural highways, according to an FHWA study, fell only from 91.1 to 88.2 km/h (56.6 to 54.8 mph) between 1973 and 1975, speed reductions could not explain an improvement in fleet fuel efficiency. But the variance of the distribution of speeds appears to have narrowed considerably. In 1973, 31 percent of highway vehicles clocked was moving at least 8 km/h (5 mph) faster than the average speed, while in 1975 only 21 percent was moving at least 7 km/h (4 mph) faster than the average speed; average speed (18) had dropped from 97.0 to 89.8 km/h (60.3 to 55.8 mph). These latter data were unfortunately not collected for trucks in particular, but it is reasonable to assume the variance of truck speeds likewise decreased. This reduction in the variation of speeds would, due to the nonlinear relation between speed and fuel use, tend to improve efficiency. A narrower range of speeds also implies less acceleration and deceleration, and this would also contribute to higher overall efficiency. It appears, then, that speeds may have changed enough to account for the apparent leveling of truck energy intensiveness.

Although no one knows exactly the effects of speed on fuel efficiency under everyday driving conditions, it is difficult to deny that many truckers could cut fuel use 10 or 15 percent with a modest, perhaps proportional, reduction in speed. To be sure, such a reduction would probably cost money in ordinary circumstances because fuel costs represent only some 6 percent of a motor carrier's costs (19). The question is whether short fuel supplies would provide the incentive for a speed reduction. Insofar as a trucking firm or private carrier can control the speed of its drivers, the aggregate fuel saving of reducing speed would provide strong incentive for doing it. The cost of traveling 10 or 15 percent fewer miles due to lack of fuel can only outweigh the costs of a reduction in speed. (If every reduction in speed causes a certain loss of business, then the optimal solution would be an intermediate one in which speed and miles traveled are reduced a certain amount; solution of a nonlinear program would indicate how much.) The larger motor carriers claim, however, that their trucks already travel under 55 mph (although it is often unclear whether it is only the average of a rather wide distribution of speeds that is under 55 mph) because the cost of fuel has already made it economical to do so. If it is true that the large motor carrier fleets stay close to 55 mph already, it is unclear to what extent further speed reductions would improve their fuel efficiency. Because of the sensitivity of fuel consumption to terrain, equipment, and the driver at these speeds, there is no reliable estimate of the average savings of slowing down to, say, 45 or 50 mph. As for owner-operators, everyone says they drive fast, but the incentive to slow down imposed by a fuel shortage is less clear in their case. The 10, 15, or 20 percent saving of reduced speed would not often make the difference between making a run and not making it, and it can be argued that independent truckers, who cannot accumulate small savings as can trucking firms, would view the matter one trip at a time.

Load the Empties

Much has been made of the fact that a fair portion of trucks on the road is empty. An Interstate Commerce Commission (ICC) survey of 13 000 trucks on Interstate highways found in 1976 that about 20.4 percent of truck miles is empty truck miles (20). Table 5 shows the results of the survey in further detail. The fraction of truck fuel burned to propel these empty trucks depends on the distribution of truck speeds. A rough lower bound on the fraction can be had by calculating that some 60 percent of the resistance encountered by an average truck moving at 50 km/h (31 mph) is due to factors other than the weight of the cargo. An average truck is taken here to be one having the average tare weight and carrying the average cargo weight among trucks sampled in the ICC survey—12 500 kg (27 000 lb) and 13 600 kg (30 000 lb), respectively. If 20.4 percent of truck miles is empty, this suggests that at least 12 percent of intercity truck fuel is used to haul empties. This is a lower bound because the presence of cargo weight is a less important factor at speeds over 50 km/h and because drive-train resistance (not estimated above) reduces further the relative contribution of cargo weight to fuel use.

How many of the empty truck-miles can be eliminated? The ICC study (20) found that most empty haulage is necessary due to specialized equipment and commodity flow imbalances. Nonetheless, a fair portion of empty trucks drive past one another in opposite directions. Some 17 percent of these empty trucks (a) consisted of the same basic type of equipment, (b) normally carried compatible commodities, and (c) could have avoided at least 25 percent of their combined travel distance and at least 50 miles had they found an opportunity to exchange loads. This number may fail to take into account all the equipment barriers to exchanging loads, but, on the other hand, it does not reflect potential savings involving trucks using different routes. If 17 percent of empty truck miles were eliminated, the intercity truck fuel savings, conservatively estimated, would be about 2 percent.

Use Mechanical Devices

Most technological improvements in fuel efficiency cannot be extensively installed or adopted under the pressure of an emergency. Two that can be put to use in a matter of months are rpm governors and aerodynamic aids. Governors are already widely installed among truck fleets, and many firms order trucks with engines that are rated to limit fuel injection and, hence, power output. It is agreed that no governor is tamper proof, and various devices designed to disable governors are sold at truck stops. But no one seems to want to deny that governors can slow down a fleet. As discussed earlier, however, it is questionable to what extent existing governor settings would or should be changed in the event of a fuel crisis.

Air drag is particularly bothersome for trucks because of their high speed and their shape. Boxlike trailers and bluff cabs, smashed flat to make room for longer trailers within legal limits, generate about 50 percent of a truck's moving

resistance at 105 km/h (65 mph) in still air. Crosswinds can worsen drag considerably because they set up turbulence on the lee side of the truck (21). Several add-on devices have been designed to smooth out some of the worst of the turbulence. Aside from the popular cab-top deflectors, there are nose cones for trailers, vanes for directing air around corners, and flexible gap fillers for reducing the eddies between the tractor and trailer. Manufacturers' claims for fuel-use reduction with such devices range as follows (22): deflectors, 6-33 percent; vanes, 3-27 percent; and gap fillers, 6-13 percent. Practical experience suggests that fuel economy improvements are more on the order of 3-5 percent for such devices (6,8,23). Many trucks already bear an aerodynamic appliance, however, and the fuel savings of two or more devices on the same truck are not additive. Furthermore, a stymied crisis economy can make and deliver a limited, if perhaps substantial, number of these appliances in the space of a few months. It is unlikely, then, that aerodynamic devices can be of significant help during a fuel crisis.

All in all, it appears that the most effective way to cut intercity truck fuel use in a crisis, short of reducing service, is to slow down. However, reduced speed itself degrades service and, when trucks are used to capacity, can reduce the ton-kilometers shipped. Since yet untapped fuel savings to be had from slowing down appear to be significant but not large, the dominant response of the intercity trucking business to a severe fuel shortage would be to curtail the number of miles driven. The number of ton-kilometers carried would not fall proportionately because many of the least-productive runs would be cut first. This is not meant to suggest that the scene would be one of orderly optimization. Disruption of deliveries in one sector can have repercussions along an entire chain of production and delivery so that a carrier's most-productive routes might dry up overnight. Yet insofar as a carrier's customers remain predictable, it can pick and choose among them—within the limits of law and contract, of course—so as to make better use of its fuel. Can the extent of service reduction be quantified in advance? Here again, any attempt to forecast economic behavior in such a volatile situation, it seems, must assimilate so many of the details of the economy and the freight transport system as to be hopeless.

It would be unwise to ignore local trucking, which consumes nearly as much fuel as intercity trucking. Table 6 (5) and the data below (5) provide insights to fuel and energy use by commercial trucking:

Fuel Type	Local Trucking	Intercity Trucking	Total
Gasoline (m^3 000 000s)	33.8	10.7	44.5
Diesel (m^3 000 000s)	6.5	29.8	36.3
Liquid propane gas (m^3 000 000s)	1.0	0	1.0
Total energy (PJ)	1450	1530	2980

There is potential for saving some of this fuel in the intelligent choice of delivery routes and consolidation of delivery runs. About half of local trucking fuel is burned by pickups, panel trucks, beverage trucks, and garbage trucks (Table 7, 5), and a good many of these trucks make fairly regular pickup, delivery, or service calls. The largest operators claim that their routes are optimally chosen already, due to the clear economic incentive to do so. They insist that any reduction in fuel means a reduction in service. This is probably not the case, however, with respect to the multitude of smaller operators. The problem of optimal routing is theoretically quite difficult, but algorithms that produce a good, if perhaps suboptimal, routing can be applied by experts. The general impression of persons in operations research is that few firms have cared to sustain the expense of hiring a consultant for this purpose, even though it is common for an optimizing of routes to result in a 10 or 15 percent savings in expense and distance traveled.

In any case, even if optimization of routes would help little, there appears to be a good deal of flexibility in local trucking. By cutting the frequency of runs so as to raise load factors, consolidating pickup-truck errands, and so on, fuel use could be reduced significantly, albeit service and convenience would undoubtedly suffer. This is not to say that a firm should cut out delivery or pickup altogether, however, since customers may consume even more fuel as they come by to pick up or deliver goods. These matters could be quantified, but extensive and expensive surveys of local trucking would appear to be necessary to obtain reliable estimates of the possibilities for fuel conservation during a crisis.

RAIL

Railroad consumption of energy is already low. Railroads use about 11 percent of the energy consumed for freight transport, less than any other freight mode except air

Table 5. Survey results of empty truck miles on Interstate highways, 1976.

Category	No. of Trucks Sampled	Empty Truck Miles (%)
All trucks	13 165	20.4
Van	6 645	18.1
Refrigerated van	2 164	14.8
Flat or lowboy	2 304	18.9
Tank	1 073	38.0
Bulk	410	39.3
Other	487	30.7
ICC authorized	7 243	16.2
Exempt	1 403	21.2
Private	4 458	27.3
Intrastate	2 547	32.9
Interstate	10 572	17.6
Not owner-operator	10 058	21.5
Owner-operator		
Long-term lease (>30 days)	2 471	18.1
Short-term lease	312	7.6

Table 6. Percentage of commercial truck fuel and energy use by fuel, range, and weight, 1976.

Weight Class[a] (lb)	Local Trucking Gasoline	Local Trucking Diesel	Local Trucking LPG	Local Trucking Total Energy	Intercity Trucking Gasoline	Intercity Trucking Diesel	Intercity Trucking Total Energy	Total Gasoline	Total Diesel	Total LPG	Total Total Energy
0-10 000	27	0	68	39	49	0	12	47	0	68	25
10 000-20 000	29	6	13	25	21	1	6	27	2	13	15
20 000-26 000	7	2	5	6	6	0	2	7	0	5	4
>26 000	17	92	14	3	24	99	81	19	98	14	56

Note: 1 kg = 2.2 lb.

[a]Based on extrapolation to 1976 of percentages derived from 1967 and 1972 data; percentages may not add to 100 due to rounding.

Table 7. Local and intercity truck energy use by body type, 1976.

Body Type	Percentage Consumption[a] Local Trucking	Intercity Trucking	Total
Pickup or panel truck	46.2	12.9	29.1
Platform truck	15.1	21.2	18.2
Cattle rack	3.5	3.2	3.3
Insulated van	1.0	5.6	3.4
Refrigerated van	1.8	11.6	6.8
Furniture van	1.7	5.8	3.8
Open-top van	0.4	1.1	0.8
Other enclosed van	8.3	26.3	17.6
Beverage truck	1.0	0.9	0.9
Utility truck	6.1	7.9	7.0
Garbage truck	1.4	1.4	1.4
Winch or crane	1.3	2.1	1.7
Wrecker	1.2	1.3	1.3
Pole or logging truck	1.2	2.6	1.9
Automobile-transport truck	0.2	2.3	1.3
Dump truck	9.4	12.1	10.8
Tank truck (liquids)	3.9	10.7	7.4
Tank truck (dry bulk)	0.5	2.7	1.6
Concrete mixer	1.6	1.5	1.5
Other	0.0	0.2	0.1

[a]Based on extrapolations of percentages derived from 1967 and 1972 data.

freight. Still, there is some potential for improving fuel efficiency in the rail system.

A few months of fuel shortage do not provide time for any appreciable technological improvements so that operational improvements must carry the day. Several have been suggested. One is to impose a speed limit, perhaps 65 km/h (40 mph), as has been done by the Soo Line (24). It is true that the resistance to the motion of a typical 100-car train is about 12 percent less at 65 km/h (40 mph) than at 75 km/h (47 mph). But it is unclear how much time freight trains spend moving at speeds above 65 km/h, and fuel saving depends as much on the manner in which the train is accelerated and braked as on the speed it attains. Partly for these reasons, there are no good estimates of the potential fuel saving that a speed limit would effect. Yet, in combination with a policy of closely matching traction horsepower to the consist and the track conditions, speed reductions can pay off. The Union Pacific Railroad achieved an 8 percent reduction in fuel use in its first year under such a policy and more in subsequent years (24).

One advantage of this or any fuel conservation policy is that it induces more careful accounting of fuel use. As things are, fuel is not ordinarily metered as it is pumped into a locomotive, and, by one estimate, some 4 percent of railroad fuel is lost through spillage (24). Although this is an obvious area for improvement, it is unclear that all of this fuel is actually spilled; some may be stolen, for instance. Also, spilled fuel is commonly caught in pans and sold for heating or salvage, or occasionally recycled for railroad use.

One railroad practice that has raised eyebrows is the extensive idling of locomotives. Two estimates of idling time are 40 percent (19) and two-thirds (24) of total operating time. The resulting energy use estimates are 2.4 percent and 4 percent, respectively, of railroad energy use. But the reasons for allowing a locomotive to idle are many. Coolant tends to leak past seals when the engine is shut down, requiring a time-consuming inspection before startup, and coolant will freeze if the weather is cold. Batteries are unreliable, and the time and separate labor required for recharging is expensive. Some railroads have adopted a policy of shutting down a locomotive in mild weather rather than let it idle for several hours, others have installed heaters to prevent freezing, and still others have installed a low-idle setting for long idle periods. The upshot is that the gradual installation of new technology can make a dent in idle fuel use, but emergency measures probably cannot.

Another possibility is heavier loading of cars. In 1977 (25), 26.2 billion loaded car-km (16.3 billion car-miles) of movements carried 1441 billion t-km (987 billion ton-miles) of freight, so that the distance-weighted average load per car was 54.9 t (60.6 tons). Since the average car capacity in 1977 was 68.5 t (75.5 tons), the average loaded car was filled to about 80 percent of its weight capacity. It has been estimated that there is space in these cars for about 5 percent more weight than they now carry (26). If heavier loading were to cut car-miles by 5 percent, an estimated 3 percent fuel saving would ensue. It is often difficult to arrange for a capacity loading, however, and heavier cars increase wear on the tracks. The heavy loading would be temporary, but it has been noted that six months of this could do significant damage. Yet little harm is done in bringing the lighter cars up to the average, and this could effect a marginal fuel saving.

Rail cars are sometimes delivered via a longer route than necessary, and this wastes a certain amount of fuel. A railroad can sometimes increase its share of the revenue to be collected for hauling a certain car by moving the car to its destination in a roundabout way rather than turning the car over to another railroad that offers a shorter route. Shippers sometimes specify circuitous routings to get better service from a particular railroad or to obtain some free storage in transit while a warehouse at the destination is being cleared out (24). It is impossible to estimate the extent of circuitous routing, however, unless a detailed flow analysis of the railroad network is carried out, an expensive job requiring more data than the railroads now provide.

Table 8 (7) estimates the ratio of empty to loaded ton-kilometers for different commodity classes--the ratio most relevant to energy use. The average ratio, weighted by the energy used in transporting each class, is 0.36. So, if all empties were eliminated, about 26 percent of ton-kilometers would be eliminated. This means that about one-quarter of rail energy is tied up in moving empties. (This assumes the locomotive requires no energy for its own propulsion—an assumption that tends to result in an overestimate—but it also assumes that the resistance provided by a car is proportional to its weight, which tends to result in an underestimate.) A good deal of empty traffic is the inevitable result of specialization in cars, however, and the ratio of empty to loaded movements has correlated highly with the relative number of specialized cars in operation (27). Yet, 46 percent of railroad energy was used to move boxcars in 1976, and the energy-weighted ratio of empty to loaded boxcar movements was even higher, 0.38. Elimination of empty boxcars, then, would reduce energy use about 13 percent, and elimination of empty boxcars without special equipment (about 65 percent of the fleet) would bring an 8 percent reduction in energy use.

If equipment imposed the only constraint, then, from 8 to 13 percent of rail energy could be saved by getting rid of empties. But imbalances of flow also constrain the matter. Traditionally, more rail freight has moved east and north than west and south, and the empties must be returned. A nationwide coordination of rail car use designed to reduce empty movements would do so at the expense of causing car shortages in the exporting areas. Conversely, enforcement of an ICC regulation requiring that empties depart the Northeast within 48 hours of arrival has eased shortages in the South and West but has increased empty-car movements (24). It is impossible to say, then, just how much the movement of empties can be cut without upsetting the distribution of cars. The railroads generally insist that the system is trimmed to the bone already due to the many costs of tying up cars in backhauls. But the most efficient use of cars requires cooperation among railroads, and competition often obstructs cooperation that, other things being equal, would benefit everyone. A tenable estimate of unnecessary backhaul movements would require a network study of the sort needed to measure circuity that can be eliminated. The Association of American Railroads is now studying freight car use, and some useful conclusions regarding empty movements may ensue.

Table 8. Rail freight load factors by commodity.

Commodity Class	1972 Ratio of Empty to Loaded		1976 Ton-Kilometers in Boxcars (%)
	Car-Kilometers	Ton-Kilometers	
Coal	0.91	0.22	0
Food and kindred products	0.84	0.35	31
Chemicals and allied products	0.95	0.30	23
Farm products (mostly grain)	0.87	0.30	27
Lumber and wood, except furniture	0.74	0.31	68
Pulp, paper, and allied products	0.95	0.41	92
Nonmetallic minerals, except fuels	0.91	0.26	17
Stone, clay, and glass	0.82	0.30	48
Primary metal products	0.78	0.27	37
Transportation equipment	0.69	0.42	46
Metallic ores	0.93	0.26	5
Petroleum and coal products	1.02	0.38	12
Miscellaneous mixed shipments[a]	0.70	0.41	100
Freight and forwarding traffic[a]	0.70	0.42	100
Fabricated metal products	0.76	0.38	49
Machinery, except electrical	0.69	0.42	27
Electrical machinery	0.70	0.47	79
Rubber and miscellaneous plastic products	0.70	0.45	90
Basic textiles	0.69	0.44	81

Note: 1 km = 0.6 mile; 1 t·km = 0.684 ton-mile.

[a]All shipments assumed to be in boxcars.

WATERWAYS

It is difficult to estimate how much fuel is consumed by the different branches of waterborne commerce, but data on the amount of commerce carried provide some idea. In 1976, domestic movements accounted for 47 percent of the 1665 million t (1835 million tons) involved in U.S. trade. Of the 864 billion t-km (592 billion ton-miles) shipped domestically, 55 percent was coastwise, 12 percent lakewise, and 33 percent internal (28). The fuel purchased in the United States for these operations comprised some 19 percent of 1976 freight transport fuel use in this country.

The fuel efficiency of waterborne transport can most readily be improved by slowing down the boats, and the potential saving is substantial. It was mentioned earlier that the energy intensiveness of a ship varies with the square of its speed so that a 10 percent drop in speed brings roughly a 20 percent saving in fuel (29). It is true, of course, that reduced speed not only degrades service but limits capacity. Yet, even in the worst case, in which capacity decreases proportionately with speed, a limited fuel supply goes furthest when the speed is reduced. It is easy to derive that, in these circumstances, the optimal speed, as well as the resulting distance covered, varies with the cubic root of the quantity of fuel available. That is, a 30 percent fuel shortage would dictate at least a 10 percent reduction in speed, which would result in at most a 10 percent reduction in the distance traveled. So the potential for fuel conservation, at least on oceans and lakes, is considerable. The situation on rivers is slightly less clear because speed reductions entail a smaller separation between barge tows and congestion and collisions could result. Yet, it should be a straightforward matter to predict the effects of reduced speed on traffic, given current flows.

Speed reductions can undoubtedly dull the competitive edge of the water mode, resulting in financial trouble for the industry as well as discouraging use of an energy-efficient mode of transport. One can assume that the difficulty of securing transport during a fuel crisis would at least partially offset this disincentive, but foretelling the behavior of shippers with any accuracy would suffer the same difficulties that beset crisis economics in general.

Another, but related, possible strategy for fuel conservation, at least in maritime shipping, is rationalization. This ill-chosen term refers to the pooling of vessels from different lines in such a way as to move the same freight more efficiently. The most-often proposed strategy is to coordinate routings so that each port is served by fewer ships rather than permitting ships from a large number of lines to compete for business in each port. This would raise load factors and allow ships to travel shorter distances because they no longer would make the rounds of several ports looking for cargo. As a result, fewer ships could be operated, or the same ships could be operated at lower speeds, without a reduction in tons shipped. Such an arrangement certainly has drawbacks. Shippers at a given port would have fewer competing lines to choose from, and departures, at least at the smaller ports, would be more widely spaced. Despite these drawbacks, the formation of such pools is far from infeasible. Following the 1973 embargo, the Federal Maritime Commission requested rationalization proposals and received several. The seven carriers operating on the North Atlantic submitted the most elaborate plan, and an examination of their situation provides a good illustration of the fuel saving possible through rationalization. A scheduling and routing of these 33 vessels worked out for the National Maritime Research Center accommodates current commodity flows while reducing speed and fuel use (30). On this hypothetical pooling, average speed would be reduced from 39 to 28 km/h (21 to 15 knots), and fuel use would shrink from 855 to 447 L/20-ft container equivalent (from 5.38 to 2.81 bbl/ton-equivalent unit)—a saving of nearly 50 percent.

Rationalization may be undesirable in the long run because it precludes competition. But the long-run evils of a lack of competition would not be an objection to a temporary rationalization agreement arranged solely in order to weather a fuel crisis. It can be presumed that a fuel shortage affecting the United States would probably involve other nations sufficiently to ensure a bilateral incentive to set up such a pool. On the other hand, the North Atlantic agreement was slow and tedious in its formulation due to disagreement over the fraction of revenues to be allotted each line. It is possible that such pooling agreements would not be arranged quickly enough to do much good in an emergency. But there is no reason a contingency pooling could not be worked out in advance, ready to go into operation whenever the participants agree the situation warrants it.

COMMENT

In closing, it should be noted that it is evidently possible to gauge the ability of our freight transport system to adapt to a temporary fuel shortage. The assessment can be difficult and expensive, especially in the highway and rail modes

where it would require a detailed network-flow analysis and extensive surveys. But there is no reason to believe it cannot be done.

It should also be noted that it is probably impossible to forecast what freight carriers and shippers would do with this sytem if a fuel crisis happened, even once regulations binding them have been specified. It is impossible because their behavior depends on both the logisitics and the economics of freight transport during a crisis and, worse, because the logistics and economics depend on each other.

Logistics has to do with where the freight is, where it is to go, how it can get there, and who has the fuel. Without this information one can only estimate what freight carriers could do with a given amount of fuel; a carrier cannot predict what would happen unless it was known how much freight there is to be moved and how much fuel there is to be burned. U.S. industry is complex and a disruption of fuel supplies upsets, among other things, the customary location of freight and demand for its movement. The location of the fuel needed to move it would be subject to similar disturbances. To trace the effects of this disruption would require two kinds of knowledge, neither of which exist. It would require detailed knowledge, all coherently assembled in one place, of the physical operation of industry and the role of transportation in it. It would also require a superhuman grasp of the economic forces that would influence this operation during a crisis.

It is even more difficult to master the economics than the logistics. Economic models ordinarily presuppose some kind of equilibrium in the marketplace, traditionally a price equilibrium. The advantage of this presupposition is similar to that of assuming a steady state in physics and engineering—it permits one to overlook a great deal of detail as to how the system moves from one state to another. But during a crisis it is unlikely that economic equilibrium would be achieved. The exchange of goods would be a direct function of where the goods are and whether they exist as well as their price. In other words, the price of a commodity would come to encode less information about its availability. Under these conditions, steady-state economics would be even less valid than it is ordinarily. The dynamics of the mechanisms whereby prices tend to equilibrium would need to be analyzed. Since this analysis would require that the logistics of supply and transport be taken into account, economics would depend on logistics and vice versa. Also, there is the additional wrinkle that consumers behave differently in a crisis than in ordinary situations. Economists, who find the prediction of equilibrated prices hard enough already, have made little progress in these more-difficult areas.

We cannot foretell, then, just what would happen during a fuel crisis, but this does not mean we cannot prepare for it. The best preparation, of course, is one that has already begun among many freight carriers: Cut fuel consumption now through programs that are too long to implement during an emergency.

REFERENCES

1. J.C. Fisher. Energy Crisis in Perspective. John Wiley and Sons, Inc., New York, 1974.
2. Annual Report to Congress—Statistics and Trends of Energy Supply, Demand, and Price. U.S. Energy Information Administration, May 1978, p. 3.
3. Crude Petroleum, Petroleum Products, and Natural Gas Liquids. Energy Data Reports, U.S. Department of Energy, Sept. 1979.
4. W.F. Gay. National Transportation Statistics. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, Annual Rept., Sept. 1978.
5. J.N. Hooker, A.B. Rose, and D.L. Greene; Oak Ridge National Laboratory. End Use Energy Consumption Data Base: Transportation Sector. U.S. Energy Information Administration, in press.
6. Jack Faucett Associates. Trucking Activity and Fuel Consumption: 1973, 1980, 1985, and 1990. U.S. Department of Energy, 1976.
7. A.B. Rose. Energy Intensity and Related Parameters of Selected Transportation Modes: Freight Movements. Oak Ridge National Laboratory, Oak Ridge, TN, ORNL-5554, June 1979.
8. Motor Vehicle Facts and Figures, 1978. Motor Vehicle Manufacturers Association, Detroit, 1978.
9. Evaluation of Maritime Industry Energy Consumption Profiles. Maritime Administration, U.S. Department of Commerce, Dec. 1977.
10. J.N. Hooker, A.B. Rose, and K. Bertram. Comparison of Operational Energy Intensities and Consumption of Pipelines Versus Coastal Tankers: U.S. Gulf Coast to Northeast Coast Routes. Oak Ridge National Laboratory, Oak Ridge, TN, and Argonne National Laboratory, Argonne, IL, ORNL/TN-7154 and ANL/CNSV-TM-6, Jan. 1980.
11. G. Samuels, D.L. Greene, A.B. Rose, and J.N. Hooker. Transportation Energy Conservation. In Advances in Energy Systems and Technology (Peter Auer, ed.), Prentice-Hall, Englewood Cliffs, NJ, in preparation.
12. J.N. Hooker. Energy Efficiency of Oil Pipeline Transport. Oak Ridge National Laboratory, Oak Ridge, TN, in preparation.
13. Statistical Yearbook. Edison Electric Institute, Washington, DC, 1978.
14. M.S. Bronzini; CACI, Inc. Freight Transportation Energy Use: Vol. 1, Summary and Baseline Results. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, DOT-TSC-OST-78-1, July 1979.
15. Federal Energy Administration; U.S. Environmental Protection Agency. Truckers Guide to Fuel Savings. U.S. Department of Transportation, 1976.
16. A.J. Broderick. Fuel Consumption of Tractor Trailer Trucks as Affected by Speed Limit and Payload Weight. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, 1975.
17. Highway Statistics. Federal Highway Administration, U.S. Department of Transportation, 1977.
18. R.H. Leilich, R.D. Cohen, A. Greene, and M.J. Kendrick; Peat, Marwick, Mitchell and Co. Energy and Economic Impacts of Projected Freight Transportation Improvements. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, 1977.
19. R. McNeil and J. Lehrer. The McNeil-Lehrer Report. Public Broadcasting System, Washington, DC, March 21, 1980.
20. Empty/Loaded Truck Miles on Interstate Highways During 1976. Bureau of Economics, Interstate Commerce Commission, April 1977.
21. C.H. Marks, F.T. Buckley, and W.H. Walston; Univ. of Maryland. An Evaluation of the Aerodynamic Drag Reductions Produced by Various Cab Roof Fairings and a Gap Seal on Tractor-Trailer Trucks. Society of Automotive Engineers, Inc., Warrendale, PA, Paper No. 760105, Feb. 1976.
22. C.L. Brunow; Innocept, Inc. An Evaluation of Truck Aerodynamic Drag Reduction and Tests. National Science Foundation, Washington, DC, NSF-RA-N 75-040, June 1975.
23. W.R. Davis and others. Operational Truck Road Tests of Truck Aerodynamic Drag Reduction Devices. Society of Automotive Engineers, Inc., Warrendale PA, Paper No. 770690, 1977.
24. Stanford Research Institute. Energy Study of Railroad Freight Transportation: Vol. 2, Industry Description; Vol. 3, Regulation and Tariff; Vol. 4, Efficiency Improvements and Industry Future. Energy Research and Development Administration, Oakland, CA, Aug. 1977.
25. Yearbook of Railroad Facts, 1978 Edition. Association of American Railroads, Washington, DC, 1978.
26. R.H. Leilich, J.C. Prokopy, and D. Ruina; Peat,

Marwick, Mitchell and Co. Industrial Energy Studies of Ground Freight Transportation. U.S. Department of Commerce, PB-236-016, July 1974.
27. R. D. H. Jones. Another Nail in the Railroad Coffin. Transportation Research, Vol. 7, No. 4, Dec. 1973, pp. 413-419.
28. Waterborne Commerce of the United States, Calendar Year 1976--Part 5: National Summaries. U.S. Army Corps of Engineers, Washington, DC, 1977.
29. Aerospace Corporation. Characterization of the U.S. Transportation System: Vol. 6, Water Transportation of Freight. U.S. Energy Research and Development Administration, March 1977.
30. J. Binkley; Center for Maritime Studies, Webb Institute of Naval Architecture. The Possible Effect of Rationalization on Maritime Fuel Consumption. National Maritime Research Center, Kings Point, NY, NMRC-KP-147, Oct. 1975.

Issues in Developing Contingency Plans for Intercity Freight

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Inherent in any understanding of the relation between trucking and energy must be an awareness of the impact of the truck industry on the U.S. economy. We live in a complex and highly advanced society. In our transportation system, trucks offer source-to-market speed and versatility to serve our needs. A special study by the U.S. Bureau of the Census revealed the importance of trucks. Consider that trucks move 83 percent of all fresh and frozen meats; 73 percent of all radios, televisions, phonographs, and records; 84 percent of all clothing; 92 percent of all ice cream and frozen desserts; 84 percent of all office and accounting machines; and 83 percent of all carpets and rugs. In fact, trucks move three out of every four tons of urban and intercity freight and generate over 100 billion dollars in revenue. Most important, all this movement depends on the availability of petroleum. Ironically, although the job done by trucking is big, the amount of petroleum needed by commercial trucks is small—only about 20 billion gal of diesel fuel and gasoline a year. This is about 7 percent of the total energy supply consumed by transportation.

The problems encountered by the trucking industry with DOE's contingency plans are twofold: (a) DOE fails to recognize the critical position motor carriers have in the nation's economy, and (b) DOE fails to recognize the variety of fuel-purchasing patterns.

I have already touched briefly on the first problem. Needless to say, it would appear that most contingency plans approach trucks per se as "overgrown" cars. The ultimate contingency plan, i.e., DOE's gasoline-rationing plan, proposed to base truck fuel coupons on an index of what the average automobile used and the truck's gross vehicle weight. Neither of these criteria recognize how and where trucks are used.

A more recent example is DOE's Special Rule 9. Under this rule, DOE allocated diesel fuel to agricultural production at 100 percent of current need. Production was not defined to include distribution. As a result, farmers were allowed the diesel fuel they needed to produce food, but trucks could not get the fuel to haul it. Later, DOE amended the regulations to include distribution. However, DOE so narrowly defined distribution as to make it meaningless. Trucks had to have the cargo already loaded. Specifically excluded were trucks on their way to pick up agricultural products. Ironically, these same amendments expanded the 100 percent allocation level to other categories, including the exploration and production of oil and natural gas. Again, DOE excluded distribution. Apparently, the rationale was that gasoline could be produced but not distributed to the local retail outlet.

FUEL-PURCHASING PATTERNS

The second shortcoming is equally disturbing. Most contingency plans cannot handle the diversity of fuel-purchasing patterns. As a result, there is no equity. Consider that trucks use more than 20 billion gal of fuel per year. About 11.7 billion gal is diesel fuel; the rest is gasoline. Many carriers use both fuels. Also, not all carriers purchase fuel in bulk. In fact, we have no idea of the percentage purchased in bulk, and neither does DOE. We do know, however, that many carriers buy exclusively in bulk quantities, others buy all fuel retail, and still others buy both ways.

As a result, some carriers find themselves falling under four sets of contingency plans: (a) diesel fuel purchased wholesale, (b) diesel fuel purchased retail, (c) gasoline purchased wholesale, and (d) gasoline purchased retail.

Diesel Fuel Purchased Wholesale

Diesel fuel purchased wholesale is currently under no allocation plan. All middle distillates were decontrolled in 1976. However, in January 1979, DOE's Economic Regulatory Administration published Standby Product Allocation and Price Regulations and Imposed Allocation Fractions. These regulations allow cargo, freight, and mail carriers 100 percent of current requirements (reduced by an allocation fraction). This is the second priority level. Base period is no longer the month of 1972 corresponding to the current month, but a period defined inadequately as "the month or quarter corresponding to the current month or quarter in the 12-month period ending with the second full month prior to the month which (DOE/ERA) issues an order...."

Although this is DOE's standby or contingency plan in case of a diesel fuel shortage, DOE did not insitute it during the diesel fuel crisis of May and June 1979. Instead, it instituted Special Rule 9, which gave 100 percent of current need to agricultural production. The trucking industry was not prepared for this action.

Fuel oil distributors were also ill prepared. Some could not even meet the demands of farm customers and cut off all other diesel users. Almost overnight, diesel fuel all but dried up in the Midwest. Apparently, the nation's farmers defined "current need" as something called "future perceived need". There were even some instances of farmers selling their "current need" to motor carriers and railroads.

Currently, motor carriers buying diesel fuel in bulk are at the mercy of the distributors. Depending on the commitment the oil company has to home-heating oil customers, motor carriers in 1979 had allocations as low as 40 percent of 1978 levels. Base periods, however, are not uniform and can be anything the oil company determines. Carriers with allocation levels below their current needs can do one of four things:

1. Seek other suppliers willing to take on new customers,
2. Purchase diesel fuel on the spot market,
3. Purchase fuel at the retail pump, or

4. Appeal to a state for set-aside supplies.

In general, carriers have found few suppliers who are willing to take on new customers. Suppliers fear that allocation controls will be reimposed and they will not be able to meet their commitments. Carriers have found, however, that, if they are willing to pay the price, they can obtain fuel on the spot market. Most carriers are hesitant about relying on the spot market for the long run. Such reliance destroys any historic record of base-period use and a supplier-purchaser relation--should allocations be reimposed. Finally, carriers have discovered that state set-aside programs (a) are on a first-come, first-served basis, (b) have usually set a priority for agricultural production, and (c) are dry before the fifteenth of the month. Carriers that anticipate running dry find no relief unless they are actually out of fuel. Contingency planning is apparently outside the realm of some set-aside managers.

In summary, with enough money and enough ingenuity carriers can find fuel. But DOE's standard response to carriers facing difficulties in the purchase of diesel fuel is that it is decontrolled. However, diesel fuel is not decontrolled. The existence of state set-aside makes it a controlled product, as did Special Rule 9 and the mandating of primary storage levels for home-heating oil in 1979.

Diesel Fuel Purchased Retail

Obviously, diesel fuel purchased retail is not under allocation. However, the truckstop itself is under DOE's Standby Allocation Plan. Truckstops under this plan are treated like extremely large suburban retail outlets. Again, no consideration is given to the fact that its many customers would receive priority status if buying bulk fuel. As a result, truckstops are forced to ration fuel on a per-gallon basis. While a limit of 20-50 gal may seem extreme to an owner of a compact car, a truck that averages 4-6 miles/gal is more severely limited.

As noted earlier, carriers buying bulk diesel fuel often resort to retail purchases to augment low allocation levels. Truckstops find themselves with new customers and traditional truckstop purchasers find themselves with new competition for limited supplies. If DOE is to have an equitable and workable diesel fuel contingency program, it must address the problem of truckstops. Attempts like those under Special Rule 9, which sought to make truckstop owners regulators of various carrier-commodity groups in terms of fuel purchase, should be abandoned.

Gasoline Purchased Wholesale

Under past gasoline allocation regulations, motor carriers receive 100 percent of current requirements (as reduced by an allocation fraction). However, the base period used was November 1977 through October 1978. On July 19, 1979, DOE published a final rule that changed the allocation levels and base period. Cargo, freight, and mail hauling by truck will not receive 100 percent of base period and will not be subject to an allocation fraction. This is the highest priority level.

It is too early to tell what effect these changes will have. By eliminating allocation levels based on current need, DOE avoids the problems experienced in auditing current need. Unfortunately, a larger problem remains. The category cargo, freight, and mail hauling by truck seems clear on the surface, but DOE regulations (especially Section 211.102 of the allocation regulations) define a truck as a gasoline-powered vehicle of more than 20 000 lb (gross vehicle weight). In other words, a gasoline-powered truck under 20 000 lb that hauls freight receives the lowest priority level. Such a definition is arbitrary and inconsistent with other DOE regulations, and it totally ignores the practical use of trucks by the motor carrier industry.

In the course of our operations, the trucking industry uses many combinations of vehicles; some are powered by gasoline, others by diesel fuel. Each truck is purchased to perform a specific function. The Commercial Vehicle Post-1980 Goals Study, cosponsored by FHWA, DOT, ICC, EPA, the National Science Foundation, and the U.S. Postal Service, pointed out that

> Most trucks used in commercial service have accordingly been purchased against quite detailed customer specifications which have been drawn up to tailor the vehicle to its job—not too big, not too small, not too powerful, not underpowered, etc. Much efficiency is built into trucks by this tailoring to the job, but much complication also arises when one attempts to characterize or average the national fleet or projected improvements in the fleet. Attempts to standardize the national fleet about some average could destroy the service evidenced today and result in greater national consumption.

Yet, despite this expressed recognition of user specialization, DOE attempts to standardize the gasoline-powered truck fleet, albeit in a contingency plan. Moreover, compounding the problem, is the fact that Section 211.123 of the regulations allocates 100 percent of current requirements (reduced by an allocation fraction) to diesel-powered vehicles transporting cargo, freight, and mail, without any limits on size or weight. The net effect of these two conflicting regulations (Sections 211.102 and 211.123) encourages the intercity hauling of cargo, freight, and mail, where most vehicles are diesel-powered, while, at the same time, it limits the pickup and delivery of cargo, freight, and mail in the urban area, where most vehicles are the smaller gasoline-powered vehicles with gross vehicle weights of less than 20 000 lb.

The nation's distribution system, however, requires the use of both diesel-powered long-haul tractors and smaller gasoline-powered vehicles if the work is to be performed at all. It is not even a question of performing the job efficiently. If we were to use only 40-ft trailers for all of the hauling performed, the cost of the service would be astronomical and the waste of fuel would be unjustified, with the result that the motor transportation system would ultimately collapse. It must be understood that conservation is not always achieved nor promoted through the use of just large vehicles that can transport a lot of materials. Rather—and it is stated repeatedly in The Commercial Vehicle Post-1980 Goals Study—conservation is achieved by using the most appropriate vehicle. Any contingency plan for the U.S. freight system must be based on this principle. As trucks switch from gasoline engines to the more fuel-efficient diesel engines, contingency plans will have to reflect and encourage this change.

Gasoline Purchased Retail

Obviously, the same problems that affect the diesel fuel retail buyer affect the gasoline retail purchaser. But, in this instance, the driver of a gasoline-powered commercial vehicle is waiting in line with drivers of passenger cars. The cost to the user is tremendous. In the past, DOE has had little empathy for gasoline-powered trucks. Its attitude seems to be that (a) with a little bit of hustle, the carrier can find gasoline, and (b) the gasoline truck is an anachronism—all truckers should be using diesel-powered vehicles.

Certainly, the recently proposed gasoline-rationing plan reflects both of these perspectives. Specifically, the plan did the following:

1. Failed to assign the trucking industry a priority level that reflected its essential role in the nation's economy and commerce;
2. Did not define the criteria that would be used in designating firms entitled to receive supplemental allotments and did not identify those documents that would be used in determining base-period use;
3. Incorrectly adopted the use of motor vehicle

registration files during the start-up period of the program as a basis for distributing ration rights to firms;

4. Unfairly distributed ration allotments to firms based on gross vehicle weight indexes during the initial phase of the program;

5. Placed too much confidence in a white market to equalize the supply and demand for ration rights;

6. Discriminated against gasoline-powered commercial trucks in assigning administrative costs on a per-gallon basis, whereas processing costs are incurred on a transaction basis; and

7. Failed to recognize that fuel use varies among different classes of vehicles within the states.

ENERGY EFFICIENCY

No statement on contingency planning would be complete without some comment on the issue of relative fuel efficiency in freight transportation. One often hears that rail is four times more fuel-efficient than truck. The implication is that tremendous amounts of fuel could be saved if traffic were moved by railroads instead of motor carriers.

Most claims of railroad superiority are based on the simple standard of per ton-mile. Yet everyone concerned recognizes no single standard of comparison is acceptable. For example, on January 15, 1980, in a press release concerning the Minneapolis-Chicago intermodal fuel comparison test, DOE's Sidney D. Berwager said

> It is abundantly clear that simply dividing the total amount of fuel that railroads consume in a year into the total number of ton-miles moved and comparing the results for intercity truck freight transportation is not realistic. Instead, a true comparison can only be obtained when the modes concerned transport freight between the same origination and destination points.

In the only true demonstration test to determine truck-piggyback fuel efficiency, DOE found that, for a dedicated train, the average trailer revenue weight for the pigtrailer revenue weight was 12.1 tons; whereas, the actual trailer revenue weight for the motor carriers was 17.1 tons. The results of this study showed that piggyback traffic operating under ideal conditions was only 1.9 times more fuel-efficient per revenue ton-mile per gallon than a motor carrier operating under normal conditions. The table below cites this and other comparisons between truck and rail fuel-efficiency factors:

Factor	Truck	Rail
Distance (miles)	420	412
Speed (mph)	42.6	38.2
Trailing gross weight (tons)	23.1	1466
Total fuel consumed, including that for line-haul and terminal use (gal)	82.3	1283.2
Trailer-miles per gallon	5.1	13.5
Trailer gross weight (tons)	23.1	18.1
Gross ton-miles per gallon	117.7	257.8
Trailer revenue weight (tons)	17.1	12.1
Revenue ton-miles per gallon	86.9	172.9

In addition, the loaded-to-empty ratio was shown to be 1 to 0 for trucks (with 45-ft trailers) and 42 to 3 for rail (with 40-ft trailers).

Interestingly, not even the Association of American Railroads (AAR) believes that railroads are superior to trucks in fuel efficiency. The AAR notes that absolute statements based on Btu's per ton-mile fail to account for average loads, circuity, empty movements, and actual engineering efficiency. As a result, only in the case of unit train service can one find railroads to be significantly more fuel-efficient than motor carriers. Left unanswered is the question of relevance, "How many trucks attempt to compete with 100-ton unit trains?"

Empty Backhauls

Contingency planners have always pointed out that trucks on the highways often travel empty. In fact, an ICC study of 13 165 trucks on Interstate highways in 1976 found that 20.4 percent of all truck miles is empty. Of these trucks, 3 percent (466) traveled empty due to factors other than traffic imbalances or equipment types.

Most planners recognize that natural traffic imbalances between geographic areas—for example, between producing and consuming regions—may often mean that there will not be a return load for every truck hauling freight to a particular point. Furthermore, most planners recognize the effect that equipment specialization has on total empty miles.

Fuel Conservation Efforts

Motor carriers are currently conserving fuel at impressive rates. For example, fuel-saving devices—once deemed too expensive to be practical—are now paying for themselves as the price of fuel increases. In fact, DOT estimates that the purchase of new and more fuel-efficient equipment has saved more than 4 billion gal of gasoline and diesel fuel through 1979. That is enough to heat more than 3.3 million homes, or all the homes in Columbus, Ohio; Boston; Pittsburgh; and Minneapolis. As of the first nine months of 1979, the major sources of these savings are 531.9 million gal due to the increased use of standard diesel engines, 1507.5 million gal due to the use of new fuel-efficient turbocharged diesels, 1133.4 million gal due to the use of variable fan speeds, 536.5 million gal due to the use of radial tires, and 229.6 million gal due to various aerodynamic devices.

Truck Size and Weight

In addition, state governments must recognize that they have a responsibility to truck fuel conservation. Fuel economy is needlessly restricted by those states that have not increased weight limits to the permissible federal maximum of 80 000 lb and by those states that do not permit the use of at least 65-ft trailer combinations. Carriers crossing multiple state lines are now forced to load equipment to the lowest limit, regardless of the fact that several of the states entered may have higher limits.

To demonstrate the degree to which the higher limits can and will result in increased efficiency and fuel savings, consider Table 1, which is computed in terms of the fuel and equipment required to transport 1 million tons of freight a distance of 1 mile. A 65-ft twin trailer operating at 80 000-lb gross vehicle weight, for example, can handle 1 million tons of freight in 38 979 trips by using 9628 gal of diesel fuel. This represents a 39.1 percent saving in trips

Table 1. Comparison of fuel and equipment required under old and new federal limits to transport 1 million tons of freight a distance of 1 mile.

Federal Limit	Gross Combination Weight (lb)	Number of Loads	Diesel Fuel Required (gal)
Old			
55-ft tractor semitrailer			
Dense freight only	73 280	42 544	10 125
Light and bulky freight	57 500	64 041	13 138
65-ft twin trailers			
Any freight	73 280	44 853	10 316
New			
55-ft tractor semitrailer			
Dense freight only	79 000	38 201	9 397
65-ft twin trailers			
Any freight	80 000	38 979	9 628

and a 26.7 percent reduction in fuel consumption, when compared to a tractor semitrailer combination under the lower weight and size limits that still exist in some states.

CONCLUSION

Trucks are essential to the national economy and cannot survive for long with existing low-allocation fuel levels. Two-thirds of the communities in the United States have no alternative to truck transportation.

A modest updating of vehicle size and weight laws could significantly reduce the diesel fuel requirements of the trucking industry. These vehicle dimensions have for some time been endorsed by the American Association of State Highway and Transportation Officials. In addition, the National Cooperative Highway Research Program, in a recently completed study on truck size and weight, noted that

> Nonuniformity in state laws relating to motor vehicle sizes and weights is costing the American public from $1.6-$2.8 billion annually. Although these additional costs most directly affect the trucking industry, transportation costs are ultimately reflected in the marketplace and in the cost of living.

It is essential that a uniform minimum 80 000-lb gross vehicle weight limit and 65-ft length limit be implemented nationwide. The sooner this is done, the sooner fuel saving as a result of such action will occur.

No matter how or what type of fuel a carrier buys, problems with most contingency plans will most likely be experienced. The only way, it seems, for a carrier to get supplies is to demonstrate repeatedly what happens when trucks do not roll. For example, it is likely that

1. Factories will close because the inbound raw materials cannot be moved;
2. Factories will close because produced goods cannot leave the shipping dock;
3. Consumers will be inconvenienced more if they cannot get gasoline, food, or clothing; and
4. A significant number of motor carrier employees will be without jobs.

Urban Goods Movement: Management Solutions to an Energy Problem

Cathryn Goddard

Urban goods movement, or local freight transportation, may appear unglamorous or perhaps unimportant, compared to stirring issues such as those prompted by an energy crisis. The movement of goods and services to and from urban areas, however, represents fully 5 percent of the gross national product of this country. Most of us are familiar with long-haul freight transportation, which accounts for 47 percent, or $103 billion, of all freight. But, in 1978, local freight transportation expenditures accounted for the majority of the freight bill (53 percent), or $116 billion.

Urban goods movement represents a part of our distribution system that can respond effectively in the short run during emergency situations such as those experienced during the 1973-1974 oil embargo. Part of this responsiveness during a crisis is also an indication of the cost saving that can take place under normal circumstances with more effective planning (1).

IDENTIFYING THE PROBLEM

Some key statistics will put our discussion in perspective. Initially, we will examine a few energy-related issues and then look at urban goods movement.

Energy Context

When I served as the director of the Office of International Energy Research at the U.S Department of the Treasury, I was one of the principal authors of the Secretary's Report to the President on the National Security Implications of Oil Imports (2). The Treasury Department has the responsibility to report on these national security implications because they stem from the impact of oil imports on the balance of payments.

Statistics prepared for this investigation highlight the nature and gravity of the oil import problem the United States is facing. Our analysis essentially compared the volume and value of oil imports for the three years (1959, 1975, and 1978) during which previous investigations had taken place.

If we look at the volume of oil imported in millions of barrels per day, excluding the strategic petroleum reserve, we observe a dramatic increase from 1.8 million bbl/day in 1959 to 6.5 million bbl/day in 1975, reaching 8.7 million bbl/day in 1978. Imported oil as a percentage of domestic production also increased significantly in the same time frame: 18 percent in 1959, 39 percent in 1975, and 45 percent in 1978. Similarly, the share of imported oil in total domestic energy demand increased dramatically in the same direction. From 9 percent in 1959, it rose to 19 percent in 1975 and reached 23 percent in 1978.

The vulnerability of the source from which the petroleum originates represents a key element for determining the effect of oil imports on national security. In 1959, OPEC did not exist, but, if we compile a total of oil imports from OPEC-member countries in that year, the share of OPEC imports over total oil imports was 70 percent. It rose to 78 percent in 1975 and to 83 percent in 1978. (This share has declined somewhat in 1979 because of increased production from the North Sea and Mexico.) Perhaps of more concern than OPEC itself, the Middle East has traditionally been considered a source of vulnerability for our imported oil supplies. Imports from the Middle East represented 21 percent of total imports in 1959, 27 percent in 1975, and 34 percent in 1978.

The value of U.S. oil imports has increased even more dramatically than the volume. The price per barrel in 1959 was only about $2.26, which, of course, was considered exorbitant at the time. The price rose to $11.45 in 1975 and to $13.28 in 1978. Current market prices vary from $26.00 to $32.00 for contract crude and even higher for spot-market purchases. Price times quantity will give you the oil import bill, which increased markedly from $1.5 billion in 1959 to $27 billion in 1975 and reached $42 billion in 1978.

Although the investigation itself was presented in 1979 and relied on 1978 statistics, the numbers for 1979 oil imports are in. In that year, we imported 8.8 million bbl/day at a cost of $60 billion. That $60 billion figure can be personalized by recognizing that it represents about $275/person in the United States.

Urban Goods Movement

Let us now turn to urban goods movement to present some key statistics for 1978. The orders of magnitude involved in

urban goods are quite staggering—3.6 million vehicles, 48 billion miles, 36 billion stops, and 9.9 billion gal of fuel.

Local freight transportation is a $116 billion business and, typically, is only a part of some other industry (3). For example, most of the companies handling local freight are not in the transportation business. They tend to be involved in selling a service or distributing a product. From the bakery truck that delivers doughnuts to the giant class 8 vehicle that transports food from warehouse to grocery store, these vehicles and services are the subset of another industry. Department stores, for example, tend to own their own facilities for delivery. In fact, for-hire transportation represents less than 10 percent of urban goods movement.

In the 1960s, shopping malls were being developed within the cities to attempt to reattract business into urban areas. One of the first thoughts that came to mind was to prevent all trucks from coming into new malls. It quickly became apparent, however, that those trucks were essential to commercial handling of the numerous goods and services that we purchase in the marketplace. Urban goods movement, in fact, is the critical final link in our multiproduct, multioutlet economy. Without the elaborate distribution network that has evolved, we would not have the variety of choice in a central location offered by our urban areas.

Urban goods movement is inherently fuel intensive. By definition, circulation in a city involves more stop-and-go driving. This initial relative inefficiency is then reinforced by the inevitable idling involved in the delivery of services and products. These apparent inefficiencies in fuel should be compared to far greater inefficiencies that would be involved were we all required to go to one central grocery store or one central service station. The inefficiency would still exist but would be shifted to the passenger movement side of the equation.

BETTER MANAGEMENT: PART OF THE SOLUTION

In more than 400 actual situations with client fleets ranging from 5 to 200 vehicles, it was found (1) that better management of urban goods fleets contributes at the same time to better management of energy resources. Three areas of improvement are considered here—different systems, different fuels, and a different approach.

Different Systems

Different systems for urban goods movement can maintain the same selection of goods while looking to a new means of transportation. For example, we can consider Buck Rogers types of future scenarios with pneumatic tubes, pipelines, or conveyor belts.

Consolidated deliveries can also make an important contribution. For example, the soft-drink distributor could also deliver candy bars during the same run. Rising fuel prices have, to some extent, encouraged this practice, which certainly took place during the oil embargo of 1973-1974. Significant marketing implications, however, result from consolidated deliveries. In general, the person making the delivery is an extension of the sales force of the parent firm. The soft-drink delivery person may not wind up selling as many candy bars if deliveries are made for both on the same run.

Another alternative is, of course, to provide less selection with the same means of transportation. Fewer specific brands could mean less need for separate bottle-beverage trucks. Fewer but larger stores could also reduce the demand for movement of urban goods. As we mentioned earlier, however, the lower number of stores could increase the vehicle miles traveled by consumers who drive to those stores.

Different Fuels

Yet another approach is to use a different fuel. Diesel, propane, gasohol, and electricity are among the many options for local freight transportation. With respect to electricity, DOE today has selected fleets performing routine services in urban areas as the showpieces for commercial application of electric vehicles. In this particular instance of a low-payload, predictable route, the electric vehicle may already be commercially feasible, even with the use of today's technology.

Different Approach

A more important near-term solution, and a more promising one even in the long run, is to rely on a different management approach. Although urban goods movement is typically managed as a step-child, it was found that there are significant cost-saving motives that justify the application of more-sophisticated management techniques. These techniques, including our proprietary Computer Assisted Route Development (CARD) system, can make significant improvements in the efficiency of movement of urban goods. Resequencing can lead to fewer miles and, therefore, less fuel consumption.

In a more elaborate case, comprehensive analysis can address not only route engineering as illustrated, but also every facet of local delivery operations, including at-depot activities, at-stop activities, stem- and on-route driving techniques, delivery management, and company delivery policies. While all of these areas are important, the greatest opportunities for fuel savings are in the last two areas.

CONCLUSION

Urban goods movement is a pivotal weight in our precisely balanced economy. During the 1973-1974 oil embargo, we saw that great accommodation could indeed take place to prevent the disruption of the supply of goods and services to urban areas.

The new systems envisioned, however, are not short-run solutions. For example, although alternate fuels will play a role in our energy future, they will not do so immediately. One possible exception, but a rather limited one, is gasohol.

Rising fuel costs provide the economic motivation for applying better management techniques to the movement of urban goods. As the price of oil rises, the dollars to be saved through better management more than justify the costs of developing and applying these techniques. The same logic is even more pervasive during a period of emergency, where the premium for uninterrupted supplies of services and products provides an economic incentive for the carrier to rely on better management techniques.

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REFERENCES

1. A Primer on Urban Goods Movement. A. T. Kearney, Inc., Alexandria, VA, 1976.
2. Effects of Oil Imports on National Security. Federal Register, March 29, 1979.
3. W. J. Markham and J. E. Morehouse. Improving Local Hauling. Commerce, 1978.

Policy Implications of Urban Traveler Response to Recent Gasoline Shortages

Robert L. Peskin

The purpose of this paper is to identify promising urban transportation-planning policy actions to reduce gasoline consumption; it is based on observations of travel behavior during recent periods of gasoline shortage and increases in price. Such policy guidance is important because it is becoming increasingly apparent that the U.S. public is not always altering its travel patterns in ways that planners have predicted. With the broad range of alternative actions recently proposed—some with huge national impacts (such as the rationing of gasoline)—and with the many levels of local, regional, state, and federal government agencies likely to be involved, planners need to develop a coordinated set of actions. These actions must be designed to provide the greatest degree of energy saving possible and, at the same time, be consistent with the travel behavior and preferences of urban travelers.

Considerable discussion has taken place in recent years about ways in which energy consumption, particularly gasoline consumed by automobiles, can be reduced for urban travel. An important and useful distinction between two fundamental concepts, energy contingency planning and energy conservation, was recently noted by Daniel Roos (1) as follows:

> Energy contingency planning [is] "stand-by" or quick-response actions designed to solve immediate energy problems after they occur. This typically involves preparing for sudden increases in transit ridership and enforcement of regulations designed to minimize energy consumption.
> Energy conservation [is] continuous and longer-term actions designed to make reduced energy consumption a permanent characteristic of the urban transportation system. It should be noted that an adequate degree of conservation would make most contingency planning unnecessary.

With these concepts in mind, this paper will review the major findings of prior studies of gasoline shortages, especially those studies of travel behavior during the 1973-1974 gasoline shortage. The discussion will note the important consistent findings between these studies and more recent studies conducted during the 1979 shortages. Based on this review, policy implications for urban transportation planning will be identified for the following time frames:

1. Short-range planning includes both immediate actions, as well as those that could be implemented within three to five years, and is primarily oriented to energy contingency planning.
2. Long-range planning involves actions designed around a concerted conservation effort and planning for more efficient travel.

It should be noted that this paper is concerned with urban travel. The impacts of energy shortages on intercity (vacation) travel, although important from a national energy policy perspective, are not reviewed except to the extent that travelers trade off between urban and intercity travel.

FINDINGS OF PRIOR RESEARCH

In this section, some travel-behavior surveys conducted during and after the 1973-1974 gasoline shortage are reviewed. This review attempts to identify those findings that are of some importance in urban transportation policy decision making. The discussion highlights those findings that recur in different survey techniques and seem to be consistent over time, as shown by more recent research findings. Those actions that relate specifically to potential energy contingency planning and to conservation are identified. For example, the Planning Research Unit of the New York State Department of Transportation has prepared many reviews as part of its continuing research on travel response to energy shortages (2,3). Liff (4) has also reviewed attitudinal approaches to exploring changes in travel behavior. This paper concentrates on the implications of such findings rather than on the techniques used to obtain them. The major travel-behavior findings considered are (a) response to changes in gasoline availability as opposed to increases in price, (b) effect of household income, (c) reluctance to alter work trips, (d) trip chaining, (e) vehicle speed reduction, (f) reluctance to use of public transportation, and (g) automobile occupancy changes.

Response to Changes in Gasoline Availability as Opposed to Increases in Price

Peskin and others (5) in a home-interview survey of Chicago's North Shore residents, observed that respondents were basing travel decisions more on the availability of gasoline than on price. This was confirmed by Skinner (6) in travel diaries recorded by families of Federal Highway Administration employees and by Sacco and Hajj (7) in their household survey in the Dutch Forks, South Carolina, area. This finding has fundamental implications for gasoline-rationing and gasoline tax proposals now being discussed by the U.S. Department of Energy. Further, it identifies an important flaw or omission in analytical tools used in urban transportation planning. To date, no modeling chain has considered the availability of gasoline as an impediment to travel.

Effect of Household Income

Becker and others (8), in a survey of Portland, Oregon, residents, used a disaggregate analysis to identify market segments that responded differentially to the gasoline shortage. They noted that, while higher-income high-automobile-ownership households were more likely to change to more energy-efficient travel behavior in response to a shortage, lower-income households that already changed were more likely to remain changed after the shortage ended. This sensitivity of behavior with respect to income was also observed by Stearns (9), based on a nationwide survey, and partially by Peskin and others (5) to the extent that the upper-middle-income households behaved like those in the other surveys.

It is quite apparent that these findings will be important in considering a gasoline tax as a means to reduce consumption. The fundamental problem, however, is that there has been no opportunity to observe the effects of price increases in the absence of changes in availability. Corsi and Harvey (10) attempted to explore hypothetical price increases by asking Milwaukee area respondents to identify price thresholds at which energy-conserving behavior would occur. Lee (11) explored pricing issues by using California traffic volume data and attempted to include the availability issue by considering the true price, which included a cost of the wait time to purchase gasoline. Both of these studies see pricing as the action necessary to achieve conservation goals. However, they do not address social equity concerns—an extremely important issue to resolve if gasoline tax increases are implemented.

Reluctance to Alter Work Trips

Hartgen (2), in a survey of New York State residents, and Peskin and others (5) showed that the journey to work was the least flexible in responding to periods of gasoline shortage and price increase. Alterations in shopping trips were typically made long before carpooling or modal changes in the work trip were made. Corsi and Harvey (12) noted that vacation travel would be curtailed before the journey to work was altered. Apparently, only in areas with a very good public transportation system was there any observation of change in the journey to work. Lessieu and Karvasarsky (13), for example, noted some decline in peak-period highway volumes in the New York City area.

The general inflexibility of the work trip was confirmed by recent research by Hartgen (14). In a nationwide survey and a survey of New York State residents, both recent behavior and projected behavior with $1.50/gal gasoline or a 20 percent shortage showed that travelers were more likely to alter nonwork travel and driving habits (e.g., reducing driving speed, shopping closer to home, tuning engines, and shopping less often) than to make any alteration in driving to work.

Trip Chaining

Peskin and others (5) observed that linking of nonwork (particularly shopping) trips was common. Kostyniuk and Recker (15) explored this idea further by using unidimensional attitudinal scaling and by ranking the acceptability of alternative modes to and from shopping. They observed some potential for nonautomobile travel for shopping trips during a gasoline shortage depending on automobile availability, prior mode used, employment status, and income. Recent research (2,3,16) notes that this is a fairly easy way to conserve energy and is one of the first techniques to be used.

Vehicle Speed Reduction

Both Neveu (3) and Hartgen (14) have shown that driving at slower speeds is among the most common actions taken to reduce gasoline consumption. Generally, the public has indicated a preference for easily taken actions such as driving slower over punitive or restrictive actions such as gasoline taxes.

Reluctance to Use Public Transportation

Despite surges of transit ridership in some urban areas, survey researchers generally found considerable reluctance to use public transportation in response to gasoline shortages (5,7,9,17). The use of the automobile was modified before travelers changed mode. This was recently confirmed in the nationwide survey concluded by Hartgen (14). It is becoming clear that public transportation will be an important energy-conserving action only for those cities with the largest transit systems.

Automobile Occupancy Changes

Peskin and others (5) observed that carpooling was not an action taken in response to shortages. Beglinger and Behnam (18), in a study of Milwaukee freeways, observed that the general downward travel in automobile occupancy was temporarily reversed during the 1973-1974 shortage but continued to decline after the shortage ended. Trentacost and Milic (19) observed no change except for small automobiles, perhaps indicating that energy-conserving individuals both drove smaller automobiles and carpooled. Recent observations by Hartgen (14) show that carpooling is still far from the most common means used to conserve gasoline.

Summary

Recent research by Meyers (20), Hartgen (14), and Rappaport and Labaw (21) confirms that the public is consistently adjusting its travel by means of small, unobtrusive, frequently taken actions and has avoided altering the automobile trip to work. Neveu (22) and Hartgen (5,14) observe that the public seems to be receptive to policy actions that encourage gasoline conservation by increasing travel options and offering incentives for their use. Punitive or restrictive measures are received less favorably. The finding that changing the journey to work is among the least likely actions to be taken to conserve gasoline is vitally important to urban transportation planners because the bulk of the planning process, particularly long-range planning, is concerned with the work trip.

The following two sections discuss both short- and long-range actions in greater detail based on the findings described above. The discussion is tied closely to two concepts: (a) the need to separate contingency planning from conservation planning and (b) the notion developed by Hartgen (5,14) and other researchers that, for energy conservation actions to work, they must be well-received by the public.

SHORT-TERM POLICY IMPLICATIONS

The time frame for short-term policy actions ranges from immediate actions to those that could be implemented within three to five years. This includes both energy contingency planning and conservation actions. For example, the recent work by the North Central Texas Council of Governments (23) is, in my judgment, among the best in the formulation of short-term policy. Virtually all of the findings noted in the previous section can be applied to short-term policy formulation. The most important observations are (a) for energy-saving actions to work, the public must be receptive and (b) transit is not necessarily the sole or best solution, except in cities with the largest transit systems.

Local- and Regional-Level Short-Term Policy Implications

Various research findings have identified actions that metropolitan planning organizations, transit properties, and municipalities can implement immediately or within several years. Some of these actions are briefly described here.

Actions to Discourage Automobile Work Trips

Changes in automobile work trips were among the least likely actions to be made in response to gasoline shortages. This finding is important because work trips are predictable and essential and because the urban transportation-planning process is driven principally by analyses of the journey to work. Nonwork travel is not as predictable in the response to the actions of transportation planners because of the discretionary and flexible nature of the trips; households can make trade-offs between discretionary trips and other goods. Actions that planners can take to directly affect work trips are the best understood and their effectiveness is easiest to forecast. Such actions would, therefore, have the greatest predictability of reducing gasoline consumption. Unfortunately, it is not possible to directly control gasoline sales for work trips alone (i.e., by either controls on availability or controls on price) because gasoline is purchased for all trip purposes. Other actions need to be taken.

A program of combined automobile disincentives and high-occupancy-vehicle (HOV) incentives is one approach that local and regional agencies can take to directly affect the journey to work. Automobile disincentives include the following:

1. Increase parking costs by increasing rates at municipal garages, imposing a parking tax, or eliminating discounts for all-day parking; and
2. Reduce parking availability by restricting the construction of new parking lots and garages, eliminating on-street parking (perhaps by using a neighborhood parking ban), and discouraging employers from providing free parking.

Potential HOV incentives include the following:

1. Improve the transit level of service by increasing the frequency of service and by reducing peak-period fares, and
2. Implement carpooling incentives by allowing parking privileges (such as reduced parking costs or preferential parking locations) and by emphasizing use of exclusive HOV lanes on freeways.

For these approaches to work, it is important that a combination of incentives and disincentives be implemented together. Hartgen (2) has noted that travelers must be presented with options to the automobile if gasoline saving is to be achieved. Placing disincentives on automobile work trips will not be sufficient, unless alternative means for traveling to work and incentives for their use are provided.

Alternative Work Schedules

Because the public is most reluctant to alter the automobile journey to work, it may be necessary to encourage, or possibly enforce, such approaches as flexible work hours or compressed work weeks. These actions can directly impact on work trips by (a) reducing the total number of automobile work trips and (b) expanding the peak period, thus reducing highway congestion (and improving energy efficiency) and crowding on transit—perhaps encouraging increased ridership.

Better Travel Information to the Public

Hartgen (2,14) has observed that energy-conserving travel will occur when the traveler is presented with alternative favorable travel options and incentives. The public, therefore, needs to know what its options are both in the event of a severe gasoline shortage and for longer-term conservation. Such information includes transit route schedules and maps, assistance in forming carpools, and accurate gasoline-supply information. Some researchers noted that some trips (particularly vacation trips) were foregone due to the uncertainty of gasoline availability. In order for travelers to conserve gasoline and still remain mobile, they must be provided with adequate information to make decisions.

Gasoline Supply and Consumption

The need for planners and decision makers to have accurate real-time information on both gasoline supply and the rate at which it is being consumed is essential. Frequent localized shortages require that more disaggregate information on national energy supplies be available, if the best decisions are to be made. Without such information, planners cannot know when to implement energy-conserving measures or how effective these actions are. Transit operators, for example, have been forced to measure the lines at service stations in order to determine how much additional service to provide.

It is not sufficient for local and regional planners to rely on gasoline-consumption data supplied by state sales tax records. This information is at best collected monthly, takes a long time to become available, and usually does not provide information for a precisely detailed area (e.g., gasoline wholesalers are typically licensed to sell anywhere within a state). The best approach would probably be to sample retail sales within an urban area. Data on both supply (gasoline in storage tanks) and consumption (from meter readings on gasoline pumps) could be collected. Witkowski and Taylor (24) call for a standardized measure of availability. This measure could be an index of supply related to population density.

Expansion of Transit Service

As noted above, the public generally has avoided changing travel modes. However, in those cities with large transit systems, there have been marked increases in ridership. In those specific markets there are many immediate actions that can be taken to increase capacity with current plants. These actions, defined by the American Public Transit Association (25), include longer peak-period service; maintenance of a reserve fleet; maintenance of resource, or stand-by, drivers; use of school buses for corridor or park-and-ride service; and maintenance of adequate fuel reserves. In funding transit actions that respond to gasoline shortages, it is important to note two things. First, the transit system has very limited capacity and probably will have the most influence in reducing gasoline consumption only in cities with the largest systems. Paratransit and other small-scale transit actions intended to solve the gasoline shortage are misguided at best and potentially harmful because they direct funds from more energy-efficient and cost-effective solutions. Second, it must be clear that the public will actually use the additional service. Running empty buses is not a solution to the gasoline shortage.

State-Level Short-Term Policy Implications

Two immediate actions that could be implemented by state governments, according to current research, are the enforcement of speed limits and state assistance for transit operating deficits. Although vehicle speed reduction was one of the first actions taken by the public to reduce gasoline consumption, enforcement of the 55-mph speed limit is still a problem on urban freeways, particularly in the West and Southwest. Vigorous enforcement, as well as public education on the efficiency of driving at lower speeds, may solve this problem. For those cities in which provision of additional peak-period transit service would result in reduced gasoline consumption, states should assist transit operators in paying for the additional operating and maintenance costs. This could be in the form of direct subsidy or through legislation to provide for an earmarked regional tax on fuel or other retail purchases.

Federal-Level Short-Term Implications

Major actions can be taken immediately and in the next few years by the U.S. Departments of Energy and Transportation and by the U.S. Congress. These actions can provide for both quick-response capability and continuous energy conservation.

The most important action that federal agencies can take is to support the actions implemented by local agencies. This support may take the form of

1. Guaranteeing adequate fuel deliveries to transit operators,
2. Allowing transit properties to build reserve fleets (the Urban Mass Transportation Administration now permits operators to retain buses they had previously intended to replace), and
3. Speeding up the grant-approval process.

Related to this is the encouragement of local energy-conserving actions. It must be recognized that many actors in the urban transportation-planning process still do not see energy conservation as a local or regional goal. It is common to have the reduction of energy conservation ranked a poor second to the primary goal of regional economic growth. A potential step toward correcting this

would be for the federal government to provide incentives for reducing energy consumption through the provision of additional funding to cities that reduce energy consumption the most. Of course, such an approach could be counterproductive because cities that are not reducing energy consumption probably would need more funding. Another approach would be to provide planning assistance and guidance in the form of agency staff and funding for consulting services to those cities without adequate staff support.

Research findings have also shown that many serious offsetting advantages and disadvantages to gasoline pricing and rationing exist. Therefore, no clear recommendation is made here. Yet, in terms of a quick-response capability, pricing has a clear advantage. The recently proposed 50-cent/gal federal gasoline tax could be implemented within weeks. A national rationing scheme, on the other hand, has been projected to take 18 months to implement. The income effects of pricing actions may reduce their effectiveness. There is strong evidence that increasing the price of gasoline will not reduce total consumption; rather, it will simply restructure the groups of people who use it. The bureaucracy involved in providing rebates to lower-income families would probably be as burdensome as that in a rationing program. The principal advantage of rationing is that it allows an a priori determination of how much gasoline will be consumed within a given period of time.

LONG-TERM POLICY IMPLICATIONS

Long-term transportation energy policy should be concerned more with the idea of conservation than with that of contingency planning. The emphasis should be on continuous planning for less-energy-intensive travel rather than on planning only for crisis-oriented travel and conservation. Some of the long-term actions suggested here refer to those that can be taken at the local, regional, state, and federal levels.

Local and Regional Implications

Witkowski and Taylor (24) argue that it is not possible to identify long-range planning actions based on observations of the 1973-1974 gasoline shortage because they were too short-term in nature. Recent research has shown, however, that travel behavior noted earlier continues to occur and that travelers are behaving in a rational manner. Thus, it should be possible to forecast behavior during future periods of reduced gasoline supply. Witkowski and Taylor advocate a more flexible approach to long-range planning, with each step allowing options to be taken that depend on gasoline supply and traveler response. Although this sort of incremental planning can be an important part of long-range planning, planners should recognize that there is still a role for large-scale capital investment for transit and for directing urban growth.

Nationally, travelers have avoided using transit, but there have been significant increases in ridership in the top 20 or so markets. Because transit can carry a large portion of travelers to activity centers and can help reduce energy-inefficient congestion on highways, the provision of additional service in these markets should be pursued. This includes both the purchase of new vehicles and the construction of new busways and rail lines.

Restructuring the pattern of land use to make trips shorter will reduce urban transportation energy consumption. Unfortunately, research findings show that changing the place of employment or residence is among the least desirable actions in response to gasoline shortages. Planners, thus, have to assume that current land use patterns will remain unchanged. There is the opportunity, however, to shape additional growth through zoning regulations and the construction of public services and facilities, such as schools, sewers, highways, and transit. Tied to transportation system development, a coordinated land use policy has been shown in theoretical research to result in significant energy savings (26).

State-Level Long-Term Policy Implications

There is some indication in the research findings that people are purchasing smaller automobiles in response to gasoline shortages. The states can accelerate this trend through vehicle registration fees that encourage the purchase of lighter-weight, more fuel-efficient automobiles.

Federal-Level Long-Term Policy Implications

At the federal level, the support of local actions, planning guidance, and the promotion of more energy-efficient travel would be steps in the right direction. For example, the purchase of additional transit vehicles and the construction of additional guideways in those markets to attract significant transit ridership will require massive federal funding.

Research indicates that, despite modest price increases, travelers will continue to consume whatever amount of gasoline is available. In the absence of a truly severe sales tax, rationing must continue to be considered because it allows for direct controls on the amount of gasoline consumed. Two important concerns still remain to be resolved, however: (a) the excessive bureaucracy required and the accompanying cost, delay, and lack of sensitivity to localized problems and (b) the inability to equitably allocate gasoline both within and between urban areas.

The research has also shown that, for the journey to work especially, the automobile will continue to remain the predominant mode of travel. Recognizing this, the federal government should continue to encourage the production of more-fuel-efficient automobiles, promote the development of electric vehicles, and promote the development of gasohol and synthetic fuel plants.

NEED FOR FURTHER RESEARCH

Perhaps the most important finding in recent studies of traveler response to gasoline shortages is that the transportation-planning profession needs to know more about how to plan under energy constraints. The federal government, particularly the U.S. Department of Transportation, can help by supporting additional studies of travel behavior and research on how this behavior will affect the transportation system and influence energy consumption. It is quite possible that some fundamental changes in the urban transportation-planning process will be required if travelers continue to react more strongly to gasoline availability than to price and continue to alter nonwork trips more frequently than work trips.

Some research in the area of travel behavior is currently under way. For example, the National Cooperative Highway Research Program is funding a study of methods to estimate changes in traveler behavior related to gasoline availability. Other avenues of research could include continuous longitudinal surveys of a fixed sample during periods of gasoline availability and price change. This could provide some insight as to the influences of pure price and pure supply, which, to date, have not been evaluated.

There has also been some progress in the development of the analytical tools to do long-range planning under energy constraints. The North Central Texas Council of Governments (27) has greatly refined the capabilities of urban transportation-planning systems programs that compute gasoline consumption on the highway network. Such a technique could be very helpful in evaluating small-scale transportation actions. In the area of modeling land use and energy relations, there has also been some progress. Mouchahoir and Nawrocki (28) have reviewed these efforts and have concluded that further model development and validation are needed. With these refinements, such models could provide useful guidance,

both for national policy and for application in specific urban areas.

A more fundamental direction for further research is the development of an urban transportation-planning process that reflects the major findings of recent traveler response to gasoline shortages. The process, which has evolved over the past 25 years, is based on the journey to work, travel time, and travel cost relations. Recent studies have shown, however, that gasoline saving is much more likely in nonwork trips and that the availability of gasoline, rather than price, is a primary determinant of travel behavior. A process that makes planners and decision makers more cognizant of this fact will result in more cost-effective and energy-efficient transportation investment and more equitable energy policies.

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REFERENCES

1. D. Roos. Efforts in National Contingency Planning for Transportation. Presented at 59th Annual Meeting, TRB, 1980.
2. D. T. Hartgen. Individual Travel Behavior Under Energy Constraints. Planning Research Unit, New York State Department of Transportation, Prelim. Res. Rept. 86, July 1975.
3. A. J. Neveu. The 1973-74 Energy Crisis Impact on Travel. Planning Research Unit, New York State Department of Transportation, Prelim. Res. Rept. 131, Dec. 1977.
4. S. D. Liff. Travelers' Attitudes and Energy Conservation. Proc., ASCE Conference on Transportation and Energy, Washington, DC, May 1978, pp. 89-110.
5. R. L. Peskin, J. L. Schofer, and P. R. Stopher. The Immediate Impact of Gasoline Shortages on Urban Travel Behavior. Federal Highway Administration, Final Rept., April 1975.
6. L. E. Skinner. The Effect of Energy Constraints on Travel Patterns: Gasoline Purchase Study. Federal Highway Administration, Final Rept., July 1975.
7. J. E. Sacco and H. M. Hajj. Impact of the Energy Shortage on Travel Patterns and Attitudes. TRB, Transportation Research Record 561, 1976, pp. 1-11.
8. B. W. Becker, D. J. Brown, and P. B. Schay. Behavior of Car Owners During the Gasoline Shortage. Traffic Quarterly, Vol. 30, No. 3, July 1976, pp. 469-483.
9. M. D. Stearns. The Social Impacts of the Energy Shortage: Behavioral and Attitude Shifts. Transportation Systems Center, Cambridge, MA, Rept. DOT-TSC-OST-75-36, Sept. 1975.
10. T. M. Corsi and M. E. Harvey. Travel Behavior Under Increases in Gasoline Prices. Traffic Quarterly, Vol. 31, No. 4, Oct. 1977, pp. 605-624.
11. W. C. Lee. The Demand for Travel and the Gasoline Crisis. Ph.D. dissertation, Univ. of California at Santa Barbara, 1976.
12. T. M. Corsi and M. E. Harvey. Changes in Vacation Travel in Response to Motor Fuel Shortages and Higher Prices. Journal of Travel Research, Sept. 1979, pp. 7-11.
13. E. J. Lessieu and A. Karvasarsky. Recent Observations on the Effect of Gasoline Price and Supply. In Better Use of Existing Transportation Facilities, TRB, Special Rept. 153, 1975, pp. 214-222.
14. D. T. Hartgen. Changes in Travel in Response to the 1979 Energy Crisis. Planning Research Unit, New York State Department of Transportation, Prelim. Res. Rept. 170, Dec. 1979.
15. L. P. Kostyniuk and W. W. Recker. Effect of a Gasoline Shortage on Acceptability of Modes for the Urban Grocery Shopping Trip. Journal of Environmental Systems, Vol. 6, No. 1, 1976-1977, pp. 1-30.
16. Opinion Research Corporation. Driving and Energy Conservation: Highlight Report, Volume 21. Federal Energy Administration, Rept. FEA/D-76/483, March 1976.
17. C. A. Keck. Effects of the Energy Shortage on Reported Household Travel Behavior Patterns in Small Urban Areas. In Changes in Individual Travel Behavior Patterns During the Energy Crisis, 1973-1974, Planning Research Unit, New York State Department of Transportation, Prelim. Res. Rept. 67, Aug. 1974.
18. R. E. Beglinger and J. Behnam. Effect of Energy Shortage and Land Use in Automobile Occupancy Rate. Urban Mass Transportation Administration, June 1975.
19. M. F. Trentacost and P. L. Milic. Changes in Automobile Occupancy Rates. In Changes in Individual Travel Behavior During the Energy Crisis, 1973-1974, Planning Research Unit, New York State Department of Transportation, Prelim. Res. Rept. 67, Aug. 1974.
20. C. E. Meyers. Factors Affecting Willingness to Conserve Gasoline. Planning Research Unit, New York State Department of Transportation, Prelim. Res. Rept. 167, July 1979.
21. M. Rappaport and P. Labaw; Opinion Research Corporation. Automobile Usage Patterns: Highlight Report, Volume 19. Federal Energy Administration, Rept. FEA/D-75-591, Sept. 1975.
22. A. J. Neveu. Public Opinion Survey on Energy and Transportation. Planning Research Unit, New York State Department of Transportation, Prelim. Res. Rept. 135, Dec. 1977.
23. Proceedings of the Urban Transportation Energy Contingency Planning Seminar. North Central Texas Council of Governments, Arlington, Tech. Rept. 26, Nov. 1979.
24. J. M. Witkowski and W. C. Taylor. Urban Transportation Planning Under Energy Constraints. Department of Civil Engineering, Michigan State University, East Lansing, Aug. 1978.
25. R. J. Hartman. Approaches to Energy Contingency Planning. Planning and Policy Committee, Energy Subcommittee, American Public Transit Association, Washington, DC, 1979.
26. R. L. Peskin and J. L. Schofer. The Impact of Urban Transportation and Land Use Policy on Transportation Energy Consumption. U.S. Department of Transportation, Final Rept., June 1977.
27. Motor Vehicle Fuel Consumption Estimation Procedures. North Central Texas Council of Governments, Arlington, Tech. Rept. 27, Dec. 1979.
28. G. E. Mouchahoir and R. Nawrocki. Transportation/Energy Analyses Methodologies. ITE Journal, Vol. 49, No. 12, Dec. 1979, pp. 28-34.

Response of Freight Transportation to Fuel Supply Shortages

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This paper describes near-term and long-range responses by freight carriers, shippers, and manufacturers to fuel price increases and availability questions since the 1973-1974 oil embargo. Near-term refers to those events that are nonrecurring, whereas long-term refers to the anticipated responses of freight movers in the next 10 years. A telephone survey that was used to collect responses from carriers suggests that near-term responses were primarily cost-cutting operational strategies and long-term planning emphasized vehicle changes to such an extent that modal attributes are effectively changed over time.

The consumer is just beginning to feel the full extent of effects from fuel price and availability questions for the freight sector. During the shortage crises, publicity was primarily oriented to passenger travel because consumer hardships were felt immediately. Recent data collection and analyses, however, have contributed to an understanding of the freight sector's energy-use problem, and they are especially insightful about changes in the truck and rail modes. The 1977 Census of Transportation shows some interesting new trends in truck use (1) and variations in modal shifts among manufactured commodities (2). There are also modeling efforts that have contributed to an understanding of fuel price increases and their impacts on freight transportation; these include the CACI modal simulations (3), the Association of American Railroads (AAR) truck cost model (4), and two cost studies of truck and rail by the Transportation Systems Center (5, 6). These sources were effective in quantifying recent and projected impacts, although they were not as helpful as the telephone survey method in perceiving individual carrier strategy options and future responses.

THE SURVEY

Throughout November 1979, informal telephone conversations with carriers and manufacturers provided the primary data for this analysis. Shipper responses were originally solicited, but, after uninformative responses by the groups contacted, secondary sources were considered to be more desirable. Information was obtained from two rail and truck associations. (This study is responsive only to these two modes because the competitive parameters and the type of shipments distinctive of other modes are often so far removed from characteristics of truck and rail.)

The sample survey for this paper in no way represents a statistically sound cross section of actors for freight carriage and vehicle manufacturers, but all of the persons contacted were well versed in the current trends in their business; thus, current industry thinking is represented. Additional carrier, manufacturer, and shipper responses were obtained through a review of transportation periodicals.

The lack of shipper responsiveness to fuel pricing and availability questions in this analysis is a real setback. Commodity-sector sensitivity to price, time, and service parameters over time is the only real means to effectively determine shipper responses and, therefore, future modal shifts. The literature hints that shippers are becoming more cognizant of transportation costs in total goods pricing and are willing to deemphasize rail shipment-time inconsistencies (7). But this exploration effort is by no means indicative of a mass movement, as many in the field intuitively feel.

THE ACTORS

The carrier respondents to the telephone survey are for-hire common carriers. But the trucking industry also consists of a number of carrier types that were included in the secondary source analysis. There are for-hire and private carriers. The for-hire segment consists of both common carriers and contract carriers plus others that are exempt from economic regulation. Each of these carriers can be distinguished from others based on the size of the firm, size of shipments, lengths of haul, and commodity characteristics. The diversity of operating attributes among the for-hire carriers is extreme. The private carriers also have operating variations, but these are primarily based on the type of commodity (or business) with which the carriers are affiliated. The shipper owns or leases the vehicle in private carrier operations. Thus, service, time, and cost variables are substantially different from any type of for-hire operation. In this paper, a carrier is defined as a regulated for-hire carrier, unless otherwise stated. Secondary source information was helpful in supplying information on for-hire, owner-operators, and unregulated truckers.

Survey data from rail carriers only included reactions of class 1 railroads. There is no shipper that has ownership of a major rail line. The ownership characteristics between truck and rail modes are substantially different because of the operating authority given to different types of carriers.

Each carrier type has responded to the energy shortage problems in different ways. The responses are described in the following sections of the paper in terms of near- and long-term consumer responses. The consumer in this case is any actor involved in the movement of goods (i.e., carriers, shippers, and vehicle manufacturers). Following the discussion of near- and long-term response measures, conclusions are made as to the overall impacts of fuel price and supply instability on truck and rail freight movement in the future.

SHORT-TERM RESPONSE

This section describes events that have occurred since the 1973-1974 embargo, as well as current issues facing freight carriers, shippers, and manufacturers. The discussion includes a timeline of events as described through telephone interviews and a literature search. The discussion of shipper reaction is based entirely on secondary source information.

Carriers

Truck

The response of truckers was by far the most vocal of any freight carrier after the embargo. Owner-operators were in the national spotlight in January 1974 when they requested assurances of guaranteed fuel allocations and higher shipping rates to recover fuel costs. The incidences of violence that occurred during the owner-operator struggle did not reflect the industry as a whole, however. Most carriers responded with reasonable short-term operating strategies.

The telephone survey revealed that, from 1974 to 1980, the trucking industry has concerned itself with three major issues: (a) energy price and efficiency, (b) inflation and cost control, and (c) deregulation. These were ranked by the respondents in order of importance. It is likely that energy pricing would take a lower priority in this list of issues if the Interstate Commerce Commission (ICC) instituted fuel surcharges at a more rapid pace than was the case in 1973.

Owner-operators felt the immediate effects of fuel price increases. Because they exist on such a narrow operating budget, there is little flexibility for price increases. On the

other hand, trucking companies are in a position to bear the crunch of short-term cost increases, such as the 1973-1974 fuel price increases, because their return on investment is so high. In fact, relative to other transportation modes, for-hire common carriers have historically received the highest revenues, according to Michael Pacquin of Thermo-Electron, Inc. For example, in 1975, the airline industry averaged a 6 percent return on investment; railroads, 4 percent; and common-carrier truckers, 17 percent.

As applications were made for increasing fuel surcharges, carriers also worked on the problem of decreasing fuel reserves. Fuel-order procedures were on a daily basis rather than monthly distributions. The Nixon Administration developed the Voluntary Fuel Allotment Plan (May 1973) that called for an assurance of 10 percent of supplies for eight priority groups (including freight carriers), but the carriers were actively developing other plans to ensure adequate fuel supplies. Richard A. Staley of the American Trucking Associations (ATA) noted that, by December 1973, some trucking firms had initiated their own fuel-trading plans to ensure adequate supply allocations to participating fleets. The Ryder System was even more direct; it ordered import diesel fuel directly to supplement its own domestically ensured supplies (8). These painstaking actions of the carriers in organizing their own fuel reserves were soon recognized by the Federal Energy Administration (FEA) as hoarding rather than as appropriate fuel supply planning, so a ruling that monthly fuel inventories be submitted from all major carriers was soon released. The carrier response to absolute bottoming out of fuel supplies was an impressive display of internal organization to ensure that at least daily supply crunches could be met. Other operational strategies were developed within the fleets to conserve fuel supplies; these are discussed here.

Ironically, the most controversial strategy for fuel saving became the 55-mph speed limit, passed in 1973. This restriction produced much more of a protest from truckers than any other issue since the 1973-1974 oil embargo. Clearly, the 55-mph speed limit had to be standard for all highway vehicles for safety reasons, but truckers had focused more on the operational problems they were likely to face at the lower speed. Initially, they refused to comply. Trucking associations asserted that the limit would create serious operational problems, cause unnecessary delays, and actually create increased vehicle fuel consumption. In rebuttal to these accusations, the Federal Highway Administration (FHWA) conducted exhaustive testing to determine the most fuel-efficient speed for truckers. The tests satisfied no one. The Teamsters Union then required a pay adjustment for over-the-road drivers adversely affected by lower highway speed limits. FHWA continued its tests via a new program—the Voluntary Truck and Bus Fuel Economy Program in 1975 (9)—that was committed to reducing energy consumption by commercial carriers through a number of options. However, it appeared that, by October 1977, the issue was moot because a DOT study then determined that no state even approached the 85 percent compliance standard for meeting the 55-mph speed limit on divided highways.

Despite the earlier inconsistencies and controversy over the 55-mph limit, the trucking companies surveyed were committed to it as an operational improvement. In fact, Kenneth J. Gentl of Overnight Transportation commented that "getting the drivers to slow down—and stay slowed down is the (operational) key". Other companies have enforced the limit more stringently by requiring metering devices on all vehicles so that maximum speed levels, lengths of haul, braking distances, and downtime can be recorded throughout each trip. The records of metered trips are filed with the driver's personnel data. Driver wage increases may then be based on the accumulated trip-proficiency records. Insurance companies will often base fleet rates on driver records; thus, there is a real incentive for carriers to keep such data on their drivers. Finally, this method of data collection has real merit in terms of coming to grips with fleet operating statistics so that the carrier has a better handle on total fixed and variable business costs. The data provide information to support investment decisions for vehicle depreciation and to determine the economic life of vehicles.

Another method of reducing the impact of energy-related constraints on the carrier has been an emphasis on increased per-vehicle loads. The issue of truck size and weight is gaining widespread attention because fuel is beginning to represent a larger share of total operating costs for intercity movements. The significance of increased size and weight on different carriers varies by the type of operation and its associated trip charges. Truck load (TL) operations, for example, involve three types of carrier movements: regular-route common carrier, irregular-route common carrier, and private carrier. Each TL move represents different line-haul shipping charges as a percentage of total costs: regular-route common carrier, 52 percent; irregular-route common carrier, 100 percent; and private carrier, 80 percent. The advantage of movement by an irregular-route common carrier to increased size and weight vehicles is immediately visible because all of the charges are attributable to over-the-road movement. The other two types of carriers can benefit by making the distribution among charges weigh more heavily toward pickup and delivery and terminal movements, similar to the way in which rail trailer on flatcar (TOFC) and rail boxcar charge allocations represent trip costs (6).

The primary emphasis of increased size and weight for carriers centers on the ability to capture increased revenue per power unit on the front haul. Aside from the energy saving on a fleetwide basis, there is added incentive through decreased labor costs. As noted above, different carrier types will be affected by increased sizes and weights to varying degrees. In the case of less-than-truckload (LTL) and private operators, increased trailer size restrictions are more favorable than increased weight because they generally cube out before they weight out. (Cubing out is an industry expression for maximizing trailer capacity; weighting out refers to maximizing trailer gross vehicle weight.) TL operators generally weight out first.

The reasons that passage of increased size and weights for all states has yet to occur is predominantly due to safety and road maintenance problems. The double trailer operations will cause visual barriers for other highway vehicles. The increased weight may cause additional road maintenance problems in already rapidly declining highway surface conditions. Bridge load-bearing weight constraints are also a problem. In the newer highway systems, the road maintenance questions are not as critical as on the older, predominantly eastern, roads.

It is no surprise that western states were the first to ratify increases in truck sizes in 1974. In fact, twin-trailer combinations are still referred to as western doubles. Eastern states have been more reluctant to ratify increased truck sizes. This issue went as far as the U.S. Supreme Court in March 1977. Wisconsin had banned twin trailers and trucks more than 55 ft in length based on the assumption that the increased capacities placed a discriminatory burden on interstate commerce. The Supreme Court ruled unanimously that cost savings and no measurable increases of safety hazards suggested that larger trucks (up to 65 ft) would not be discriminatory; therefore, the court approved the increased size. Although this set a precedent, it in no way cleared the issue on a nationwide basis. Some 14 states have yet to ratify increased size and weight restrictions. (Further details on the increased size and weight problem are included in the long-term strategy section of this paper.)

Increasing the vehicle size is one way to improve the average load factor; thus, carriers have focused on the problem by increasing capacities for each vehicle trip. (For truck hauls, a trip includes fronthaul and backhaul loads.) According to Richard A. Staley of ATA, the empty backhaul and deadheading problems that many of its member carriers

were concerned with were researched by the association. Then ATA developed a computerized system to match loads between carriers on a 24-h basis. The system was called the Computerized Interchange Substituted Service (CISS). CISS solicits loaded trailers for unhitched tractors. The carrier advertising the load delivers a trailer to the matched carrier's terminal for hauling to a destination terminal at a fixed fee of $0.70/mile. ATA's goal was to reduce deadhead mileage by 25 percent and to reduce operating costs. Ryder truck lines had established a similar matching service four years earlier. The loads were offered to any participating subscriber to the matching service. Although both load-matchup programs did not represent the number of carriers that the system had planned, the concept caught on and, for some fixed-route services of carriers, inbound and outbound traffic has been paired on a regular basis. In May 1975, the ICC attempted to formalize such pooling efforts through the promotion of legislation that also called for joint rates between modes on matchups, route-deviation allowances, and motor carrier substitution of service to further reduce empty backhaul movements. It is unclear why the legislation failed (8).

Empty backhaul issues are inherent to any freight transportation mode. It is unlikely that carriers will ever eliminate nonrevenue vehicle miles, but some advocates suggest that deregulation may put the deadheading issue to rest forever. The evidence suggests that increasing backhaul loads will only serve to increase time and service impediments on the revenue haul. Empty truck movements will continue to exist regardless of the emergence of deregulation or free-market entry (10).

ICC empty backhaul data support the statement that few improvements on backhaul loads are likely to occur. The survey showed that 20 percent of all truck movements is empty, and 14 percent more is LTL. Private carriers showed 27 percent empty loads, while exempt commodity carriers and regulated carriers showed 21 percent and 16 percent, respectively (11).

Private carriers are shippers that transport goods via their own transportation system. Trucks operating under a private carrier are nonregulated and are the fastest-growing fleet. If ownership characteristics continue similar to past trends, the less-efficient goods movers will haul a larger percentage of freight with disporportionately higher energy consumption because of the low-load capacity attributes.

There has been at least one effort to improve private carrier average loads. In June 1974, the ICC proposed permitting private carriers to lease trucks and drivers in their fleet to regulated motor carriers as a means of saving fuel. Unfortunately, the blatant institutional constraints obvious from the beginning caused a lot of antagonism between the carrier groups, and the plan died.

From 1973 until today, truck carriers were forced to make immediate changes to respond to the supply-side constraints. Legislative issues developed, daily fuel shortage problems persisted, and operational constraints dominated each carrier, but the situation clearly caused immediate actions that responded to the near- and long-term needs of the industry.

Rail

Rail carriers did not have to be as responsive to the near-term energy supply constraints as the competitive trucking mode. Shipping constraints that arose for rail carriers largely centered on terminal movements by trucks to a final destination. At the time of the most severe shortages, truckers responded first to line-haul TL deliveries. Rail interchange loads took a lesser priority. Terminal operators were often forced to call numerous carriers to move the load out of the operations area, explained Vern McCullough of the Green Bay and Western Railway (Wisconsin).

Increased movements by rail created some of the worst constraints. If freight forwarders were incapable of routing loads through truckers, they would look to rail as the only alternative. Boxcar shortages developed because no trucks were available at the receiving end; cars were left to wait in the terminal area, said Bob Howard and M. Ditlier of the Sante Fe Railway (Chicago).

No immediate strategies could be cited by the rail carriers surveyed; but, as a result of the lack of responsiveness during the crunch periods, new measures have been put into effect that are likely to have more of an impact on long-term developments. These include increased emphasis on (a) intermodalism so that terminal area costs to the shippers (in terms of service and time) are not as excessive, (b) better shipment inventories to match destination of goods, and (c) new rates that give greater cost savings to full-car shipments in order to improve load factors.

Shippers

The telephone survey did not include shipper-group detail, but secondary sources have illustrated some of the changes prompted by energy constraints. Some of the larger shippers are looking at trade-offs in cost, time, and quality-of-service attributes in determining which shipments, currently moved by truck carriers, are flexible enough to go by rail (7). Shippers sensitive to costs are likely to be transporting low-value goods, which implies that they may be willing to give up time and service quality attributes in favor of cost savings and, therefore, commit some movements to rail. Any analysis of this trend would have to be on a commodity-specific basis in order to determine the likeliness of modal-choice changes by given shipper groups over time. In some cases where shippers use rail as the primary mover, a private truck fleet is used to supplement critical (i.e., time-sensitive) movements. The private truck is likely to be characteristic of low annual vehicle miles of travel (VMT), reflecting that the irregular supplement of shipper-owned truck fleets has an adverse effect on total truck energy consumption because of their traditionally low productivity.

Some new operational strategies that shippers use to reduce transportation costs generally have had positive effects on reducing energy. A strategy that one shipper used to reduce pickup and delivery charges and decrease dockside congestion has decreased shipper costs. A traffic manager discovered that the same type of shipment came to the shipper's dock several times a week. By merely specifying a larger shipment one time a week, the pickup and delivery charges were reduced, there were no dock-queuing problems, and less dockside labor was required. Although the load factors of each delivery vehicle still did not substantiate TL rates, the shipper was able to benefit through the indirect decreases in operating costs (12).

Manufacturers of Truck and Rail Equipment

Vehicle manufacturers have responded to truck conservation through purchase of new equipment in the past five years. The Voluntary Truck and Bus Fuel Economy Program contributed to quick market penetration of both new engine designs and vehicle accessories. Table 1 (1) and the information below (13) show that the per-vehicle saving and the stock penetration for fuel conservation devices are noteworthy:

Equipment	Fuel Conserved (gal 000 000s)	Savings per Vehicle (%)
Aerodynamic devices	49	6
Medium-duty diesel	32	4
Fuel-efficient diesel	288	33
Class 7 and 8 dieselization	78	9
Variable fan devices	206	24
Radial tires	204	24

Table 1. Number of vehicles (in thousands) that use fuel-conservation equipment, 1977.

Equipment	Type of Vehicle Light	Medium	Heavy	Heavy-Heavy	Total
Radial tires	3 850.7	117.8	45.1	310.4	42 967.9
Drag-reduction devices	96.8	6.1	3.6	50.2	157.0
Variable-speed fans	2 603.6	123.2	36.3	164.0	2 927.5
Fuel-efficient engine	13 311.6	88.5	43.6	197.4	1 641.5
Axle or drive ratio change	827.0	335.2	327.6	407.3	1 897.5

Some of these measures are additive. For example, if a gasoline heavy-heavy truck without conservation devices was replaced by a diesel heavy-heavy truck with an airfoil, a diesel bottoming cycle engine, and radial tires, according to the Voluntary Truck and Bus Fuel Economy Program, the new vehicle would realize a saving of as much as 72 percent on an intercity trip. (This calculation suggests that some of the program's assumptions are misguided.)

The manufacturers reacted rapidly to the increased fuel-efficiency needs of the truck carriers, and the preliminary data suggest that commercialization efforts were minimal because of immediate market response to the new devices. Rail equipment did not go through the same easy transformation to fuel conservation accessories. (Rail developments are discussed in the next section of this paper.)

LONG-TERM RESPONSE

A long-term response implies a reaction to the energy supply and price situation by a given carrier during the past five years, but with effects that are not likely to be realized until perhaps 10 years from the initiation. Long-term responses tend to have technological rather than operational orientations.

Carriers

Trucks

Just as truck carriers had immediate short-term reactions to the energy picture, they are also cognizant of the importance of continued efficiency improvements within the mode. Truck energy intensities are likely to decline at a more rapid rate than any other freight transportation mode because of the more extreme sensitivities of that mode to changing energy futures.

The composition of truck fleets is likely to change in the future. Projections of the truck stock show increased dieselization and declining intercity vehicle miles per truck for the heaviest size classes (14). The vehicle mile projections are based on a preliminary analysis of the 1977 Truck Inventory and Use Survey Data (1). These data are somewhat alarming because they indicate that, for the first time since the survey began, vehicle stocks, vehicle miles of travel, and energy consumption are on a declining growth rate. There is evidence of increased portions of the stock in fleets of 10 or less, suggesting that private fleets operating in urban areas represent the largest growth sector.

Consolidation terminals are in the planning stages for larger common carriers. The terminals allow long-haul vehicles to maintain intercity fuel efficiencies, with supplemental small delivery vehicles to make short-run, LTL deliveries to the final destination in an urbanized area. The heavier, high-capacity trucks are on the line-haul portion of the trip to the consolidation terminal, where smaller, less-full consumptive vehicles complete the delivery to final destinations in an urban area, according to Staley and Gentl.

Rail

Rail carriers should have more noticeable efficiency and operations improvements over the long term. Excessive federal financing of rail research and development, as well as terminal and switching improvements, should provide for a healthier system in the future. Interestingly enough, many of the rail improvement strategies are intermodal in nature and center on heavy emphasis of trailer-on-flatcar and container-on-flatcar (COFC) operations.

The Sante Fe Railroad has taken center stage in the TOFC state of the art. Santa Fe has large TOFC yards that can facilitate regular traffic at a greater rate than any other road in the business. In May 1977, the Six Pack was introduced to carry six trailers per flat car. The car cuts the regular tare weight by 35 percent and, therefore, reduces per-car energy consumption. The Santa Fe went a step further in April 1978, when it introduced the Ten-Packer, which has a 10-trailer capacity per flat car. The Chicago-Barstow run tests show that the Ten-Packer is 15 percent more fuel-efficient than the traditional two-trailer flat cars.

Coincidental to the development of the Ten-Packer was work by the Southern Pacific to create a two-container flatcar that is capable of stacking the containers, but with a tare weight 45 percent lower than a traditional flat car.

Rail electrification has also been studied as a long-term efficiency improvement. In May 1973, the Southern Railroad initiated electrification of the Cincinnati-Chattanooga freight route, a distance of 338 miles. Longer-haul unit train routes are the most likely beneficiary of electrification improvements. A pilot demonstration program on the Black Mesa and Lake Power Railway is scheduled, which will primarily cater to unit coal train traffic.

Truck-rail intermodalism is stressed in this research largely due to the emphasis on only truck and rail improvement strategies. There are cases in which rail could be more cost competitive by using waterways for certain hauls. Low-value bulk goods that are sensitive to shipping costs more so than time factors such as coal, taconite, and iron ore and with destinations that require only one intermodal transfer are likely to find rail-water movements cost effective. If shipping requires a second transfer, cost advantages disappear because of prohibitive transshipment costs. Lower shipping costs can be realized for bulk commodities through rail-water shipments so that modes are capable of increased revenues in addition to an energy saving for the entire movement. The concept of lowered, delivered western coal costs to eastern markets was explored in work completed in the past year at the Argonne National Laboratory (Illinois). In a case study, several western-coal-user demands were aggregated in order to capture lower unit train rates to a midwest transshipment site. The coal was to be ferried to Michigan utilities located on the lake shore. Lower per-ton coal transport costs were calculated for the move (15).

Some rail carriers have a special interest in developing similar intermodal projects because of the potential prospects for increased traffic to the rail line. The Burlington Northern has especially benefited recently in the development of western coal fields. This line is currently working on a project with American Commercial Barge Lines to develop a rail-to-barge transfer terminal that will serve to decrease rail transport costs. In yet another instance, the rail carrier has become a short-haul waterway carrier in order to capture line-haul rail traffic. The same is true for the Southern Railway. The Southern Railway owns and operates its own barge line on the Ohio and Tennessee Rivers, which contributes to the reduction of its total transport costs to contracted carriers.

Manufacturers

New vehicle technologies are apparent in both modes, but developments related to trucks appear to be occurring at a

Table 2. Calculations used in determining projected heavy-heavy diesel truck bottoming cycle penetration and energy consumption and savings, 1985-2000.

Factor	1985	1990	1995	2000
Number of heavy-heavy diesel intercity trucks (000 000s)	0.98	1.18	1.43	1.43
Bottoming cycle penetration (000 000s)	0.01	0.3	0.47	0.40
VMT per heavy-heavy truck (000s)	61.38	60.91	60.45	60.45
Heavy-heavy truck VMT with bottoming cycle (000 000 000s)	0.31	17.24	28.53	24.18
Net vehicle fuel efficiency				
Heavy-heavy standard	4.76	4.76	4.76	4.76
With bottoming cycle	5.47	5.47	5.47	5.47
Diesel fuel saved (gal 000 000 000s)	0.08	0.47	0.79	0.67

more rapid rate than those for rail. A greater sensitivity to efficiency improvements over the next 15 years is the predominant driving force of manufacturer improvements (16). Energy-efficiency improvements (e.g., accessory options such as fan clutches, radial tires, and aerodynamic devices that were discussed as elements of the Voluntary Truck and Bus Fuel Economy Program) are likely to penetrate the market without significant manufacturer incentives. This type of equipment change, which reduces fuel consumption, is, in a sense, proven technology with an already assured market.

New technologies that will have more significant impacts on the power-unit fuel consumption, such as engine design alternations, are now in research and development. Few of the new technologies are likely to penetrate the heavy-heavy intercity truck fleet as soon as they come on board, but gradual penetration should occur through the mid-1990s. The interesting aspect of these new technologies is that they all seem to compete for the same market; thus, estimates of fuel conservation by each new technology cannot be considered as an additive function. Because much of the research is in its initial testing phase, competition among new technologies for a relatively small vehicle stock may never become a problem. Some of the concepts may drop out due to high production-line start-up costs, environmental constraints, or specific engine problems that prove the engine design to be less efficient than was originally thought.

One concept that appears to be a good prospect for commercialization by 1985 is the heavy-duty diesel truck bottoming cycle program. The program involves increasing diesel energy efficiency by recycling exhaust heat. When class 7 and 8 trucks are traveling intercity routes (i.e., line-haul portion of the trip), the bottoming cycle is most effective. The new engine designed for this purpose should realize a 15 percent fuel saving over the line-haul trip. Table 2 (16) shows the calculations that were made for an analysis of the bottoming cycle program. Other energy-saving truck technologies that are likely to penetrate the heavy-heavy truck stock in the future include the turbocompound diesel (8 percent saving), advanced heavy-duty gas turbine (30 percent saving), and the adiabatic diesel (33 percent saving). All of the new technologies are projected to come onboard during the mid-1980s.

Hardware programs for rail are less developed, but projections show that, during the early 1990s, the medium-speed diesel alternative fuels program and the Rankine bottoming cycle should provide substantial improvements. The alternative fuels program is scheduled to derive fuels from coal or oil shale, thus giving a 100 percent petroleum saving at the time of substitution into the locomotive fleet. This is based on work in progress at Argonne under the direction of Marianne Millar.

Other programs that have developed new technolgies are biomodal in nature. The Strick Corporation is attempting to commercialize a 26-ft, two-axle vehicle that is capable of increasing payload capacity some 20 percent by carrying one trailer on its back and towing the other. The two-trailer concept is called cab-under, referring to the power unit that is much lower than the conventional semi. The Bi-Modal Corporation and North American Car have introduced a combined highway-railway trailer with interchangeable road and rail wheels at its rear. The trailer may realize an operating cost saving of 75 percent over all-highway operations. This estimate assumes that the trailer does all line-haul on the rail.

SUMMARY

Conversations with carriers and manufacturers, as well as secondary source information, indicate that motor carriers are very responsive to energy supply constraints and are seeking operational and new technology strategies that will improve fleet fuel efficiency. The most obvious concern for freight transportation carriers is centered on increased payload capacities of the vehicles. This trend to upsize freight vehicles is occurring at the same time that personal passenger-vehicle manufacturers are involved in efforts to downsize. Growing pressure on states to ratify increased size and weight for trucks is likely to show near-term energy-intensity improvements. Increased load factors and vehicle carrying capacity will hedge increased fuel costs for truckers. Other ways that carriers are responding to decrease near-term fleet consumption is through enforcement of the 55-mph speed limit, accessory energy-conservation equipment, driver-efficiency measures, and aggregating shipments to increase loads of the backhaul.

Rail carriers were hurt during the 1973-1974 gasoline shortages because the trucking portion (pickup and delivery) of their operations faced serious delays. TOFC and COFC developments will reduce the terminal-area pickup and delivery problems through immediate unloadings, with significant shipment time saving.

Long-term improvements in truck and rail are technology specific. The new engines and alternative fuels programs are scheduled for commercialization in the mid-1980s. Based on the experience of market development of fuel conservation equipment for freight vehicles, any cost-effective technological changes that will reduce energy consumption are likely to develop a market independently and require little marketing effort for fleet penetration.

REFERENCES

1. Truck Inventory and Use Survey (1963, 1967, 1972, and 1977). U.S. Bureau of the Census, 1964, 1968, 1972, and 1980.
2. Commodity Transportation Survey. U.S. Bureau of the Census, 1972.
3. M.S. Bronzini. Freight Transportation and Energy Use. CACI, Inc., Arlington, VA, DOT-TSC-79-1, July 1979.
4. W. Martin. AAR Truck Cost Model. American Association of Railroads, Tech. Memorandum 78-12, Washington, DC, Oct. 1978.
5. J.F. Murphy. Railroad Cost Modeling. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, Vol. 1, SS-212-41-27, Sept. 1976.
6. D.P. Sullivan and R.J. Kochanowski. Truck and Rail Cost Effects of Truck Size and Weight Limits. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, DOT-TSC-321-16-0, Dec. 1979.
7. J.D. Williams. High Trucking Costs Spur Interest in Rails for Many Companies. Wall Street Journal, Sept. 19, 1979.
8. What's Happening in Transportation. Transportation Association of America, Washington, DC, 1973-1980.
9. The DOT/SAE Truck and Bus Fuel Economy Measurement Conference Report. Society of Automotive Engineers, Inc., Warrendale, PA, P-59,1975.
10. C. A. Bisselle. A Preliminary Assessment of Empty

Miles Traveled by Selected Regulated Motor Carriers. Mitre Corp., McLean, VA, MTR-7081, Jan. 1976.
11. Empty/Loaded Truck Miles on Interstate Highways During 1976. Bureau of Economics, Interstate Commerce Commission, 1977.
12. A.W. Todd. Impact, Knowledge, and Choice—One Company's Management of Inbound Transportation. Proc., Transportation Research Forum, Vol. 20, No. 1, Richard B. Cross Co., Oxford, IN, 1979.
13. Motor Vehicle Facts and Figures, 1978. Motor Vehicle Manufacturers Association, Detroit, Dec. 1977.
14. R.E. Knorr and M. Millar. Projections of Direct Energy Consumption by Modes: 1975-2000 Baseline. Argonne National Laboratory, Argonne, IL, ANL/CNSV-4, Aug. 1979.
15. R.E. Knorr and K. Wilkie. An Analysis of a Coal Brokerage for a Midwest Site. Argonne National Laboratory, Argonne, IL, ANL/CNSV-TM-21, Oct. 1979.
16. R.E. Knorr, S.J. Labelle, and M. Millar. Markets for New Transportation Technologies: Changing Energy Use Futures. Pergamon Press, Inc., New York, Oct. 1979.

Consumer Reactions to the 1979 Gasoline Shortage

Jill L. Habermann (in conjunction with a presentation by Lois Jacobini)

The gasoline crisis of 1979 started on the West Coast of the United States nearly four months after the Iranian revolution in December 1978. The revolution precipitated the cutoff of approximately 500 000 bbl/day of crude oil normally destined for U. S. markets (500 000 bbl of crude oil represents approximately 10 million gal of gasoline). Reactions from every sector of the economy set in as the gasoline shortages spread.

To understand the underlying motivations for the reactions from consumers, industry, and government during the gasoline shortage, it is necessary to understand the relation of the average U.S. citizen to the automobile in psychological terms. Paul W. McCracken, who received the National Automobile Dealers Association's Freedom of Mobility Award in 1979, remarked that "a strategy for a national energy policy, which assumes automobiles must be abolished...will fail because it will fail to perceive the extent to which an automobile is for the common man not only the symbol, but an important source, of freedom." Right or wrong, decision makers in the United States tend to perpetuate this concept of the automobile as a symbol of freedom. Consequently, many decisions concerning gasoline were shortsighted and sought only to increase supplies. Short-term plans that perpetuate the use of the private automobile as the primary travel mode—for example, automobiles that are more fuel-efficient and gasohol to stretch fuel supplies—are more popular and pose fewer political and economic risks. The alternative, which is long-term planning, involves changes in life-styles, such as carpooling and using mass transit.

The issue at hand is not to evaluate the U.S. love affair with the automobile; rather, it is to evaluate the reactions to the 1979 shortage in relation to reactions to the 1973-1974 shortage and to speculate on future implications.

Richard J. Barnet, who wrote The Lean Years: Politics in the Age of Scarcity, calls for the development of a high degree of public participation, understanding, and decision making, which would lead to the development of a sense of stewardship. Stewardship is the concept that each one of us has the responsibility to inform ourselves and evaluate our past and current actions in order to plan for the future. This paper develops the thesis that the kind of information available to the U.S. public and the manner in which it was presented was a major factor in the types of consumer responses that occurred during the first six months of 1979. These reactions, in turn, motivated many government and industry decisions that did not necessarily accurately reflect needs.

Extrapolating Barnet's stewardship theory, I submit that the development of a national energy-awareness program is important to ensure rational, nondisruptive, long-term planning for energy conservation in the transportation sector. Some 50 percent of the petroleum imported by the United States is used to fuel personal motor vehicles. The average citizen used 11.7 bbl of gasoline in 1979, compared to 2.8 in France, 1.8 in Italy, 2.8 in the United Kingdom, 3.2 in West Germany, and 1.9 in Japan. Faced with an inexorably diminishing world petroleum supply, the United States must divide up available sources among transportation, agriculture, residential, and industrial sectors. With cooperation, communication, and accountability at every level of society, the United States can conserve and reduce foreign oil imports. The transportation sector is potentially the flagship sector for assessing the U.S. commitment to energy-conservation awareness.

REGIONAL DIFFERENCES

Quality of Information Flow

In any situation, one's reactions are usually based on two types of information: actual first-hand experience and information culled from a variety of second-hand sources. Most people consciously evaluate the information received from second-hand sources (i.e., television, newspapers, annual reports, and government documents) before taking action. When the gasoline lines started in California, most citizens were already aware of the correlation between the Iranian oil shutoff and scattered predictions of spot shortages nationwide. Nevertheless, there was little continuity in the information made public at first. The White House balked at giving the nation a realistic report, i.e., that gasoline was going to be expensive and in short supply. The White House was concerned that too much publicity would trigger the same panic buying, hoarding, and topping off that exacerbated gasoline shortages during the 1973-1974 oil embargo. Also, it was unwilling to take responsibility for the inevitable negative reactions to mandatory rationing and conservation plans.

The quality and consistency of the information flow represent the first step in establishing a sense of awareness in the consumer that leads to rational action, an evaluation of consequences, and a new awareness. The then DOE Secretary James Schlesinger announced on February 10, 1979, that the halt of Iranian oil exports was "prospectively more serious" than the oil embargo of 1973-1974. Then, four days later, the vice chairman of the Ford Motor Company, Phillip Caldwell, said that this gasoline crisis would not be as severe as the crisis caused by the 1973 cutoff because there were more gasoline stocks available and more fuel-efficient cars being manufactured. (The average automobile in 1979 got 16.4 miles/gal compared to the 1974 figure of 13.7 miles/gal.) U.S. Deputy Secretary of Energy John O'Leary warned on that same day that the current fuel pinch was but a foretaste of permanent shortages that could appear by 1981. The chairman of Exxon Corporation, C. C. Garvin, shortly thereafter

commented that the allocation system instituted by DOE was largely responsible for the gasoline shortage.

Other groups issued conflicting data as well. The U.S. Library of Congress issued a study on March 1, 1979, which concluded that the shortage in the United States was not related to foreign production shortages but to inventory mismanagement and market manipulation by the oil companies. Another study by the Office of Technology Assessment, an arm of the U.S. Congress, questioned the continued viability of the automobile as the primary method of personal transportation. Many different kinds of figures were used and manipulated by various groups, confusing the public and leading to widespread cynicism as to the credibility and motives of the federal government and of the oil companies.

Action Groups

Faced with a myriad of conflicting data, consumers and industry were hard pressed to present a united plan of action to their respective subgroups. Sectionalism and polarized positions developed as each of the various groups assessed its gasoline needs in terms of the total supply available—understanding that its gains would be another group's loss.

Negative reactions set in as various groups fell into the pattern described by Harold Wakeley in his study on predicting consumer responses to gasoline shortages. Wakeley notes the division of these reactions into two types: (a) the reactance theory, which is the belief that a person will respond with hostility to a perceived loss of freedom of choice, and (b) the learned-helplessness theory, which is the belief that the ability to control future situations is based on a person's perception of how much control he or she had over a similar past situation. For example, after the initial shock and subsequent reactions to the gasoline shortage, special-interest groups began organizing to influence regulatory and legislative action and to take positive action in order to alleviate obvious setbacks, such as reduced availability and higher prices. One group, the gasoline retailers, organized into state associations and proposed a nationwide shutdown of service stations for four days to protest DOE's controls on gasoline prices. The U.S. Department of Justice sought a court order to prevent the shutdowns. Traveling salespeople launched a campaign to petition for special exemptions such as those received by doctors, farmers, and truck drivers. A group of service station operators, represented by the Independent Gasoline Marketers Council, sued DOE and sought to bar it from enforcing its stand-by gasoline-allocation plan, which they claimed discriminated against independent dealers. The dealers said DOE's regulation, which would bar the imposition of previously deferred price increases during emergencies, would cause economic hardships for the independents.

Federal Responses

DOE had two mechanisms with which to handle the gasoline shortage. One was the federal stand-by gasoline-rationing plan, the regulations for which were not completed until January 1980, and the second was the gasoline-allocation program that was theoretically in place at the time the shortage began.

Development of the federal stand-by rationing plan was a long and arduous process that began in February 1979 with the White House calling for patriotic voluntary energy-conservation measures, such as increased use of carpooling and mass transit and strict observance of the 55-mph speed limit.

The call for voluntary measures prefaced the White House's request to Congress (February 26, 1979) to give the President stand-by authority to order four types of energy-conservation measures, depending on the state of emergency. These measures would close service stations on weekends or Sundays; order employees, including those of state and local governments, to restrict commuter parking (to force the use of mass transit); ban the use of electricity for neon signs and other outdoor lighting (largely a symbolic gesture); and restrict the range of temperature settings for thermostats in public buildings.

This major gasoline-rationing plan was eventually scrapped, a victim of special-interest lobbying. The plan, as originally written, would be triggered by a severe energy-supply interruption. Owners of registered vehicles would have received gasoline-rationing checks every three months, which were redeemable for coupons. Coupons would then be redeemable for a certain number of gallons based on the type of vehicle to be used during those three months. Recipients of the coupons would be allowed to sell them on a white market. Essential services would receive as much fuel as needed, with farmers receiving top-priority allotments. A mechanism would allow each state to distribute coupons for hardship cases as needed. Congress would have 60 days to approve the plan, following a formal request for authority by the President. The cost to set up the approved rationing system was estimated at $53.4 million for 1979 and the same for 1980. The plan is similar to the one proposed by former President Gerald Ford, except that the allotments in his plan were to be based on licensed drivers rather than on registered vehicles.

President Carter's gasoline plan was discussed in Congress for seven months and changed substantially three times before the U.S. Senate passed the measure. (The major change based allotments on statewide consumption of gasoline rather than on the number of registered vehicles; this favored rural states.) The U.S. House of Representatives, split by parochial interests, turned down the Senate's plan. It then proposed its own plan, which called for one driverless day per week per car and a $5 minimum purchase for gasoline to prevent topping off.

The Senate then rejected the House version and passed its own measure suggesting that the President develop a federal plan and the governors develop their own state plans. The Senate's suggestion was eventually adopted by DOE with White House approval. The Senate proposal encourages states to draft energy-saving plans best suited to their regions and then to send them to Washington for federal approval. The President was authorized to draw up a national conservation plan, effective in the event of an emergency in a state that had no prepared or approved plan.

News articles did not herald this suggestion as the first acceptable federal stand-by gasoline-rationing plan. Most news articles carried headlines with negative connotations. No emphasis was placed on the fact that the Congress and DOE, with the approval of the White House, decided to share the responsibility of long-term energy-conservation planning with state and local governments through transportation modification. So, although the states experienced more responsible participation, the general public was still digesting contrary information and had no motivation to provide responsible input.

The U.S. General Accounting Office (GAO) called DOE's gasoline-allocation plan a chaotic program in need of overhaul. DOE has legislative authority granted by Congress (in 1973) to manage supply distribution when shortfalls drop below 20 percent. When the 1979 supply shortage developed, federal and state governments were not prepared to manage the supplies. The allocation system is supposed to allocate supply according to a historic base period. In other words, suppliers sell gasoline to purchasers based on the volume they bought in 1973. Essential purchasers receive a 100 percent allotment, and nonessential purchasers receive a fraction of their base-period volume. DOE was in charge of allocating supplies from the refiner to wholesalers to retail stations to bulk end-users. DOE failed, mainly because its program was five years old and the historic base-period volume statistics were inapplicable. The day-to-day operations were inadequately managed, and auditing enforcement and information-monitoring facilities did not exist in a usable form. DOE also lacked the ability to provide program

guidance to states to help them administer their set-aside programs. Lack of planning prior to the 1979 shortage meant that DOE was trying to create a viable program in the midst of the shortage—changes were made on an ad hoc basis with limited information.

In a report on gasoline allocation (April 1980), GAO recommends that the allocation program be revised. It emphasizes that there should exist distinct but complementary roles and responsibilities for government and industry and that unnecessary government regulation be avoided and industry be allowed to exercise its operational judgment within clearly defined and understood guidelines and regulations. Strong monitoring, compliance, and enforcement divisions are critical to the prevention of allocation abuses in the future. Instituting a rolling base period, instead of a historic base period, would provide a much more accurate reflection of supply and distribution patterns, thus enabling DOE to work more effectively with state and local governments.

State and Local Responses

State and local responses to regional shortages are examples of attempts to achieve a workable balance between alleviating short-term crisis-oriented problems and planning ahead to forestall similar, future supply disruptions.

The general public is aware of the different types of plans organized by state and local governments at the beginning of what seemed to be a shortage that would rival the one created by the 1973-1974 OPEC oil embargo. The plans included flag systems to denote gasoline supply status at specific stations, gasoline sales on an odd-even license-plate system, topping-off penalties, minimum- and maximum-purchase requirements, weekend closings, and so forth. The point is that state governments took the initiative to prevent panic buying and to spread supplies as evenly as possible throughout the course of one month's gasoline allocation.

For the most part, customers obeyed these mandatory rules. The success of the different types of imposed sale restrictions was due to the perception that a shortage did exist. But imposing mandatory restrictions, such as rationing, gasoline price decontrol, and economic penalties for downtown parking, can only be effective in the short run because the imposed rules do not educate the consumer as to how to plan and participate in long-term energy-conservation behavior.

Local transit operators have been successful in both contingency planning and in conservation-awareness development. They have developed societal goals, specific objectives, and performance indicators—all necessary components for a long-range conservation program.

The American Public Transit Association (APTA) emphasizes that predictable federal funding will allow public transit systems to formulate long-term plans with high energy-conservation savings. According to APTA, transit buses are up to 15 times more energy-efficient than automobiles, achieving 280 passenger-miles/gal compared to the 19 passenger-miles/gal achieved by the average commuter automobile. Transit riders saved 37 165 000 bbl of petroleum fuel in 1978. If funds can be guaranteed ($50 billion will be needed over the next decade), intercity transit-system development is a solution that will both conserve energy and maintain the freedom of mobility so important to people in the United States.

Federal support of urban mass transit system improvements is growing. President Carter's plan sets aside $2.41 billion for mass transit financing. These funds are essential, as pointed out by former U.S. Secretary of Transportation Brock Adams. He voiced skepticism that public transit could be a short-term or a long-term solution to cut down energy use unless adequately funded. He stated:

> I'll get as many people out of cars and into mass transit as I can, but the most I can see doing is 15 to 20 percent, if all works well.... If we had a 10 percent shift of people (immediately) away from their automobiles, it would swamp us—overload the public transportation system. Trains, planes, and buses all share only 15 percent of the travel between cities; the other 85 percent go by car.

Public-awareness programs that present clearly stated facts comparing the cost-effectiveness of public and private transportation help motivate consumers to consider making the work trip by public transit rather than by private automobile. An informed consumer is a rational consumer. An aware consumer is a consumer who will make decisive efforts to think in terms of long-range goals.

Priorities

Short-term goals cater to a crisis-oriented society and to special-interest groups. For example, production priorities set by U.S. refiners and by political considerations created the so-called heating oil and gasoline controversy that pitted the short-term political goals of the Carter administration against the various business and consumer interests affected by the menace of a summer gasoline shortage. DOE called for the oil industry to build up middle-distillate stocks, including diesel fuel and heating oil, from 114 million bbl in April 1979 to 240 million bbl by October 1979. Many industry representatives questioned the wisdom of reducing gasoline availability during the summer driving season to assure adequate heating supplies the following winter. The types of priorities set up by DOE and the White House demonstrate the importance that awareness of needs plays in determining both long-term national programs and short-term, special-interest programs.

Another example of a short-term goal taking priority is state and local efforts to acquire more diesel fuel as demanded by businesses in specific areas. Instead of considering the long-term issue, which is what increased diesel-fuel use will do to the air quality, the federal government sought to meet the demand from states for increased diesel fuel to alleviate the demand for gasoline. Promoting strict air pollution standards—a long-term beneficial social goal—would slow diesel-automobile development and make unavailable to the U.S. public an automobile that would have 25-30 percent greater fuel efficiency than a gasoline-powered car. Again, the priorities of the federal government showed a greater commitment to the short term than the long term.

The state and federal gasoline-allocation plans discussed earlier prioritize long-term considerations, as well as provide mechanisms to alleviate short-term supply shortages. DOE has been setting voluntary state gasoline-conservation targets for each quarter of 1980 to help achieve President Carter's goal of holding U.S. gasoline consumption in 1980 down to an average of 7 million bbl/day. This figure represents a 400 000-bbl/day or a 5.5 percent drop in average use in 1979. Including national targets for reduced fuel consumption within the state plans emphasizes for the public the importance of participating in a national conservation effort.

Industrial Sector

Gasoline is a petroleum product unlike most others in that its use is not restricted to either the industrial or consumer sector of the economy. Its use spreads across the entire spectrum of the U.S. economy. Its reduced availability in 1979 caused primary, secondary, and tertiary effects to ricochet throughout the economy—some negative and, surprisingly, some positive.

One sector hard hit was the automobile industry. U.S. manufacturers were not ready for the rapid market shift to smaller fuel-efficient automobiles. General Motors lost money on domestic sales. Ford Motor Company lost $1 billion in 1979 in sales in North America and expects to lose another $1 billion in 1980. American Motors Corporation, which recently went into partnership with Renault of France, was the only U.S. automobile company that showed a profit last year. One out of every four cars sold in the

United States is a foreign car (in California, the ratio is 2 to 1).

DOT pushed the automobile industry to increase further the fuel efficiency of their products. The U.S. Environmental Protection Agency is requiring that each company's new fleet of automobiles averages 27.5 miles/gal by 1985. The goal was to cut daily national consumption of gasoline from 7.5 million bbl/day to 4.5-5 million bbl/day. The U.S. automobile industry is resisting this trend, according to Brock Adams, who noted that "the faster the mileage must rise, the earlier they (the automobile industry) will have to incur development costs."

William J. Abernathy of the Harvard Business School believes that the U.S. automobile industry is unprepared for the 1980s, which will mark an era of rapidly changing and innovative automobile technology. The companies operate on economies of scale that tend to discourage innovation. Innovation requires new production techniques that disrupt the mass-production techniques that cut costs for the U.S. automobile industry. Abernathy says that the companies have sought to perfect existing technologies and maintain mass production rather than promote innovation. The end result finds companies that cannot adapt to fast-changing technologies and are susceptible to economic hardship. New firms, such as Honda, are concentrating on developing new technologies and might eventually replace the older, more conservative, and slow-moving firms.

It is not that manufacturers are totally oblivious to trends; the U.S. automobile market is unpredictable. For example, in early 1979, Ford Motor Company was selling out of its 1979 models of the Mark V Lincoln Continental, its biggest luxury car. Then the gasoline lines started, and the trend reversed. Automobile makers offered customers rebates of up to $1000 on slow-selling large cars rather than on small cars, as suggested by the White House, as an incentive to purchase the more fuel-efficient vehicles. U.S. consumers are willing to wait nine months for a Volkswagen Rabbit and pay substantial amounts over sticker prices to purchase diesel-fueled cars rather than take advantage of the rebates. U.S. manufacturers have not been able to provide the consumer with a product that he or she is interested in, thus creating a loss for the U.S. automobile industry and for the nation's economy in general.

The state of the art in innovative technology is as unpredictable as market trends. Detroit's main problem is maintaining an acceptable profit margin. For Detroit, the traditional money maker has always been the big automobile and its spare parts and accessories. According to John Z. DeLorean, who headed General Motors' Chevrolet Division in the early 1970s, the 1975-1979 top-of-the-line Cadillac Seville was just a luxury version of the inexpensive Chevrolet Nova. He also noted that a Chevrolet Caprice cost $300-$400 less to build than a Cadillac Coupe de Ville, but the Cadillac sells retail for $3800 more. In other words, if the market for large, luxury models falls off, Detroit stands to lose a lot of money.

Small cars were never big money makers. What has been Detroit's reaction? Raise the price of the smaller cars--the Chevette's sticker price has risen 20 percent since 1978. But Detroit is still worried that it has not read the market correctly. It is worried that people might resign themselves to buying gasoline at $2/gal and still dream of, and buy, a full-sized Cadillac.

In reading the market, Detroit has been cautious, or disbelieving, of the apparent trend toward smaller cars because of the experience in 1974. In 1974, most consumers continued to buy large, luxury automobiles, believing that the shortage was only an anomaly in the gasoline-distribution system. A misreading of the current market situation could result in severe economic hardships for the already financially strapped automobile industry.

Despite numerous problems, many people familiar with the ups and downs of the industry are optimistic about its future. The optimism stems from the fact that people in the United States will soon be replacing the 100 million automobiles they bought in the 1970s—thus giving U.S. manufacturers a huge new market. Industry representatives believe that the automobile industry has already experienced its worst slump and is ready to spring forward. Both General Motors and Ford are expanding their overseas markets and, along with American Motors, are ready to produce the small cars that consumers want on a large scale. A world automobile is to be developed—an automobile that will be a standardized vehicle, with its major parts manufactured all over the world. It is expected that Japanese competitors will start production in the United States to avoid future U.S. import restrictions. Obligated to manufacture its automobiles with U.S. labor, the Japanese will lose their competitive pricing edge.

These different viewpoints as to the future of the U.S. automobile industry emphasize how difficult it is to predict the market behavior of the U.S. consumer. The bottom line for the industry is to produce fuel-efficient automobiles that appeal to the U.S. consumer, conserve energy, and produce profits.

The trucking industry suffered more immediate effects than did the automobile industry. Diesel fuel supplies became very tight, prices soared, and tempers flared. The truckers participated in hostile acts, such as blockading road access to southern Florida, participating in cross-country convoys, and blocking truck stops and fuel pumps.

State gasoline plans, implemented to help private consumers obtain adequate and consistent gasoline supplies, did not give truck drivers priority allotments. For independent truckers, especially, this was an economically disastrous situation.

Transient truckers were not accounted for when allocations were made to truck stops. Truckers carrying perishable goods were not given special status and suffered economic setbacks due to the lack of planning and to inflexible base-period allocation figures.

Agri-businesses consume the most gasoline and diesel fuel at harvest time, when the produce is shipped out. When allocations were cut to 80 or 90 percent, many firms found fuel supplies even more scarce because allocations were based on 1978's allocation level at harvest time, which did not coincide with the 1979 harvest period. (It is common to have harvest times that fluctuate yearly.) A DOE decision to give agricultural production activities priority in diesel allocations reduced the trucking industry's share of diesel fuel from 20 to 14 billion gal/year and forced the price to $1.00/gal or more. The price represented a 41.4 percent increase since January 1979.

Trucking and union interests brought their complaints to the U.S. Interstate Commerce Commission (ICC) in early May 1979; they asked for the authority to pass through cost increases in a rapid and efficient manner. One month later, the trucking industry asked for priority in fuel allotments and a 120-day waiver of truck size and weight laws. The truckers received the surcharge they requested largely due to the perception that, without it, independent truckers would instigate a nationwide strike. Two months later, an ICC commissioner, Thomas Trantum, demanded an investigation into the use of surcharges that, he said, reaped windfall profits of about $123 million for many general commodity carriers. According to Trantum, these carriers needed a surcharge of 3 or 3.7 percent to offset fuel price rises (ICC, Ex Parte 311, August 21, 1979). Some 40 percent of these carriers' shipments were truckload freight, which meant that the carriers received 1.5 percent more money than needed to offset the price hikes because the surcharge was applied to all truckload shipments. The ICC reduced the surcharge from 2.7 to 1.6 percent and was promptly sued on August 30, 1979, by the Central States Motor Freight Bureau and nine other major motor carrier rate bureaus in federal court to reverse the ICC's decision. The regulatory and legislative aspects of the trucking industry have many political ramifications that make it difficult to evaluate future alternatives.

One obvious solution to the truckers' problem is to increase fuel efficiency and fuel-conservation techniques. A 10 percent increase in fuel efficiency will result in an

annual fuel saving of 1 billion gal. To actually realize this saving is another problem. According to Thomas Dougherty, vice president and general manager of the International Harvester Company's North American Truck Operations, no major technological changes in truck design are expected. Rather, many small conservation initiatives will be taken that, when pooled, will provide substantial fuel savings. The problem here is that many truckers instituted fuel-conservation measures as early as 1973 and 1974. Most units are operating at fairly efficient levels. Another idea that complements increased fuel efficiency is increased freight per gallon. Federal gross weight limits have been increased to 80 000 lb. By lightening the rig and increasing the payload, fuel costs are lowered because the increased payload offsets the fuel costs. The corollary is minimizing empty or partially loaded miles, known as deadheading.

Truckers suffer from tight fuel supplies, makers of large automobiles are experiencing soft demand, motels on highways in out-of-the-way areas are accommodating fewer travelers, powerboats and campers are not selling due to uncertain fuel supplies, and vacation home developers have been affected by people who save gasoline for essential activities. Some sectors of the economy have been helped by the shortage. Sales are strong for small-automobile makers and sellers. Railroads are experiencing increased passenger use. Travelers are switching from automobiles to buses. Telephone companies are profiting by people who make contact by telephone rather than by travel. Resorts near cities and close to home are gaining in popularity. For every industry adversely affected by the shortage, there seems to be another that is benefiting

Assuming assured supplies, the rising price of gasoline constitutes an economic problem in and of itself. Consumers who have to spend more of their fixed incomes on gasoline—an estimated $18 billion more was spent in 1979 than in 1978—save less and buy fewer other goods. Unemployment rose in 1979 and layoffs and shorter work weeks were common. Many industries are coping with shortages and higher prices by thinking in the short term and curbing expansion and investment scenarios. The effect on the general economy is high unemployment, inflation, and soft real estate markets. Unless the United States commits itself to concentrated efforts at fuel conservation, economic recession is inevitable.

COMPARISON WITH 1973-1974 OPEC OIL EMBARGO

Variation of Consumer Responses

Everyone remembers the gasoline lines that appeared during the 1973-1974 oil embargo. Strategies developed at the time to cope with the crisis were short-term in scope and often implemented too late to be effective. As soon as the lines ended and supply increased, most people lost interest in fuel-conservation measures. Allocation plans were shelved. Many dealers returned to selling gasoline on a 24-h/day basis. Big-automobile sales rose. Conservation plans were left incomplete.

Some federal and state agencies had the foresight to begin evaluating the long-term implications of the shortages, namely that the United States was growing increasingly dependent on highly unstable sources of crude oil and making little effort to curb consumption, unlike most other industrial nations. State agencies developed contingency plans to forestall the side effects of similar shortages should they occur in the future. A major part of the planning went into attempts to disseminate information to targeted areas. The net effect in the beginning of 1979 was quick consumer response to the gasoline shortage—consumers went more readily to public transit than they did in 1973.

Increased ridership started in 1974 during the crisis, reversing a 28-year decline in public transit use. The problem came later when consumer responsiveness was not met by responsiveness from the public transportation sectors. Consumers then became disenchanted with inadequate alternative travel modes.

The average motorist was better-prepared for the 1979 shortage than for the 1973-1974 embargo, both psychologically and sociologically. New subway lines in Washington, D.C., and Atlanta and a $1-billion improvement program for the New York City transit system offered new alternatives to commuters. The improvement in automobile fuel efficiency since 1973 made the available gasoline go further. Preventive methods of conservation, such as carpooling and vanpooling, were implemented along with more strict enforcement of the 55-mph speed limit. This measure saved an estimated 200 000 bbl/day of oil. Strict compliance would save another 200 000 bbl/day.

Heightened consumer awareness in 1979 reduced the number of unnecessary trips in private automobiles, for example, for shopping and leisure activities. Businesses in these sectors were immediately affected; sales at shopping centers declined, and companies that were involved in the travel industry suffered. The economic impact on these industries was more severe in 1979 than in 1973-1974 because the 1979 shortage occurred during the peak summertime shopping and travel season. Even though 77 percent of the U.S. public believed that the oil companies hoarded gasoline, they accepted the fact that it was not available.

The 1973 crisis, on the other hand, took the nation by surprise. Most people had no recollection of a similar occurrence in their recent memory. By 1979, most people remembered 1973 and resigned themselves to the possibility of a gasoline shortage. Even considering this and all the factors described above, the 1979 situation was still marked by violence and the continued lack of a coordinated energy policy.

Consumers were still skeptical about the existence of the shortage because of the conflicting information they received. The fact that the shortage seemed to hit some areas of the country much harder than others seemed to reinforce this skepticism. Legislators, regulators, producers, and local government officials must help develop awareness programs that will provide consistent information to the consumer. Efforts have started, but they are not coordinated. Without coordination and some type of national program designed for different groups, efforts at informing the consumer will continue to fail.

Lessons Learned—Federal Actions

Decision makers have since learned that the most important lesson in terms of future action by DOE and DOT is coordination of policy. In 1973, stop-gap measures were the most common approaches to alleviate shortages. In 1979, federal agencies were still promoting short-term policies at the expense of long-term considerations, as demonstrated by the ineffectiveness of DOE's allocation program.

After the 1979 shortage subsided, the White House, DOT, and DOE set aside more than $16.5 billion of the July 15, 1979, energy plan for long-term conservation in the transportation sector. (The basic goal of the comprehensive energy program is to cut U.S. oil imports in half by 1990.) Conservation in the transportation sector would be promoted through programs, such as ridesharing, driver efficiency, federal-level participation in meeting the same conservation goals, energy-efficiency pledges (by corporations, state and local governments, unions, civic groups, and trade associations), and an energy-efficiency awards program to recognize those who make outstanding contributions to energy conservation. Drivers would be responsible for fuel efficiency through careful driving, coupled with the automobile industry's commitment to produce an acceptable fuel-efficient automobile. In these ways, fuel conservation in the United States would begin to be a participatory and coordinated effort.

The National Energy Conservation Program was unveiled on April 29, 1980. This is the first attempt to present a coordinated federal agency program and is aimed at participatory conservation efforts. The program seeks to

increase public awareness of the need to conserve energy. Public- and private-sector employers will be asked to achieve 20 percent employee participation in ridesharing, or a 20 percent increase in participation (known as the 20/20 program). DOT has established a National Ridesharing Information Center under the program with a ridesharing network and workshops around the country to teach employees how to promote ridesharing. Through the Driver Efficiency Conservation Awareness Training program, DOT will provide driver-efficiency teach-ins for 3000 representatives of public and private employers and offer general public-service advertising to inform the public about gasoline-saving techniques. The Interagency Conservation Action Group (ICAG) is a cabinet-level task force encouraged by the White House. It has representatives from DOE, DOT, and the U.S. Departments of Housing and Urban Development, Agriculture, and Commerce, who are responsible for formulating energy-conservation outreach groups. These groups will ask the advice of government, business, labor, civic groups, and associations to promote energy conservation in the transportation, agricultural, and residential sectors. If this plan is managed efficiently and well promoted, it will successfully begin to instill in the U.S. public a sense of stewardship—the ability to take the responsibility for reducing the wasteful use of gasoline.

FUTURE IMPLICATIONS

Understanding the Problems

According to the National Transportation Policy Study Commission's final report on National Transportation Policies Through the Year 2000, critical uncertainties exist concerning the future capability of the United States to achieve energy conservation and develop alternative fuel sources. The commission asks the following questions:

1. How can future transportation systems provide energy-efficient movement of people and freight in a balanced system at the lowest social and economic costs?
2. How can transportation demand be reduced to conserve energy without seriously impairing mobility?
3. What strategies may be employed to conserve existing transportation energy sources? and
4. How many new transportation technologies or alternative sources of fuel can be developed to maximize the efficiency of new systems and provide adequate fuel supplies?

Another question needs to be asked, "How do you get the private consumer and the commercial consumer to develop long-range planning capabilities?" According to the policy study commission, a future-oriented energy-conservation policy for transportation needs must take into account changing value systems and changing economic factors. The only comment the commission makes on energy conservation is that "free energy markets should provide the proper incentives to producers and carriers to use fuel-efficient vehicles and practices. Retain fuel-efficiency standards until such free energy markets can be achieved."

The issue of whether to abolish price controls on gasoline is a major question with no clear answer. On August 16, 1979, Schlesinger admitted that the U.S. government cannot determine supply allocations under a system of price controls better than a free-market system can. Binding price controls tend to exacerbate shortage situations when consumer demand for gasoline exceeds the supply available at the maximum-allowable price. The available supplies, which cannot meet the demand, must then be allocated by a government allocation system that has proved to be very inefficient, inflexible, and inequitable, thus compounding supply problems.

Price controls have also affected the production and supply of unleaded gasoline. Limits on refiners' return on investment for refinery improvements needed to produce larger quantities of unleaded gasoline have discouraged production. The price-control structure could result in future shortages of unleaded gasoline.

Creative Courses of Action

Allowing the development of free energy markets in anticipation that higher prices will reduce consumer demand can only be considered a part of the solution to the problem of reducing gasoline demand. Gasoline and diesel-fuel demand can be price-inelastic at times. A study by the Congressional Office of Technology Assessment showed that a 15 percent increase in the price of gasoline yielded only a 3 percent reduction in vehicle miles traveled.

Serious long-term conservation planning should concentrate on reducing gasoline demand permanently. Demand should not only be reduced artificially by economic restrictions to alleviate a particular shortage situation. A national energy-conservation awareness program should be developed to provide consistently accurate information in a simple manner in order to guide the consumer toward an eventual reassessment of value systems that prioritize the use of the private automobile. The National Energy Conservation Program is a good start.

The program should be expanded to include educational seminars and information on a higher level than simply training individuals in fuel-efficiency techniques. Through creative use of ICAG, major participants could provide input--for example, federal, state, and local agencies; multijurisdictional agencies; trade associations; labor unions; educational institutions; banks; oil companies; and Congress. Issues to address would include government policies, regulation and finance, public transportation, transport technology, intergovernmental relations, and economic development and land use.

The information program would have to be developed with enough built-in flexibility so that it would appeal to a variety of groups—from high school groups to company employees enrolled in energy-conservation programs.

The ICAG is an excellent way of providing a forum for gathering pertinent data, especially from DOE and the oil companies. The information ideally should be disseminated by representatives from the private sector, in conjunction with federal support or support from institutions such as the Transportation Research Board. The program's biggest obstacle would be establishing credibility for its information.

It is the responsibility of every citizen, especially those knowledgeable in energy conservation and transportation planning, to promote gasoline conservation as a way of life.

The National Energy Act orders that petroleum imports be reduced by 6 million gal/day by 1985. If transportation use accounts for 50 percent of total petroleum use in the United States, then significant changes must be made in transportation systems in the next decade. Development of a national energy-conservation awareness program could significantly alter transportation modes in the United States by the year 2000.

Predicting Consumer Response to Gasoline Shortage

Harold Wakeley

Traditionally, much of psychology has been concerned with the manner in which humans respond to their environment when many features are unchanged or changed in a manner related to previous experience. The response of humans to radically altered situations or those with minimal information related to rational selection of alternatives has previously been of less interest. The problem of minimizing the cost of disaster and understanding the mechanisms by which people assess risky situations has led to the development of a considerable body of literature related to the study of human response under conditions of minimal information, low certainty about outcomes, minimal control over outcomes, or time pressures. A sudden gasoline shortage possesses many of the characteristics of these situations, and a review of this literature appears to be useful in explaining previous behavior and developing rules for limiting or guiding future response choices.

RISK ESTIMATION

The need for studying decision-making behavior has become most apparent during the past 25 years. During this period, increasing societal and personal costs associated with less-than-optimum decisions have indicated that improvements in decision making may be profitably exploited. It is during this period that problems with the application of utility theory and its presumption of objective rationality on the part of the consumer have shown the need for a better tool for predicting market behavior. The claim has been made that utility theory "permits strong predictions to be made about behavior without the painful necessity of observing people" (1). This may be so; however, some significant sacrifices in accuracy and reliability appear to accompany this approach. As more research on consumer behavior has been performed and as human cognitive limitations have been more clearly defined, it has been shown that expectations, perceptions, motives, and intentions often deviate significantly from values that would be predicted if human beings always optimized their choices. There are severe limitations on a person's ability to process sensory signals and to store and use the information available (2-4). Human failures to always elect the most-efficient alternatives or payoffs are, at least in part, attributable to the necessity of adopting certain simplification strategies when handling large amounts of conceptual information.

A number of attempts have been made to provide alternatives to use maximization by accounting for the limited capacity of humans for information storage and handling. For example, a theory of bounded rationality has been devised that states that cognitive limitations force people to construct simplified models of the world in order to cope with it. Many a person is content to know that his or her car will probably run if gasoline is put in it, without wanting to spend time considering any of the technical details or the theory of transportation system operation. By understanding the way in which this simplified model is constructed and by defining the limits of its performance, a better approximation to the prediction of human behavior can be obtained (5).

The validity of the above assertions is at least partially supported by the results of survey techniques that have been found to predict economic behavior in many situations where more traditional tools have produced either less accurate or even erroneous predictions. Our particular concern is with predicting behavior relative to transportation choices under conditions of high uncertainty or where information about the probability of selecting the best choice is meager and suspect. For example, it has been found that subjective decisions in favor of a particular mode of transport are only partially based on a rational evaluation of objective, or economic, parameters (6). The biases affecting choice are asserted to be directly attributable to the personality structure of individuals (psychology), and objective facts can modify the ultimate choice only to a limited extent (6).

The problem is approached from a slightly different perspective when human protective actions in the face of risk are examined. For example, the option of obtaining insurance against disasters, such as floods, does not correspond at all well to the actual probability of loss (7). Although utility theory assumes that risk-averse individuals should desire a mechanism to protect them from rare catastrophic losses that they could not bear themselves, in actual practice people prefer to insure against relatively high-probability, low-loss hazards and tend to reject insurance in situations where the probability of loss is low and the potential losses are high (7,8). As borne out repeatedly in laboratory and survey studies, people show a definite disinclination to worry about low-probability hazards. Given limitations on time and energy and the limited cognitive capacity referred to previously, there are finite limits to the amount of concern that can be expended on a given threat. Therefore, it appears more useful to ignore low-probability threats and attend to those everyday matters that repeatedly claim significant expenditures of effort. There may be some rational understanding that the probability of efficiently obtaining adequate information about low-probability events is itself very limited and will not provide an adequate payoff for the investment.

There is an additional factor in this assessment. Frequent high-probability threats apparently come to be considered as a normal and continuing cost of doing business. Therefore, making claims and receiving payments by insuring against high-probability losses are viewed as returns on the premium. In other words, the insurer believes that he or she will obtain a sufficient return on the investment, thus making the overall expenditure profitable or, at the very least, not involving a significant loss. On the other hand, insurance against a low-probability risk is viewed as having no possibility of receiving a positive return and, hence, is a needless expenditure of money. People attempting to solve their personal gasoline-shortage problems may apply a substantially similar risk-probability model to their evaluation of the situation at hand and decide that, because the gasoline-availability scenario is becoming increasingly unstable, it is worthwhile to top off the tank as routine insurance.

BIASES IN HUMAN JUDGMENT

There are several principles enunciated that describe in general terms the sources of bias that lead to errors of probability assessment or prediction (9). In addition to being generally incapable of satisfactorily estimating the error and unreliability of small samples of data, people consistently rely almost exclusively on specific information and neglect prior probabilities. Similarly, rarely is adequate allowance made for the validity of information. Neither can people adequately discount information from correlated sources. These problems are related to the normative aspects of statistical prediction and only represent the beginning of prediction problems.

In addition to the above basic problems of data-base comprehension, a number of biases consistently affect performance. The estimated probability of an event increases dramatically with the ease with which relevant instances can be imagined and by the number of such instances that are readily retrieved from memory. If a stalled automobile or a man with a gasoline can is observed,

the probability of such an event happening to the subject will be overestimated and overprotected against, despite the actual probability of such an occurrence. Secondary to these factors are the influences of recency and emotional saliency that have significant effects on perceived probability. An appreciation of the importance of these availability biases is demonstrated by the fact that the frequency of accidents, cancer, botulism, and tornados as causes of death are all greatly overestimated, while the frequencies of asthma and diabetes are greatly underestimated (10).

Another source of bias, and one that every experimental psychology student should be familiar with, is anchoring bias. The strain of processing information can be considerably eased by using a natural starting point or anchor as a first approximation to the judgment. Anchor points are frequently no more valid than random numbers, yet they exert a considerable influence on judgment. Whether a high or low anchor point is available for use in making a best estimate affects significantly human judgments in the absence of additional information (11).

The last of the most significant biases is hindsight bias, a subject with considerable relevance to the overall topic of contingency planning. Being told that some events have happened invariably increases our feeling that it was, in fact, inevitable. Studies of predictions, foresight, and preparations made for events indicate that people have a much better idea of what was going to happen after it has occurred than they had before the event (12).

When the capabilities of humans to estimate probabilities are examined, it is surprising that utility theory predicts human behavior as well as it does. In fact, cognitive limitations are pervasive in decision making and exert their greatest effects under conditions where motivation and involvement are greatest. Not only do we have a considerable inability to conceptualize events that have never occurred, but events in recent memory or those that are readily envisioned exert an effect out of all proportion to their statistical probability.

Similarly, it is a comparatively simple matter to limit the cognitive capacity available to a person making a particular decision and even further limit his or her ability to process the relevant information. This is achieved by complicating the task through the deliberate introduction of irrelevant, erroneous, or conflicting data. The possibility of the decision maker coming to anything approaching a rational decision then becomes vanishingly small. Practically speaking, probably the best that can be said for decision making under these conditions is that (a) there are usually opportunities for correcting decisions on the basis of subsequent information and (b) the bulk of the population is likely to make the same or similar decisions when given the same information. As a consequence, there need not be a winning decision, but it is likely that everyone will bear some loss, thus making the situation tolerable for everyone. In fact, if all group members believe that losses are apportioned equally, significant inequities in distribution will be tolerated. If members suspect inequity, individual or separate plans to maximize individual shares will proliferate. Even though gasoline rationing during World War II was significantly inequitable, the belief in equity played a significant role in maintaining the program's success.

BEHAVIORAL THEORIES

With this brief overview of the human ability to select appropriate protective strategies, it may be useful to recognize that considerable work has been done in the development of helpful theories describing responses to uncontrollable outcomes. Having assumed that some estimate of the degree of control over a particular event is obtained from the preceding information, some feelings are likely to control response or the selection of a strategy. In point of fact, feelings of lack of control have been viewed as a cause of many types of antisocial behaviors. Instances in which people have been provoked to apparently senseless violent acts, such as assault, murder, and vandalism, have been subsequently associated by the perpetrator with a feeling of helplessness or powerlessness in a given situation. In at least one instance, a group of children was attacked by a night worker who became enraged because their noise prevented him from sleeping. Similarly, recent reports of violence directed toward service stations or displaced toward groups or individuals have been traced to feelings of sudden powerlessness over a gasoline-shortage situation that had previously been well under the control of the individuals. The felt control is related to the amount and certainty of available knowledge.

The various states of knowledge under which decisions can be made are divided into three categories: certainty, risk, and ignorance. These represent the full range of degrees of control over outcomes that are possible. Decision theory is generally concerned with the risk category and rarely with those instances in which occurrence is an absolute certainty or in which there is complete ignorance of possible outcome. The very recognition that a possible outcome exists, by establishing anchoring biases and through other psychological factors, will have some value for decision making. Risk assessment has been briefly addressed.

The psychological theories that handle the two remaining no-decision categories (certainty and ignorance) are the reactance theory and the learned-helplessness theory. Reactance theory is concerned with the responses of individuals whose reinforcement is eliminated or threatened with elimination, unless responses are altered. Learned-helplessness theories are concerned with individuals who are exposed to unavoidable aversive events regardless of any response they may make.

REACTANCE THEORY

Reactance theory predicts that, whenever an individual's freedom is eliminated or threatened with elimination, the individual will be motivationally aroused to reestablish that freedom (13). According to reactance theory, a person will only respond when he or she feels that control over a behavioral option has been eliminated or threatened. Thus, response to the availability of gasoline is vitally affected by the following variables: the expectation that the individual possessed control over the gasoline source to begin with, the strength of the threat to the individual's access to gasoline, the importance of the access to gasoline, and the implications of this threat for the individual's other freedoms.

Reactance theory provides a number of predictions related to gasoline shortages. If the individual is subjected to an uncontrollable outcome (gasoline shortage) and is unable to engage in a behavior that the individual originally felt free to pursue (e.g., drive to work), or is faced with an undesirable option that would ordinarily be avoided (e.g., ride the bus), several changes in behavior and mood are predictable. The attractiveness of the threatened behavior will be increased and the motivation to continue with this behavior will increase. If the threatened behavior cannot be engaged in, alternative or related behaviors may be adopted to provide restoration even though they are not optimum or efficient, thus demonstrating by implication that the person could engage in the established behavior if desired. Resorting to gasohol or buying one's own service station may represent this type of response. Finally, hostile and aggressive feelings will be experienced. Aggression may be directed toward the responsible agent, although it is far more likely to be displaced to another agent or object.

LEARNED HELPLESSNESS

The learned-helplessness theory of response is concerned with individuals exposed to unavoidable aversive events. The theory predicts that exposure to unavoidable aversive events impairs an individual's ability to subsequently learn

responses to avoidable aversive events. Theorists explain that this phenomenon represents learning by the subjects that their behavior and the outcomes of specific events are independent of each other. The lack of a relation between response and outcome is then generalized to new situations. In other words, when there is absolute certainty that one has no control over a situation, there is little motivation to exert effort or to try to demonstrate control.

The learned-helplessness theory probably has greatest application to the description of behavior of hostages or others whose environment is totally beyond their control. Emulation of the behavior of those in control becomes a common response mode, even though the responses have no effect on the situation. For the general population experiencing a gasoline shortage, there are likely to be a sufficient number of alternatives so that little of this behavior will be observed.

One of the principal derivations from helplessness theory as applied to the possibility of a gasoline shortage is the effect of an individual's perception of who does have control over the situation. In experiments where the locus of control was with either a special authority or an anonymous super authority, significant differences in perception and response occurred. A test was devised so that frustration was attributable to either bureaucratic operation or to the personal behavior of the bureaucrat (14). In the initial condition, when the individual was led to expect to not have control over the situation (i.e., bureaucratic bungling was a constant for everyone exposed to the problem), performance was worse than when the individual controlled outcomes under unrestricted conditions. Behavior, however, was at least consistent and productive. Where the frustrating experience was arranged to be attributable to personal characteristics of the bureaucrat, response was uniformly negative, with test subjects cheating on the task and adopting a variety of obstructive and aggressive tactics. The conclusion, related to response to gasoline shortages, is congruent with real-world experience in that people will accept an imposed limitation on behavior if they have no expectation that they should be able to control the situation to a significant degree and if an expectation of evenly distributed limitations is reinforced. Contrarily, if an expectation is built that some people could control the situation differently—that is, helplessness is not universal—generally disruptive and nonresponsive behaviors will follow.

IMPLICATIONS OF THEORIES

The brief summary of the reactance and learned-helplessness theories presents us with two different conclusions that are related to two possible outcomes—experienced or anticipated. Reactance theory predicts that loss of control over a situation will result in renewed attempts at mastery, while the learned-helplessness model suggests that experience with loss of control will impair subsequent problem solving. Individuals will react to loss of control by becoming hostile and aggressive according to reactance theory, while the learned-helplessness theory predicts passivity. A combined model of reactance and helplessness theories has been proposed in which the expectations of control, learning that one has no control, and the importance of the outcome to be controlled are combined to determine an organism's response (15). An expectation of control leads to reactance, and an expectation of no control produces helplessness and impaired learning and performance.

Important for our purposes is the fact that uncontrollable aversive outcomes that affect a large number of people (a gasoline shortage) may have different psychological aftereffects than outcomes of other shortages of equal magnitude that are perceived as unique or rare. This effect relates to some of the earlier discussion of estimation of risk and overemphasis of frequently or recently occurring events. In addition, the relative deprivation of other individuals will affect response in a manner similar to the behaviors of subjects exposed to either uniform bureaucratic or personal frustration. Where the frustration is perceived to be uniform (i.e., bureaucratic frustration), there was some moderate decline in performance. Where there are large perceived discrepancies (i.e., personal frustration), the subject will resort to a variety of obstructive and negative tactics. Similar behavior is to be anticipated under gasoline-shortage conditions.

Individuals are motivated to perceive the world as a predictable, orderly place where people get what they deserve, derogate the victim of uncontrollable outcomes, or blame a person associated in some way with an outcome rather than attributing it to chance (16). Unfortunately, people are not capable of accurately assessing probabilities or risks. As a consequence of biases in decision making, people have definite and predictable ideas about whether a gasoline shortage is predictable or deserved. As a consequence, their response will be to some extent predictable. Most important, the continuum from certainty or uncertainty reflects a considerable diversity of decision-making strategies. To the extent that there is certainty about the outcome and to the extent that the individual does not have prior expectations about a different outcome, there will be acceptance of the conditions as stated or delivered. If it is perceived that these conditions are uniform for all other individuals, acceptance of them will be even further enhanced.

COPING WITH FIRST-TIME EVENTS

The theoretical constructs described above and the conclusions drawn apply to a number of situations that correspond to potential shortage conditions. One area that has been well studied is human response to disaster. Several valuable generalizations have been drawn from the disaster literature that are useful when trying to derive some hypotheses for application to shortage models. Parameters may include a population, the physical characteristics of the environment, a requirement for substantial change in behavior on the part of individuals and groups, and both short- and long-term significant changes in the goals and objectives of the affected population. The generalizations that have been drawn from the disaster literature are presented here (17).

1. A constellation of behaviors occurs in response to disasters or extreme situations (18). The symptomatology is characterized by three phases. The first phase occurs immediately after the disaster incident and behavior tends to conform to a kind of emotional shock. Dazed, stereotyped behaviors are most commonly observed. The second phase is characterized by docility, coupled with high suggestibility. The third phase consists of an initial depression, followed by a coping recovery process.
2. Nonrational or uncontrolled forms of behavior are very much rarer than popular accounts indicate. Compelling pressure to act and a compressed time perspective, coupled with a perception that escape will soon be impossible, are the conditions that most frequently lead to either flight or freezing (panic) behavior.
3. Individuals tend to perceive and interpret disaster cues and causal agents with reference to those features of the environment with which they are most familiar. Periodically, different information will be interpreted in the most parsimonious manner (i.e., a manner congruent with known previous conditions).
4. Considerable variability in the perception of the causal agent exists. Correct identification of operative parameters under changed conditions requires considerable analysis and comparison.
5. Previous experience or practice in coping with a set of changed conditions provides significant assistance in the quality and quantity of response.

The characteristics of response to a new situation

represent all human behavior in a new situation to some degree. Where possible, behaviors within the repertoire are usually adapted or modified as an economic means of providing response. Or, where competition exists, the most efficient or conserving frame of reference will be selected for use as a model in the interpretation and evaluation of the threatening condition. As emphasized previously, the cognitive structure of human beings and their experiences tend to distort or bias evaluations in a consistent manner so that a logically consistent evaluation of any changed conditions is not known to the individual. Instead, the individual operates within a system that incorporates trade-offs between time and energy available, perceived use of attending to low-probability events, and a number of social or psychological values that significantly bias an ultimate choice.

The problem of anyone confronted with a prospective gasoline shortage—and a large population unprepared to respond to the shortage—must include an appreciation of the most economic and effective method of ensuring that all members of the group respond in a manner that is acceptable and does not tend to exacerbate conditions. To this end, the objective must be to provide information that will be reliably and rapidly interpreted and used as a basis for making consistent decisions about courses of action. To this end, there are several general rules related to the type and method of information presentation that will significantly improve its acceptance and use. With the aim of giving knowledge, changing attitudes, and ensuring that the behavior takes place, the most effective findings include the following (19):

1. Specificity of information to the situation,
2. Positive unambiguous instruction,
3. Information close in time and place to where the desired behavior is to take place,
4. Relation of information to existing attitudes and knowledge,
5. Existence of elaborative or in-depth descriptions and accessibility of substantiating material, and
6. Emphasis on reasons for adopting the behavior other than that it is required or constrained by conditions.

The information preparation and presentation (a) must not imply that the situation in which the individuals are involved is catastrophic or of an enduring nature, (b) must not dwell on the undesired alternative behaviors, and (c) must not allow the formulation of independent courses of action. All information must be prepared so that it can be interpreted as a planned and comprehensive effort directed specifically toward solution of the problem within a finite and acceptable time-and-space framework. The authority for courses of action must be clear and unambiguous, with the sanctions for failure to respond in the desired manner presented clearly and defined so that the individuals perceive a high probability of some low or intermediate penalty for their failure to comply.

IMPLICATIONS FOR GASOLINE-SHORTAGE SITUATIONS

The response of consumers to initial energy shortages has been congruent with the predictions drawn from the disaster models and the decision-theory models described previously (20). Many of the behaviors, including riots, gasoline lines, and innovative strategies (e.g., adopting alternative fuels and extra fuel tanks) correspond to the predictions. With additional information and experience with the new conditions, consumers will develop a revised and more-sophisticated set of behaviors and beliefs. These are likely to continue to overestimate the probabilities and costs of well-known problems and significantly underestimate the lesser, well-visualized aspects of the shortage scenarios.

Attribution of blame is currently displaced to oil companies and the government as the primary culprits. Initially, however, displacement was to those individuals (service station personnel) immediately available in time and space. A lack of information, planning, and rules of behavior for response to a gasoline shortage reinforces pessimism about whether other individuals will engage in energy conservation efforts and, hence, individual disposition to conserve. As a response to this condition, consumers are in favor of government intervention and controls over energy. Recognition of the personalized nature and readily visualized inequities of rationing and tax increases psychologically reinforces any existing opposition to these methods as solutions. At least one highly visible measure, perceived as enforceable, is the 55-mph speed limit, which most consumers endorse (21). The acceptability of this alternative and the rejection of rationing and taxes correspond to some aspects of the learned-helplessness model. In this model the inevitability of the costs plays a considerable role in the ultimate acceptance and response to the plan's penalties. It can be conjectured that, because there is very little experience with catastrophic system failures comparable to the loss (shortage) of a primary source of energy, consumers appear to believe that there is a vanishingly small probability that this can, in fact, be a possible outcome.

A cheering note for utility theorists is that middle-income groups in particular are more likely to reduce energy consumption if prices continue to rise. These results are not explicable from a psychological point of view; rather, these results are attributable to the fact that lower-income groups have either fewer alternative responses or have implemented all available energy-conserving responses at their disposal. The upper-income groups are unaffected to any significant economic extent by any realistic increase in energy costs. The sole group with significant energy use and without a compelling and continuous need to monitor expenditure is, therefore, the middle-income group. Survey results support this view.

Beyond this finding, few demographic and socioeconomic factors appear useful in explaining energy attitudes and behaviors. This brief outline of applicable models is presented as a suggestion that a social psychological approach may be of some assistance in preparing communication and organizational programs for use in responding to anticipated gasoline shortages.

REFERENCES

1. H. A. Simon and A. C. Stedry. Psychology and Economics. In The Handbook of Social Psychology (G. Lindzey and R. Aronson, eds.), Addison-Wesley, Reading, MA, 1969.
2. G. A. Miller. The Magical Number 7, Plus or Minus 2: Some Limits on Our Capacity for Processing Information. Psychological Review, Vol. 63, 1956, pp. 81-97.
3. J. S. Bruner, J. J. Goodnow, and G. A. Austin. A Study of Thinking. Wiley, New York, 1956.
4. A. Newell and H. A. Simon. Human Problem Solving. Prentice-Hall, Englewood Cliffs, NJ, 1972.
5. H. A. Simon. Models of Man: Social and Rational. Wiley, New York, 1957.
6. W. Brog, D. Heuwinkel, and K. Neumann. Psychological Determinants of User Behavior. Report of the 34th Round Table on Transport Economics (Paris, May 6-7, 1970, European Conference of Ministers of Transport), OECD Publication Center, Washington, DC.
7. H. Kunreuther and P. Slovic. Economics, Psychology, and Protective Behavior. American Economic Review, Vol. 68, 1978, pp. 64-69.
8. M. Friedman and L. J. Savage. The Utility Analysis of Choices Involving Risk. Journal of Political Economics, Vol. 56, 1948, pp. 279-304.
9. D. Kahenemand and A. Teversky. On the Psychology of Prediction. Psychological Review, Vol. 80, 1973, pp. 237-251.

10. P. Slovic, B. Fischhoff, and S. Lichtenstein. Cognitive Processes and Societal Risk Taking. In Cognition and Social Behavior (J. S. Carroll and J. A. Payne, eds.), Potomac Books, Inc., Washington, DC, 1976.
11. A. Teversky and D. Kahneman. Judgment Under Uncertainty: Heuristics and Biases. Science, Vol. 185, 1974, pp. 1124-1131.
12. B. Fischhoff. Hindsight ≠ Foresight: The Effect of Outcome Knowledge on Judgment and Uncertainty. Journal of Experimental Psychology: Human Perception and Performance, Vol. 1, 1975, pp. 288-299.
13. J. W. Brehm. Responses to Loss of Freedom: A Theory of Psychological Reactance. General Learning Press, Morristown, NJ, 1972.
14. C. B. Wortman and J. W. Brehm. Responses to Uncontrollable Outcomes and Integration of Reactance Theory and the Learned-Helplessness Model. Advances in Experimental Social Psychology, Vol. 8, 1975, pp. 277-336.
15. D. C. Glass and J. E. Singer. Urban Stress: Experiments on Noise and Social Stresses. Academic Press, New York, 1972.
16. M. J. Lerner. The Desire for Justice and Reaction to Victims. In Altruism and Helping Behavior (J. R. Macaulay and L. Berkowitz, eds.), Academic Press, New York, 1970.
17. E. Walster. "Second Guessing" Important Events. Human Relations, Vol. 20, 1967, pp. 239-250.
18. R. A. Levit. Human Behavior in Extreme Situations: Generalizations from a Review of the Disaster Literature. Proc., Human Factors Society, 22nd Annual Meeting, 1978.
19. M. Wolfenstein. Disaster: A Psychological Essay. Free Press, Glencoe, NY, 1957.
20. R. G. Sell. What Does Safety Propaganda Do for Safety? A Review. Applied Ergonomics, Vol. 8, 1977, pp. 203-213.
21. D. Anderson and C. Cullen. A Review and Annotation of Energy Research on Consumers. Consumer Research Branch, Department of Consumer Corporate Affairs, Ottawa, March 1978.

Short-Run Traveler Responses to Alternative Gasoline-Allocation Plans: Some Modeling Results

Joel Horowitz

The possibility that serious gasoline shortages may occur in the United States is prompting government agencies to give increased attention to the development of ways to allocate scarce gasoline supplies among travelers. A large number of allocation procedures are potentially available, including allocation by allowing the retail price of gasoline to rise to a market-clearing level, by means of queues at service stations (i.e., persons with the greatest desire or ability to spend time waiting in queues tend to receive the greatest allocations of gasoline), and by various rationing systems.

Quantitative estimates of the likely impacts on travel of gasoline shortages when different gasoline allocation procedures are in effect presumably could help government agencies and others to determine how the adverse effects of shortages can best be mitigated or equitably distributed. However, the development of such estimates has been impeded by a lack of satisfactory data and estimation methods. Virtually all of the data that are currently available for transportation forecasting studies in the United States were acquired before the 1973-1974 gasoline shortage and, hence, do not reflect any changes in travelers' tastes (e.g., changes in the value of travel time or in the extent to which the schedule inflexibility of carpooling is disvalued) that may have occurred as a result of or since this shortage. Nor do currently available data reflect transportation system changes (e.g., new transit systems) or changes in urban demographic and land use patterns that may have occurred since the large transportation studies of the 1960s and early 1970s. Moreover, transportation data sets typically pertain to urban weekday travel and, hence, do not include much of the recreational travel that may be most severely affected by gasoline shortages. Even if more recent and comprehensive data were available, their relevance for forecasting the effects of severe gasoline shortages could be questioned, as the forecasts almost certainly would require extrapolations to shortage conditions or allocation procedures that were not represented in the data.

The methodological difficulties of forecasting travelers' responses to gasoline shortages are also severe, although they may be more tractable than those resulting from data deficiencies. Past efforts to estimate the effects of gasoline shortages on travel and travelers have been based on surveys of travelers' responses to the 1973-1974 gasoline shortage (1-4) and on travel demand forecasting studies that have been predicated on disaggregate travel demand models (5-6). However, despite substantial differences in data and methodology, these survey and modeling studies have consistently indicated that, in the short run, most households tend to adjust to gasoline shortages or price increases by decreasing nonwork travel frequencies and nonwork trip lengths, whereas relatively few households change their modes of travel for either work or nonwork purposes. Although this consistency of results is encouraging, the survey and demand-modeling methods on which the results are based have important limitations. By themselves, the survey results cannot be used for forecasting, except in a very loose and qualitative way, and they are not suitable for comparing the impacts of various alternative gasoline-allocation procedures. The disaggregate demand models are, of course, designed for use in forecasting. These models permit treatment of a broader range of travel and policy options than can be dealt with by alternative modeling approaches. However, past disaggregate demand-modeling studies of the effects of gasoline shortages or price increases have not included certain potentially important short-run traveler responses (e.g., notably increased use of multidestination travel). The only gasoline-allocation method that has been treated in these studies is that of allowing the retail price of gasoline to rise to the market-clearing level. Thus, much of the potential value of the disaggregate demand-modeling approach to forecasting short-run effects of gasoline shortages remains unrealized.

The purpose of this paper is to present the results of applying an improved version of the disaggregate demand-modeling method in connection with a currently available data set to develop some exploratory estimates of the travel impacts of a gasoline shortage. The methodological improvements consist of including increases in multidestination travel among the modeled responses of travelers to gasoline shortages and of including several

gasoline-rationing procedures among the allocation systems that can be analyzed. The data set that is used was obtained from the 1968 Washington, D.C., area transportation study. Although this data set suffers from all of the previously mentioned data deficiencies, it is not substantially different in this respect from other available data sets. It does permit certain qualitative conclusions to be reached that may be applicable to current circumstances.

DEFINITION OF SCENARIOS AND QUESTIONS

It is assumed that the available supply of gasoline is less than the quantity demanded at the current retail price. (The reasons for this shortage are not addressed in this analysis and are not represented in the analytical framework.) It is further assumed that the responsible government agencies have decided to allocate the available gasoline supply among travelers by one of the methods noted below.

1. The retail price of gasoline is allowed to rise until the quantity of gasoline demanded equals the quantity available.
2. Gasoline is allocated by white-market coupons. With this method, the retail price of gasoline is fixed below the market-clearing level, and travelers are issued coupons that entitle them to purchase set quantities of gasoline at the established retail price. Although the total number of coupons issued to all travelers is fixed, individuals can alter their allocations by trading coupons with other individuals at a price determined in an open market. [This allocation plan is analytically but not administratively equivalent to the alternative plans that (a) establish a tax on gasoline sales and rebate the tax receipts to individuals in a way that is independent of their gasoline purchases and (b) establish the nontax portion of the retail price of gasoline at a fixed level and set the tax rate at the level that clears the retail gasoline market. Since this latter tax plan is analytically indistinguishable from a white-market coupon plan, it is not analyzed separately here.]
3. Allocation is made by means of traditional rationing. In this method, the retail price of gasoline is fixed below the market-clearing level. Travelers are allocated fixed quantities of gasoline that cannot be traded to others. (The likelihood that a black market in gasoline would arise if this rationing method were implemented is acknowledged but is not treated in this analysis.)
4. Allocation by means of queuing at service stations is also possible but is not treated in this analysis. [See Mahmassani and Sheffi (7) and Prins, Wolfe, and Lerman (8) for discussions of analytic approaches to queuing.]

In the short run, travelers can respond to the gasoline shortage and the various gasoline-allocation methods by changing their travel habits and patterns. In the long run, they can respond by changing the numbers and types of vehicles they own (e.g., by purchasing automobiles with increased fuel economy) and by changing the locations of their residences and places of work. In this analysis, only short-run responses are considered. These include changing travel modes and frequencies, reducing average trip lengths, and linking individual trips together into multidestination tours. In general, it can be expected that different gasoline-allocation systems will cause gasoline shortages to have different impacts on travel and travelers, even if the supply of gasoline and aggregate gasoline consumption do not change.

The analysis of allocation systems discussed in this paper is based on four questions:

1. How do the three allocation methods differ in their effects across income groups?
2. How do the methods differ in their effects across trip purposes (work and nonwork)?
3. To the extent that gasoline shortages affect nonwork travel, does the effect consist mainly of reducing trip frequencies and lengths (which may have serious economic effects) or of increasing the use of multidestination tours (which may be economically neutral)? and
4. To what extent can adverse impacts of gasoline shortages on nonwork travel be mitigated through the implementation of measures aimed at reducing automobile use for work trips, such as work-trip transit improvements?

ANALYTIC METHOD

The analytic method used here consists of developing forecasts of travel demand in the presence of a gasoline shortage with alternative gasoline-allocation plans in effect. These forecasts are then used to compute various indicators of the effects of the shortage and the allocation plans. The travel demand forecasting models that are used consist of a disaggregate model of work-trip modal choice (9) and a disaggregate model of nonwork travel behavior (10). The work-trip modal choice model includes the drive-alone, carpool, and transit modes. The nonwork model treats multidestination travel and nonwork travel frequency and destination choice. Previous investigations have indicated that changes in modal choice for nonwork trips are unlikely to constitute significant responses to gasoline shortages. Therefore, to minimize the computational complexity and expense of the nonwork model, nonwork modal choice has not been modeled.

In the price-increase scenario, the effects of increases in the price of gasoline were represented in the work and nonwork models by increasing the values of the appropriate travel cost variables. In the white-market scenario, these variables were increased to reflect the sum of the pump price of gasoline and the price of coupons. In addition, household incomes were increased to reflect the market value of the white-market coupons allocated to them. In the traditional rationing scenario, the usefulness of each trip was reduced by an amount that is proportional to the quantity of gasoline consumed on the trip. The proportionality constant was chosen so that households would not consume more gasoline than was allocated to them.

The indicators of the effects of gasoline shortages and allocation plans that were modeled are total automobile vehicle miles of travel (VMT), total gasoline consumption, work-trip modal choice, automobile VMT on work trips, gasoline consumed on work trips, automobile VMT on nonwork trips, gasoline consumed on nonwork trips, nonwork-person sojourn frequency (a visit to a nonwork location other than home), nonwork-person tour frequency (a complete home-to-home round trip that includes one or more sojourns), number of nonwork sojourns per nonwork tour, nonwork trip length, remaining income (the difference between total household income and expenditures for transportation), and sales of white-market coupons. These indicators were computed as averages across the entire group of households whose travel behavior was modeled and as averages across separate income groups.

APPLICATION TO WASHINGTON, D.C., AREA

The model system was used to estimate the short-term responses of automobile-owning households in the Washington, D.C., area to a 15 percent reduction in the supply of gasoline available for weekday travel. Since non-automobile-owning households make few trips by private automobile, any impacts of a gasoline shortage on these households would occur mainly through the effects of the shortage on the performance of public transportation systems. (Because these effects are not discussed here, the impacts of gasoline shortages on non-automobile-owning households are not treated.)

Because data that would enable weekend travel behavior to be modeled are unavailable, the results given here pertain only to weekday travel. However, for the purpose of computing the effects of gasoline shortages on remaining

Table 1. Percentage change in impact indicators for the price-increase, white-market-coupon, and traditional rationing scenarios.

	Price-Increase Scenario				White-Market-Coupon Scenario				Traditional Rationing Scenario			
	Income Level				Income Level				Income Level			
Indicator	1	2	3	All	1	2	3	All	1	2	3	All
Gasoline consumption												
Work trips	-14	-4	-2	-3	-9	-3	-2	-3	0	-5	-9	-7
Nonwork trips	-87	-35	-4	-24	-85	-40	-0.2	-25	0	-15	-32	-22
All trips	-67	-20	-3	-15	-65	-22	-1	-15	0	-10	-22	-15
Automobile VMT												
Work trips	-15	-4	-2	-3	-10	-3	-2	-3	0	-6	-10	-8
Nonwork trips	-89	-38	-10	-28	-87	-44	-7	-29	0	-17	-37	-25
All trips	-67	-21	-7	-17	-64	-23	-5	-17	0	-11	-25	-17
Work-trip modal choice												
Drive alone				-6				-6				-8
Shared ride				+6				+7				+8
Transit				+31				+20				+40
Nonwork travel												
Sojourns	-84	-34	-7	-26	-82	-39	-3	-25	0	-5	-6	-5
Tours	-83	-17	+28	-6	-81	-23	+37	-4	0	-10	-22	-14
Sojourns per tour	-7	-20	-27	-21	-7	-21	-21	-22	0	+5	+20	+10
Average trip length	-32	-16	-16	-13	-32	-17	-18	-15	0	-15	-28	-18
Remaining income	+0.3	-11	-10	-9	+52	+5	-5	+2	0	+1	+1	+1
Effective gasoline price[a]				+468				+630				
Coupon sales[b]					+1.58	+0.12	-1.01	0				

Note: Income level 1 = less than $11 500; level 2 = $11 500-$30 000; level 3 = $30 000 or more; all are 1979 dollars.

[a]The effective gasoline price is the retail price plus the price (per equivalent gallon) of white-market coupons.

[b]The net sales (+) or purchases (-) of white-market coupons is expressed in units of gallons of gasoline per household per day.

Table 2. Percentage change in impact indicators for the white-market-coupon scenario with transit improvements.

	Income Level[a]			
Indicator	1	2	3	All
Gasoline consumption				
Work trips	-25	-17	-11	-15
Nonwork trips	-78	-23	-2	-15
All trips	-64	-20	-4	-15
Automobile VMT				
Work trips	-29	-17	-12	-15
Nonwork trips	-81	-6	-4	-19
All trips	-65	-22	-7	-17
Work-trip modal choice				
Drive alone				-16
Shared ride				-11
Transit				+330
Nonwork travel				
Sojourns	-64	-33	-1	-17
Tours	-72	-5	+33	+3
Sojourns per tour	-6	-19	-25	-20
Average trip length	-28	-13	-14	-11
Remaining income	+36	+2	-3	+1
Effective gasoline price[a]				+434
Coupon sales[a]	+1.59	+0.06	-0.93	0

[a]As defined in Table 1.

incomes (i.e., total household income minus transportation expenditures), it has been assumed that gasoline shortages cause percentage reductions in weekend gasoline consumption that are equal to the percentage reductions in weekday gasoline consumption for nonwork travel. Weekend nonwork gasoline consumption as a percentage of weekday nonwork consumption was estimated by using data from the Nationwide Personal Transportation Study (11). The assumption that the percentage reductions in weekday and weekend nonwork gasoline consumption are equal implies that the total reduction in gasoline consumption for all trip purposes and on all days of the week is approximately 20 percent in the cases noted here.

In the white-market-coupon and traditional rationing scenarios, coupons and gasoline have been allocated on a per-household basis. Incomes, prices, and motor vehicle fuel economy have been updated from 1968 to 1979 values. In other respects, the characteristics of the modeled population are as they were in 1968.

The results obtained by means of the three allocation scenarios are shown in Table 1. In all scenarios the main effect of the gasoline shortage is to cause reductions in nonwork travel. Sojourn frequencies and trip lengths are both reduced. Depending on the allocation scenario, reductions in nonwork travel account for 80-90 percent of the 15 percent reduction in total weekday gasoline consumption. In the pricing and white-market scenarios, households show no tendency to make increased use of multidestination travel as a means of compensating for the effects of reduced gasoline supplies. Rather, there is a tendency to make short, single-destination tours in place of longer, multidestination ones. This tendency is particularly apparent among high-income households. However, in the traditional rationing scenario, there is a tendency to make increased use of multidestination travel.

The effective price of gasoline is higher in the white-market-coupon scenario than it is in the price-increase scenario. (In the white-market scenario, the effective price of gasoline is the sum of the controlled retail price and the price of coupons.) This is because in the white-market scenario, household effective income is increased by the market value of the coupons allocated to it. These increases in incomes enable a household to tolerate higher effective gasoline prices while maintaining given levels of travel than it can tolerate in the price-increase scenario in which income does not increase.

In the pricing and white-market-coupon scenarios, the greatest reductions in travel are among low-income households, and the smallest reductions are among high-income households. The large reductions in low-income household travel and the associated saving of travel costs cause the average remaining income of such households to increase in the pricing and white-market-coupon scenarios. The increase is especially apparent in the latter, as low-income households (and, to a much-lesser degree, middle-income households) sell gasoline coupons to high-income households. Households in the high-income group are both willing and able to pay the increased price of gasoline in the pricing and white-market-coupon scenarios. Therefore, high-income household travel is reduced considerably less than that of low- and middle-income households, and high-income households experience large reductions in remaining income. Middle-income households also experience large reductions in remaining income in the price-increase scenario. However, in the white-market

scenario, middle-income households sell coupons to high-income households and, as a result, experience an increase in average remaining income.

In the traditional rationing scenario, which is not price-based, the distribution of impacts of a gasoline shortage across income groups is significantly different from the distributions that occur in the pricing and white-market-coupon scenarios. In the traditional rationing scenario, all households receive equal allocations of gasoline. Because high-income households tend to travel more and to use more gasoline than low-income households, equal allocations of gasoline require high-income households to reduce their travel substantially but low-income households need not reduce their travel at all. Because the price of gasoline is fixed in the traditional rationing scenario, the average remaining income of low-income households is not changed by a gasoline shortage. However, the average remaining incomes of middle- and high-income households increase, owing to the reductions in travel by these households.

The ability of transit improvements for work trips to achieve reductions in work-trip gasoline consumption and, thereby, to mitigate the adverse impacts of gasoline shortages on nonwork travel was investigated for the white-market-coupon scenario. It was assumed that (a) transit in-vehicle travel times for one-way trips would be equal to the corresponding automobile in-vehicle travel times and (b) transit out-of-vehicle travel times (including both walk and wait times) would be no more than 7.5 min/one-way trip. This represents a considerably higher level of transit service than is likely to be available to most travelers. The impacts of a gasoline shortage with white-market-coupon allocation and the transit improvements in effect are shown in Table 2. Although the impacts of the gasoline shortage on nonwork travel are mitigated by the transit improvements, these impacts still are severe. Thus, it appears that the provision of even very high-quality transit service for work trips cannot prevent gasoline shortages from substantially reducing both nonwork sojourn frequencies and nonwork trip lengths.

CONCLUSIONS

Since the results presented in the preceding section are based on old data, it is useful to consider the extent to which these results might change if they could be rederived by using more recent data. Such data would reflect the changes in land use, transit service quality, and demographic characteristics of the Washington area population that have occurred since 1968, as well as any changes in tastes that may have occurred.

Clearly, any of these changes could alter the quantitative results that are presented in Tables 1 and 2. However, the major qualitative features of these results—notably the large impacts of gasoline shortages on nonwork travel, the inability of transit improvements to prevent these impacts, and the distribution of impacts across income groups—are determined primarily by tastes and by a household's ability to afford the costs of travel. Accordingly, these qualitative features are not likely to be highly sensitive to changes in land use, transit service quality, and aggregate demographic characteristics.

Changes in tastes—especially changes that would cause work-trip travelers to be more receptive to using high-occupancy modes and cause nonwork travelers to make greater use of multidestination travel—could substantially affect the qualitative features of the results presented here. The extent to which such taste changes may have occurred since 1968 is largely a matter of conjecture. However, the extreme differences between the impacts of gasoline shortages on work travel and nonwork travel that are exhibited in the results mentioned in the preceding section of this paper suggest that very large changes in tastes would be needed to achieve a significant redistribution of these impacts from nonwork to work travel. The previously cited surveys of travelers' responses to the 1973-1974 gasoline shortage suggest that this shortage did not cause substantial behavioral changes. Thus, it is certainly possible and, perhaps, even likely that the main qualitative characteristics of these results are as applicable now as they were in 1968.

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REFERENCES

1. T.M. Corsi and M.E. Harvey. Energy-Crisis Travel Behavior and the Transportation Planning Process. TRB, Transportation Research Record 648, 1977, pp. 30-36.
2. A.J. Neveu. The 1973-74 Energy Crisis: Impact of Travel. Planning Research Unit, New York State Department of Transportation, Albany, Prelim. Res. Rept. 131, 1977.
3. R.L. Peskin, J.L. Schofer, and P.R. Stopher. The Immediate Impact of Gasoline Shortages on Urban Travel Behavior. Federal Highway Administration, U.S. Department of Transportation, 1975.
4. M.D. Stearns. The Behavioral Impacts of the Energy Shortage: Shifts in Trip-Making Characteristics. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, 1975.
5. Cambridge Systematics, Inc. Analytic Procedures for Urban Transportation Energy Conservation. U.S. Department of Energy, Rept. DOE/PE/8628-1, 1979.
6. Cambridge Systematics, Inc. Carpool Incentives: Analysis of Transportation and Energy Impacts. Federal Energy Administration, Rept. FEA/D-76/391, 1976.
7. H. Mahmassani and Y. Sheffi. Queuing and Search Delays Due to Gasoline Station Closings. TRB, Transportation Research Record, 1980, in preparation.
8. V. Prins, R.A. Wolfe, and S.R. Lerman. A Simple Analytic Model for Understanding Gasoline Station Lines. TRB, Transportation Research Record, 1980, in preparation.
9. T.J. Atherton and M.E. Ben-Akiva. Transferability and Updating of Disaggregate Travel Demand Models. TRB, Transportation Research Record 610, 1976, pp. 12-18.
10. J.L. Horowitz. A Utility-Maximizing Model of the Demand for Multidestination Nonwork Travel. Transportation Research, Part B, in preparation.
11. Purposes of Automobile Trips and Travel (Nationwide Personal Transportation Study). U.S. Department of Transportation, Sept. 10, 1974.

Missed Opportunities: Institutional, Social, and Political Barriers to Governmental Responses to Energy Crises

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Ballot measures and initiatives recently passed by voters in several states are manifestations of a mood in the United States to limit the degree of governmental influence in our lives. Tax-cutting measures, spending limitations, and other attempts to control government activities reflect the public's lack of confidence in government's ability to provide solutions to a myriad of problems. This feeling marks a significant change in the attitudes that prevailed from World War II until the 1970s when it was assumed that government could and should find solutions to a host of economic and social problems. Although people now want less government, they still want the problems solved. They have simply come to recognize that solutions to the problems are best developed by those who must implement them—individuals, community groups, and corporations.

When faced with an energy crisis, people will find their own solutions to the problem with a minimal amount of assistance from government. They will only turn to government when they cannot develop solutions on their own or when obstacles exist that only government can remove. Governmental response to energy crises represents a series of missed opportunities—for example, government has failed to recognize the desire and ability of individuals, community groups, and corporations to solve problems on their own, and various institutional, political, and social barriers preclude government from responding to a crisis in an effective and efficient manner.

INSTITUTIONAL BARRIERS

Two forms of institutional barriers exist at the local level—government fragmentation and regulatory constraints. Because so many entities at the local level are involved in transportation activities, stalemates and indecision are common occurrences. Several factors point to missed opportunities for local governments.

One factor is that no mechanism exists at the local or regional level to provide comprehensive energy conservation-contingency planning. Counties and cities recognize that energy contingency planning cannot be done in a vacuum and that it must be related to other social, legal, and fiscal considerations. However, the proliferation of single-purpose agencies makes it difficult to produce comprehensive solutions at either the state or local government level. And where comprehensive planning organizations exist at the regional level, they tend to lack any authority to implement or enforce their plans. They are more often a convenient means for dispensing funds rather than for reconciling competing priorities and concerns.

In addition to the lack of comprehensive planning, transportation planning lacks a mechanism for coordinating the efforts of local governments and service providers. Although each metropolitan area possesses a metropolitan planning organization (MPO) to serve in that capacity, most MPOs are voluntary associations without any legislative mandate to carry out their plans or work. And when alternative coordination mechanisms are established to deal with a specific energy crisis (e.g., the gasoline shortage in Los Angeles in 1979), they often result in extensive and time-consuming agency approvals. Local governments must identify, prior to a crisis, what mechanism will be used for coordinated comprehensive planning and must ensure that each entity's role is clearly defined.

Regulations also serve as a barrier to the efficient development of contingency plans. Most states regulate the start-up and routes of private commuter bus operators. Because of the length of time required for approval by state public utilities commissions of new routes (45-60 days in some cases), it is not feasible for private operators to supplement or substitute for public transit services during a crisis.

A similar situation exists regarding the use of jitneys. Many local governments have regulations prohibiting their use. Although jitneys provide an effective supplement to transit in certain corridors, the length of time required for local approvals precludes their use in emergencies. State and local governments must revise or streamline regulatory procedures to permit timely entry of alternative services during a crisis.

SOCIAL BARRIERS

While institutional barriers can be modified or eliminated, many of the social barriers reflect long-standing traditions or attitudes that are more difficult to change or influence. A significant reason why government cannot respond effectively to an energy crisis is the nature of our urban form. Our nation has made a conscious decision to produce a low-density urban environment consisting of single-family homes on individual lots. This dispersion results in two phenomena: (a) the inability to provide a sufficient number of carpool or vanpool matches to any given work location and (b) the inability of transit to efficiently cover many areas of a region.

Because of our desire for a low-density life-style, we have committed our society to the automobile. Rather than creating an image in which the automobile is used in a fuel-efficient manner, advertising and the media have made it socially acceptable to drive alone. The United States has created and perpetuated the image of the urban cowboy—the king of the road cruising in an automobile. We are conditioned to think that freedom and flexibility can only be achieved if we own and operate an automobile, and we look negatively at those who are transit-dependent. As a result of this bias, people tend to view any alternative to driving alone as a less-than-desirable mode. It is, therefore, very difficult to promote ridesharing as an energy contingency or conservation activity. People will reduce unnecessary trips and make adjustments in their driving habits before they will share rides. Through media and advertising, we need to create a positive image for alternatives to driving alone.

Another social barrier that government must face is the concept of the 9-to-5 job. The movement of large numbers of people to and from work at approximately the same time creates massive peaking problems, particularly for transit. During an energy crisis, the system cannot accept any additional demand. Flex-time or staggered work hours offer the potential for relieving the peaking problems somewhat. Although government may attempt to encourage use of these concepts, the actual implementation must be done by individual firms. And though it is a sound concept, implementation is often quite difficult. To ensure that flex-time or staggered hours can be implemented during an energy crisis, government needs to establish guidelines for employers to follow and to get employers to consider this as part of their firm's contingency planning.

POLITICAL BARRIERS

Governments suffer from a credibility problem. While calling for conservation or contingency measures to be

carried out by the public or employers, governments have failed to set an example by having or carrying out similar actions. Provision of free parking for all government employees, failure to have government employees develop (at a minimum) personal contingency plans, and the lack of aggressive implementation of governmental contingency measures have placed government at all levels in a position of being ill-prepared to deal with a crisis. During the gasoline shortage in 1979, many private employers were better prepared to deal with the crisis than either the city or county of Los Angeles.

This credibility problem leads to another barrier—even if government plans for a crisis, people will not believe government. So, carefully developed plans may prove to be inappropriate as people respond differently than government had anticipated.

Another obstacle to effective governmental response is the creation of special-interest groups, which has occurred within the past few years. Each of these groups represents a narrow constituency with its own parochial view on a problem or issue. As a result, elected officials find it difficult to develop broad solutions or programs. We have become a society that knows how to debate solutions but not how to discuss a problem. Confrontation and adversarial modes used by these groups make it difficult, if not impossible, to discuss individual perceptions of the problem and to construct solutions that satisfy a variety of needs. For local governments trying to develop contingency plans, this leads to the production of plans that reflect the concerns of the most-vocal interest groups.

In addition to a lack of credibility and to the demands of interest groups, local government officials (administrative and elected) harbor certain attitudes that serve as barriers to effective governmental response. First, there is an engineering-construction bias in transportation planning and programming. This results in solving problems or meeting needs through the development of capital-intensive services and facilities. These projects require extensive design work and lead time to construct or use. Government, until recently, has placed a heavy emphasis on increasing the supply of facilities (e.g., roads or rails) or services (e.g., transit) rather than on attempting to influence demand (through marketing and advertising).

A second attitude held by many government officials is that transit must be very basic. Many officials find it difficult to spend public dollars to make transit as comfortable or as convenient as the automobile. The fact that many areas did not have attractive transit systems represented a missed opportunity to capture new riders during the gasoline shortage in 1979. Many riders who turned to buses were turned off by the poor quality of service and stock and have since reverted to their automobiles. Although ridership peaked during May and June, it has since declined and leveled off.

The final attitude possessed by government officials is, in many respects, the basic reason why government cannot respond effectively to crises. For every problem there is a program, and with every program there is bureaucracy that does not move quickly. By the time government finds the mechanism to coordinate its activities, debates the solutions to the problem, creates the plans to meet the problem, and establishes the bureaucracies to carry out the plans, the public has long since taken matters into its own hands and found its own solutions.

Government would be well served in taking a minimal role in responding to energy contingencies. Questions about the ability of government to respond decisively and quickly because of institutional, political, and social barriers abound today. However, the public mood raises questions about whether government should respond to them. This does not imply that there is no role for government, only that government should do the least necessary to facilitate individual responses to energy crises. It suggests that government must do a better job of identifying what the public wants and needs. It means planning with people, not for people. In doing so, government would be serving both itself and the public interest. If, however, government insists on assuming a larger role, it will only serve to fuel the current public sentiment to "clean house".

Selected Issues Related to Governmental Responses to Energy Shortfalls in the Transportation Sector

William H. Crowell

The variety of energy supply and cost perturbations that have shocked the economy of this country (and others) since the early 1970s has gradually forced a serious rethinking of the way the transportation sector will go about moving goods and persons in the future. The unprecedented rise in the cost of petroleum-based fuel during 1979, where consumers saw the price of gasoline essentially double, has finally sensitized the traveling public to these concerns.

In the past, it frequently appeared that people did not really believe that an energy crisis existed; or they would accept that it existed while showing a strong reluctance to take any serious remedial measures. The recent political reaction to energy taxation in Canada, for example, and the consistently negative response to major increases in fuel taxes in this country, show the real difference between acceptance of the problem and some of the possible cures. The reluctance is to be expected given the energy-intensive tradition of the United States relative to other industrialized countries. This country's energy use per capita is more than twice that of West Germany, France, and England and almost three times that of Japan (1). An important factor in this wide gap is that the eight other industrialized countries in Europe plus Japan had an average energy consumption per unit of transportation output (e.g., ton mile or passenger mile) that was 60 percent lower than that in the United States, while the averages for the other residential and commercial sectors were only 10-25 percent lower (1). Most of the transportation-sector differential is due to passenger travel, with U.S. citizens by using relatively heavy, energy-inefficient automobiles for 95 percent of their trips versus an estimated 22 percent for Japan (2). People in the United States have a fairly clear reason for underplaying possible crises and resisting substantial moves to alter energy use—to do so is to go against a strong tradition of carefree energy consumption.

When viewing the most recent energy shortage of 1979, one does not have to be an energy expert to realize that the responses made by various levels of government, especially state and local, were not much better than in the 1974 shortfall. A number of federal laws and regulations had been passed—and at least partially enacted—in addition to the establishment of the U.S. Department of Energy (DOE). A majority of the states made some attempts to improve their energy readiness. However, the bulk of these actions appeared to be more theoretical than pragmatic when it came to relieving travel pressures that the supply interruptions produced. The significant change in the level of financial support for mass transit operations, to a great extent caused by the 1973-1974 crisis, did alter the modal picture, or at least allow transit to hold its ground in some

areas, by maintaining (or expanding) service levels and moderating fare increases. However, conventional transit handles only 1 out of every 20 trips nationwide, and even the dramatic stories of huge patronage increases from Los Angeles and elsewhere could not change this fact. The picture on the freight side of the problem is much more clouded and complex because (a) regulatory control is even more involved and (b) the availability of alternative modes for a given freight trip is less likely than that for person trips.

One of the most important overall factors of the whole contingency-responses question, however, is that the ability of the nation's economy to react effectively to true petroleum shortages is mainly dependent on local reactions and adjustments that follow federal (e.g., allocations) and state (e.g., odd-even plans and minimum sale regulations) actions. In addition, the social, economic, and fiscal impacts--most keenly felt at the local level--create a frustrating situation whereby local governments try to tackle problems whose causes and principal remedial actions are exogenous to the area. The recent voluntary energy goals for gasoline-demand reductions asked by President Carter of all states are an example of this. When faced with a voluntary reduction (that the President can make mandatory) of roughly 11 percent relative to 1979 levels by the end of this year, states depend primarily on locally controlled transit, paratransit, and transportation management schemes to attain such goals. This situation, in many ways, parallels a state's responsibilities under the Clean Air Act; many urban areas become heavily involved in their state's submittal of transportation control plans to reduce vehicular travel as part of the air-quality implementation plans. The problems and goals are defined and mandated at the federal level, the states bear the legal responsibility of attaining these goals, but the actual programs and strategies (and their positive and negative socioeconomic impacts) are mainly local concerns.

THE FEDERAL OVERVIEW

A brief overview of the federal perspective in the overall contingency-planning picture shows that the bases for major federal actions in this area are the Emergency Petroleum-Allocation Act of 1973, the Energy Policy and Conservation Act of 1975, and the Gasoline-Rationing Regulations of March 1979. The Emergency Petroleum-Allocation Act gives the Executive Branch the authority to determine in what manner scarce petroleum resources will be distributed (by user group and geographic area) and to determine reasonable ceiling prices for these products. It sought to try to minimize the economic and social disruption associated with petroleum shortages. The essential components of this allocation program are (a) establishing current available fuel supply relative to some base period, with the ratio of the two equal to the allocation fraction and (b) judging which sectors of the economy would get as much fuel as in the base period, or some lesser amount as determined by the application of the allocation fraction. Important here is the fact that public transit services would receive an amount equal to 100 percent of their current requirements times the allocation fraction.

The Energy Policy and Conservation Act gave the President the power to initiate a variety of contingency actions. Clearly the most extreme and controversial of these actions involves a stand-by gasoline-rationing program. The various programmatic options still being debated include a fixed gasoline ration per registered automobile, the legal sale of coupons on a white market, and special supplemental allocations for public transportation operations. This act also allows the President to implement mandatory energy conservation plans for states, the strategic petroleum reserve (e.g., the storage of oil in salt domes), and the scheduled improvement of motor vehicle energy efficiency.

Energy Taxation

It is interesting to note that the Energy Policy and Conservation Act also ruled out the use of a user tax system as part of any fuel-rationing program. This solidified the country's continuous resistance to fuel taxation and, particularly, to retail gasoline levies. Other countries have considerably higher federal-level gasoline taxation; generally, these high tax rates have been in effect since World War II or earlier. Unlike this country, Western European countries have traditionally been oil importers, and excessive use of petroleum products would, and currently does, place a severe burden on their economies and currencies. The picture of the United States as a major self-sufficient petroleum producer has clearly changed, but the way that the nation prices (i.e., controls supply) its petroleum sales has not (3). The tax recently proposed by President Carter on imported oil, with a projected impact on gasoline prices of up to 10 cents/gal, is a partial move in this direction. Some observers feel that this action is too little and too late. Moreover, the political survival of more taxation is doubtful, particularly with the probable passage of some form of the so-called excess profits tax and the already-large increases in gasoline prices over the past nine months.

Some domestic critics and many foreign ones feel that this country's underpricing of energy has placed it in an economically vulnerable position, exposed this and other oil-importing countries to greater pressure from members of the OPEC and delayed the development of alternative energy sources. However, several points have to be remembered before the United States contemplates plunging into the world of high taxation (50-75 cents/gal or more) of gasoline. If the goal of the tax is primarily to reduce gasoline use, is there sufficient transit and paratransit infrastructure in place to handle the trips diverted from automobiles? Furthermore, the equity considerations of such a control-by-price method cannot be easily resolved, particularly if the tax is added in one large increment. This has traditionally been one of the main arguments for the rationing system with the white-market element (even though this clearly does not remove the charge of the "rich getting all the gas they want" so often leveled at a taxation-based reduction scheme).

There, of course, is no reason why such taxation should be limited to motor vehicle fuels only. Taxation could play a major role in domestic and world conservation of irreversible resources, the conversion to other forms of energy and more energy-efficient commerce and life-styles, and the likelihood and severity of the very energy emergencies that are the focus of this meeting.

Gasoline Rationing

The gasoline-rationing regulations, in addition to spelling out the rationing program, cover a range of other actions available to the federal government, including (a) a restatement of allocation and price-control schemes and mandatory conservation goals; (b) increased enforcement of speed limits; (c) minimum-purchase, odd-even, and other service station operation controls (since relegated to the states by the President); and (d) a set-aside program for discretionary use of states for emergency allocation.

In summary, it is clear that the federal government has rather extensive authority in the energy contingency area, with actions ranging from voluntary programs to complete control of the supply allocation and the price of fuels.

THE STATE PERSPECTIVE

The very nature of the petroleum industry, particularly its national and international structure, and the broad regulatory powers held by the federal government in this area, have left the states in wait-and-react position. All major decisions on domestic oil production, imports, geographic and sector allocation, and pricing policies are

essentially in the hands of the federal government—particularly the Executive Branch. The Energy Policy and Conservation Act did establish a requirement for states to develop energy conservation plans for all sectors, including transportation, and the voluntary gasoline-demand reductions that DOE is putting forward for 1980 for each state is an outgrowth of this act.

The principal involvement of the states in contingency planning and implementation is their incremental control, within the overall context of federal guidelines, over the supply and retail sale of gasoline for motor vehicles. This control has two major elements:

1. Fuel set-aside programs—the release of set-aside fuel reserves during periods of supply disruption, and
2. Gasoline sales limitations—the constraints placed on when and how much gasoline can be sold (the main options here include odd-even sale days, minimum-purchase requirements, and, in some cases, controls on when service stations are closed or open).

A number of states independently established some form of set-aside program before the federal program was in place. Many had also implemented one or more of the gasoline sales restrictions before the President relegated his authority in this area to the states in 1979. In a short-term supply contingency these types of market interventions, particularly the direct limitations on sales, are crucial to the quick control of the panic-buying pattern that is often a central element in a fuel shortage. Such consumer patterns, fed by the fear of being caught with no gasoline and no available supply, can seriously disrupt the supply-demand balance well beyond any actual reduction in the supplies being delivered to service stations.

Assume, for example, that a state had a supply shortfall of roughly 10 percent for its 7 million registered vehicles. Typical weekly demand was 10 gal/vehicle, and the average vehicle's 15-gal tank was usually half full. The vehicle fleet would therefore consume roughly 10 million gal/day (7 million vehicles x 10 gal/week ÷ 7 days/week). The moving storage in these vehicles would be about 52.5 million gal (7 million x 7.5 gal/tank)—the equivalent of more than a 5-day supply for the entire state. However, if a panic atmosphere led the average driver to top off his or her tank with 3 gal/day more, this would represent a 40 percent increase in the moving storage, thus making more fuel unavailable for sale at stations (4). The net impact of these panic purchases can be reviewed from two perspectives:

1. At a time when the actual gasoline supply available for sale at stations is being reduced by 10 percent, the topping-off problem can effectively reduce available supplies much more; and
2. With supplies to stations decreasing and a parallel decrease in demand hoped for to balance it out, panic-fed demand, particularly in the short term, can actually increase.

Sales patterns from the mid-1979 crisis months show, of course, that gasoline sales did decline. Although sales nationwide in the first three months of 1979 were above the levels of the previous two years, by May they were lower (the first time since 1974 that monthly sales were below levels of the previous year) and continued to remain low throughout the rest of the year. The largest travel drops were on rural stretches of the Interstate highway system, mainly due to the changes in recreational travel brought about by fears of supply problems on long-distance vacation trips and, to a lesser extent, by increases in fuel prices. (Even for an automobile trip of 2500 miles, for example, an increase of 20 cents/gal figured at 15 miles/gal would only add about $33 to the cost of the vacation—a relatively small amount when compared to the probable total trip cost.) The serious impact that these travel diversions created for the tourist-oriented economic base of states such as Arizona, New Mexico, Florida, and others is well known, and it is clear that the impact of the shortage and its size differed considerably among states.

However, an equally perplexing intrastate pattern has been apparent in the two major supply disruptions. While certain areas of a state experienced serious supply disruptions and all of the associated social and economic impacts, other sections were barely affected. This dichotomy was very evident in New York during the 1979 crisis. The greater New York City area had a serious gasoline-supply shortage, accompanied by typical long station queues and shortened operating hours. However, other areas of the state, some very close to the New York City area, experienced only minor fuel supply problems or none at all. One would expect that the greater New York City metropolitan area, with the most extensive transit system in the country, should bear a greater burden on some common basis (e.g., reduction per capita), but this supply disparity was significant.

Similar disparities in the severity of the most recent shortage among various locations within a state occurred in other states as well. The extreme social and economic disruption that accompanies a real (or at least partially imagined) gasoline supply problem makes it essential for states to learn how to identify, address, and help resolve such imbalances. The major constraints are that (a) states in many ways have very little control over such fuel-allocation matters; (b) there are clearly political considerations involved when it is proposed to give area A's fuel to another, possibly creating some supply problems in A in the process; and (c) there is often no easy, inexpensive, quick method of redistributing such supplies—that is, there is nothing comparable to the power grid or pool used by utility companies to transmit almost instantaneously huge amounts of energy among areas within a state or among different states.

In summary, state governments are placed in a difficult middle ground between the more fully empowered federal agencies at the top level and the regional and local officials, agencies, and authorities grappling with the direct impacts of the shortages at their very doorstep. States have exerted considerable leverage in the past in the control of retail gasoline sales, have some flexibility and discretion under federal allocation schemes, and would play a similar role under the most likely rationing plans. Recent surveys by the National Governors' Association show that most states have already adopted or are actively developing contingency policies and often have some meaningful enabling legislation to support these plans (5). There still remains, however, the question of how a state can and will act as the single voice that must claim the achievement of a certain percentage reduction in fuel use, while the real pressure (political, financial, social) remains primarily at the local level. This point is the principal focus of the next section of this paper.

CONTINGENCY PLANS FROM REGIONAL AND LOCAL PERSPECTIVES

Much of the discussion that I have heard at various meetings and conferences about the energy crisis contingency-response plans and the like is, unfortunately, similar to that concerning the overall governmental handling of the air quality problem. Once again, the pattern has been established wherein the federal government sets goals to be met by the states, but problems and programs are dealt with mainly on the local level. If the nation's success in this endeavor were measured by comparing the goals of the Clean Air Act and other related legislation to the actual programs in place, the scorecard might read this way: (a) producing new cars with lower emissions—fair, with considerable foot-dragging and delays by manufacturers, government agencies, and others; and (b) reducing the volume of polluting activity (in this context, vehicular travel)—poor to nonexistent. Travel and modal-choice habits were (and are) deeply engrained in the nation's psyche. Political, social, and economic resistance to the far-reaching, ambitious transportation control plans of the

early 1970s was intense, and it effectively showed that the local political mandate simply was not there to change things that quickly. Legislation eventually caught up with reality, and the 1977 amendments to the Clean Air Act (by 1977 most major goals were originally supposed to have been achieved) now talked of 1982 and 1987 deadlines.

The similarities between the transportation energy-conservation contingency programs and the approach to the air quality question are many and should (it is hoped) provide energy planners with some guidance on what to do and not do. The following points deserve special attention.

Common Strategies

Clearly, the experience with trying to reduce vehicle miles of travel (VMT), improving transit patronage, and so forth for air quality reasons (including special programs for air quality emergencies) should provide some aid in selecting and realistically evaluating the potential success of proposed schemes.

Lack of Consistent Public Support

The public supported the concept of environmental improvement and the "moral war" on energy problems, but both programs have shown a strong tendency to languish over the long term. The public's general lack of any true bite-the-bullet spirit after the 1973-1974 shortage and substantial cost increases is a case in point. The various energy programs do, however, have something that environmentalists do not—the strong reminder of supply shortages and huge cost increases.

Key Dependence on Mass Transit

Both programs have looked to conventional transit modes (and none recently at paratransit) as the key to reducing emissions and/or energy per passenger mile. The big difference, however, is that the environmental programs have had to depend on regulated incentives to use these modes, while energy programs once again have the occasional benefit of suddenly experiencing a desperate need for transit (e.g., the temporary transit crush in California in mid-1979).

Regulatory Mandate Versus Available Funds

Many urban areas complained that the strategies needed to reduce VMT also required more funding than was available for planning, administration, operations, and capital improvement, particularly in the mass transit area. The National Mass Transportation Assistance Act of 1974 and later revisions changed this somewhat, but many cities are still fiscally unable to carry out the types of service and fare policies that could really affect modal split. Although energy contingency programs are helped by the strong transit demand that such emergencies create, the operational side is very difficult and expensive (e.g., short-term expansion of capacity, additional vehicles and operators, and overtime pay). There are also extraordinary costs associated with special traffic management problems, provision of alternative travel information, control of special transit and paratransit services, and the like that can place a financial burden on localities.

Protection of Local Economic Base

Much of the private sector resisted plans to reduce VMT as a means of improving air quality, mainly because such schemes are viewed as reducing accessibility. This resistance was the primary reason for the defeat of these plans. There is clearly an equally strong relation between the policies to handle the economic disruptions of a person and goods movements that have been disrupted. The competing needs, for example, of downtown retail centers versus large malls on the periphery of urban areas can be difficult to balance when creating a package of emergency response strategies.

LOCAL-LEVEL RESPONSIBILITIES

Numerous meetings, conferences, and workshops, along with the painful but valuable experiences of the 1974 and 1979 gasoline shortages, have shown that all levels of government must be prepared to respond quickly and thoroughly to such emergencies as they arise in order to reduce their negative impacts and the spread of a panic atmosphere that can only worsen the problem. One recent guidebook to the development of contingency plans (6) determined that the main responsibilities of local governments are in the areas of (a) activities related to transportation system management and transportation improvement plans, (b) ridesharing and carpooling, (c) alternative work schedules, (d) client-agency transportation services, and (e) conventional transit services.

I feel that these types of programs are the most crucial ones in terms of quickly establishing alternative travel methods to the 95-5 (95 percent automobile and 5 percent other) modal split that exists in nonemergency situations. Although the federal and state governments have control over what one might call fuel-shortage correction actions (e.g., allocation, rationing, and gasoline sales controls), the real burden of response (when the real shortfall is actually defined) falls on local officials, agencies, and, of course, the traveling public.

A number of basic factors directly affect the planning and implementation of such local plans. Some of these factors are discussed briefly here.

Sources of Financial Assistance

From what sources will funds be made available to finance the development of such plans and, more important, their implementation? Metropolitan planning organizations (MPOs) have recently been mandated to include contingency plans in their overall transportation-planning activities, but they did not receive any funding increment to cover these activities. Transit assistance under Section 5 of the National Mass Transportation Assistance Act currently has no method of responding to higher deficits related to contingencies. Similar questions associated with state and local aid plans need to be addressed.

Full Determination of Responsibilities

The myriad of agencies, authorities, MPOs, and the like that have gradually complicated the handling of transportation, especially in urban areas, have also made it difficult to develop single-purpose plans that avoid overlap, have a clear delineation of responsibilities, and are accepted by all parties involved. The fact that MPOs are generating, or at least coordinating, such planning efforts, at a time when relations between MPOs and various state and local agencies are strained at best in many urban areas, seriously jeopardizes the process.

Full Private-Sector Involvement

A recent extensive transportation survey of 400 firms in New York City (7) showed that many firms had been irritated in the past by the limitation of their participation in air-quality-control planning to the token-representative level. While they realized that their interests were different from those of government agencies and that they really did not expect any kind of veto power over such plans, they did want to play a more meaningful direct role in the planning process. This was particularly true in the goods movement area about which they felt government agencies were rather naive. In energy emergencies, the common problem that the private and public sectors face is more easily accepted than the air quality problem, and the potential economic impacts can be much more severe.

However, local officials must allow full participation by business interests and not let the attitude of "we are above any special interests" keep out or alienate the private sector.

Conventional-Transit Versus Special-Transit Conflict

Since the early 1900s, the tradition has been to provide a single form of public transit on a monopoly- or controlled-franchise basis that minimized or eliminated competition. Various federal legislative actions have furthered this tradition. While the acceptance of paratransit, the brokerage concept, and related schemes has grown of late, there are still numerous roadblocks to the expansion of such schemes. This is particularly true if such plans are, to some extent, pushed before an emergency hits to both ensure readiness and aid overall conservation. Numerous studies have shown how transit and paratransit modes often compete directly with each other rather than draw jointly on the pool of drive-alone commuters.

CONCLUSION

The material presented here was not intended to address all of the relevant issues associated with energy contingency problems and constraints faced by various levels of government. Rather, I have merely tried to identify and discuss a number of key issues that I feel have not been covered sufficiently and need to be. This conference provides a useful forum for the discussion of these topics, although it is clear that they cannot be fully resolved at this time. The experiences with plans to reduce vehicular emissions showed how a public drive to attain a specific goal (improved air quality) can get hung up at the point where the business-as-usual pattern of doing things has to change if any real impacts are to be expected. Many of the long-standing concepts of transportation in this country (e.g., low energy taxation and elimination of transit's competitors) that bought us into the 1970s are now being challenged, and some may have to change or at least become much more flexible. This will not be an easy task, because programs that produce a net benefit will still have winners and losers. It is to be hoped that the exchange of ideas at conferences like this and occasional shocks like the mid-1979 energy crisis will help prompt useful change and will do more than just get us through shortages every five years.

REFERENCES

1. J. Darmstadter, J. Dunkerley, and J. Alterman. How Industrial Societies Use Energy: A Comparative Analysis. Johns Hopkins Univ. Press, Baltimore, 1977.
2. Energy Conservation in the International Energy Agency: 1976 Review. Organization for Economic Cooperation and Development, Paris, 1976.
3. K. Erickson. The Political Economy of Energy Consumption in Industrial Societies. In International Energy Policy (M. Heisler and R. Lawrence, eds.), Lexington Books, Lexington, MA, 1980, pp. 113-143.
4. W. McShane, A. Block, and W. Ihlo. The Energy Advantages of Public Transportation. Research and Education Division, Urban Mass Transportation Administration, Draft Rept., March 1980.
5. Listing of Major State and Regional/Local Plans, Energy and National Resources Program. National Governors' Association, Washington, DC, March 1979.
6. D. Hartgen and others. Guidelines for Transportation Energy Contingency Planning. Presented at FHWA-UMTA Energy Contingency Planning Conference, Albany, NY, May 1979.
7. W. Crowell and A. Block. The Impact of Transportation Control Plans on the Economy of the Manhattan CBD: Vol. 1, Business Community Survey. Tri-State Regional Planning Commission, New York, March 1978.

Government Agencies and Fuel Shortages: Past Actions, Current Problems, and Future Opportunities

Charles Carlson

The fuel shortage of 1979, like the shortage of 1974, caught the nation unprepared. Government agencies, political leaders, private businesses, and consumers were generally unprepared to cope with a sudden drop in fuel availability and a sharp rise in fuel prices. Among the major consequences of this lack of preparedness were (a) public anger, confusion, and frustration over queues at service stations and the apparent inability of government to solve the problem; (b) severe overloading of all forms of public transportation services in many localities; and (c) substantial damage to important sectors of the U.S. economy (e.g., travel and tourist industries).

Some of these negative impacts probably could have been avoided if government agencies and the private sector had sought to implement well-constructed transportation contingency plans when the shortage struck. Unfortunately, few organizations possessed these plans in the spring of 1979.

Lacking comprehensive contingency plans, what did major institutional actors do in response to the 1979 fuel shortage? In addition, and perhaps more important, what reforms would help the nation prepare for and respond to future fuel shortages? This paper attempts to provide some answers to both these questions, albeit from a general and primarily qualitative point of view. The paper focuses on mass transportation services (i.e., transit, paratransit, and ridesharing services) and automobile travel.

IMPACTS OF THE SHORTAGE

Other papers prepared for this conference describe in detail the impacts of the 1979 fuel shortage on passenger travel and the national economy. For this reason, only a few observations are necessary here prior to discussing the ways in which major institutions responded to the shortage.

Most analysts believe that, in comparison to unconstrained demand, there was a national retail gasoline shortage of between 5 and 10 percent during the late spring and summer of 1979 (1). This shortage first became visible in May and peaked in late June and July. Because of a variety of factors, including government policies and petroleum-producer actions, this shortage was not felt evenly throughout the country. Indeed, some areas of the country had little or no difficulty with their fuel supplies during the shortage period; however, the northeastern region of the United States and several states scattered across the country experienced shortages that may have approached 20 percent.

Some statistics help to define the national impacts of the 1979 shortage. Table 1 shows the percentage change in the use of various modes that occurred in 1979 over such use during the same months of 1978. (Data for Table 1 and Table 2, which follows, were obtained through informal communication with representatives of these modes and

Table 1. Percentage change in vehicle miles of travel in 1979, by mode, when compared to same period in 1978.

Month	Highway[a]	Public Transit[b]	Amtrak	Intercity Bus Travel
January	+4.2	+4.76	+8.8	
February	+3.3	+3.53	+4.6	
March	+2.9	+6.44	0.0	+7.2[c]
April	+1.9	+1.72	+16.9	
May	-2.0	+7.30	+17.2	
June	-4.8	+10.44	+24.5	+13.1[c]
July	-6.3	+10.76	+27.6	
August	-3.6	+8.40	+21.4	+12.3[d]

[a]Includes primary and local rural roads, as well as urban roads.
[b]Includes bus and rail.
[c]Quarterly figures.
[d]Incomplete third-quarter figure.

Table 2. Percentage change in 1979 sales of vehicles for personal transportation when compared to same period in 1978.

Month	U.S. Passenger Cars	Imported Cars	Domestic and Imported Bicycles	Motorcycles	Recreational Vehicles
January	+17.8	+2.1	-1.1	-5.5	+5.7
February	+7.9	+11.3	+1.9	-6.7	-11.3
March	-1.1	+27.9	+2.7	+9.2	-26.2
April	-10.6	+24.4	-4.1	+4.6	-33.7
May	-15.8	+30.3	-2.0	+13.8	-44.0
June	-25.1	+8.4	+11.5	+12.8	-57.7
July	-8.9	+17.4	+20.8	+13.0	-56.8
August	-6.8	+2.2	+33.0	+13.5	-54.0

selected materials.) Changes in commercial air travel are not reported here because, in addition to the shortage, the industry was strongly affected by deregulation, fare reductions (e.g., discount coupons), and the United Airlines' strike during the late spring and summer of 1979. However, according to the National Business Aircraft Association, business aircraft travel hardly changed at all during the shortage. As shown in Table 2, sales of various transportation vehicles also were strongly affected by the 1979 shortage.

Vehicle sales were not the only sector of the economy to be strongly affected by the shortage. Travel and tourist industries and recreation areas also lost business as a result of the gasoline shortage. The National Park Service, for example, reported these percentage changes in the number of person days at the country's national parks: December 1978-February 1979, + 7 percent; March-May 1979, - 2 percent; and June-August 1979, - 13 percent.

Hotel occupancy rates also dropped in many areas, with roadside establishments experiencing the most significant declines. The occupancy rate of one of the largest hotel chains, for example, dropped by 6 percent in May, 4 percent in June, and 11 percent in July. Other major chains, however, reported that the shortage had little or no effect on their overall occupancy rates because continued high use of airport, downtown, and destination hotels compensated for declines in patronage in more remote areas (1).

Obviously, these national figures obscure the impact of the shortage on particular states. It should also be noted that factors other than the shortage probably affected many of these statistics. Initial research, however, does suggest that these indicators moved in similar directions in all states that experienced a shortage of gasoline. Surprisingly, many states that experienced little or no shortage did note changes in travel volumes and economic activity comparable to those in states severely affected by the shortage. If this finding is confirmed by more in-depth research, it may have significant implications for policymakers at both the state and national levels.

INSTITUTIONAL RESPONSES TO THE SHORTAGE

Federal Government Response

The primary federal responses came from the President, Congress, and DOE. Many of these responses, however, focused on long-term solutions to the nation's transportation energy problems rather than on short-term actions to eliminate or minimize the impacts of the shortage. Because this paper is most concerned with the latter class of actions as they apply to mass transportation services and automobile travel, only those measures are described below.

Between January 1 and September 1, 1979, DOE took a variety of actions to fine tune its allocation program and provide fuel to essential activities such as mass transportation services. DOE revived its set-aside program for middle-distillate fuels, thereby allowing states to control and distribute up to 4 percent of their total middle-distillate supply to users who could demonstrate hardship or special circumstances. The agency also strengthened its gasoline set-aside program by increasing the amount of gasoline that a state could direct to particular users from 3 to 5 percent. Both of these actions enabled states to provide fuel from their set-asides to transit systems, intercity bus companies, school bus and taxi operators, and other providers of mass transportation who could not obtain fuel from their normal suppliers.

To ensure that mass transportation services had access to fuel, DOE issued Special Rule 9, which permits mass transportation services to receive all the diesel fuel they require for their operations. DOE also revised its classifications of priority users of gasoline and placed mass transportation services in the priority-user category. This classification entitled gasoline-powered mass transportation vehicles to 100 percent of the fuel that they used during a DOE-defined base period. Some time after the shortage, DOE added vanpools to the list of priority users of gasoline under the allocation program.

Some analysts contend that DOE's allocation program caused as many problems as it solved during the shortage. They cite the natural rigidity of the program and the uneven distribution of the shortage across the nation. They also note the inability of the allocation program to respond to geographic shifts in fuel demand over time.

Despite these criticisms, it seems clear that the allocation program did help to resolve the fuel supply problems of mass transportation services during the shortage. The program also allowed states to use their set-asides of gasoline and diesel fuel in flexible and timely ways to provide fuel to essential activities or users who were experiencing particular hardship as a result of the shortage.

In March 1979, two months before the shortage first manifested itself in the retail gasoline sector, President Carter submitted three national contingency plans and a gasoline-rationing plan to Congress. In addition to the rationing plan, one of the three contingency plans—mandatory weekend closings of service stations—focused on the transportation sector. (The weekend-closing proposal is an interesting example of the confusion that resulted from the fuel shortage. DOE proposed mandatory weekend closing of service stations as a national contingency plan. Once the shortage struck, however, station operators began closing voluntarily on weekends to conserve their fuel supplies. Ultimately, state action was needed to force at least some service stations to stay open on weekends for the purpose of maintaining tourism and other important elements of local economies.) Debate on these plans lasted for several months. Ultimately, both plans were rejected by Congress.

Just prior to the shortage, 18 state governors did not possess authority to implement certain measures designed to minimize queues at service stations. Such measures include (a) regulation of the operating hours of service stations, (b) institution of odd-even license plate plans for gasoline purchases, and (c) regulation of the amount of gasoline

purchases through minimum-purchase requirements (in dollars, gallons, or half-tank requirements). On May 29, 1979, the President issued Executive Order 12140, which gave all governors the authority to impose these types of measures. As described here, many states took advantage of the executive order and did implement gasoline control programs.

Throughout the shortage, DOE attempted to balance production of gasoline for summer driving with production of heating oil for the winter. This balancing effort led to several shifts in DOE policy. Just prior to the shortage, DOE ordered refiners to give heating-oil production the highest priority. After the shortage struck California, DOE ordered refiners to step up their gasoline production. In July, DOE again gave the highest priority to the production of heating oil.

DOE, the President, and Congress were not the only federal participants in efforts to manage the fuel shortage's impacts in the transportation sector. Several shortage-related actions were also taken by DOT and the Interstate Commerce Commission (ICC). During June and July, DOT issued a series of notices that

1. Permitted transit authorities to keep their old buses when they ordered new ones, thus reversing an older policy and encouraging the creation of reserve fleets at the local level for use during emergencies (2);
2. Allowed transit authorities to use federal funds to rehabilitate old buses rather than purchase new ones—a regulation that was adopted because of a backlog in bus orders, uncertainties about new bus designs, and a need to increase the number of buses on the road (3);
3. Encouraged transit authorities to construct and operate fuel storage facilities with federal funds—a policy intended to reduce the fuel supply problems of transit authorities by freeing them from daily concerns about fuel availability; and
4. Urged metropolitan planning organizations (MPOs) to undertake contingency planning as part of their regular work programs.

These initiatives, however, had only limited effects during the shortage because of the long lead times required for implementation.

For its part, the ICC issued an emergency declaration that permitted interstate bus carriers to introduce service on routes operated by their competitors, provided these carriers met certain ICC-defined criteria. This declaration took effect in early July and expired in mid-September. Several carriers, notably the Greyhound Corporation, took advantage of this declaration and did operate new services during the July-September period. Few data exist, however, on the relative value of these new services.

State Government Response

When the fuel shortage struck, a majority of the states could claim that they had contingency plans to deal with fuel supply disruptions in the transportation sector. In fact, most of the contingency plans prepared prior to the shortage were little more than shopping lists of measures that a governor or state legislature might use in the event of a shortage. Equally important, state-developed transportation contingency plans generally emphasized voluntary rather than mandatory programs. Finally, few of the plans included specific implementation procedures or estimates of the degree to which the plans would influence fuel demand during a shortage.

Because the fuel shortage varied in severity from state to state, response by state governments varied in similar ways. For example, as of July 1, 1979, Georgia had taken virtually no action to reduce fuel consumption by its residents. Maryland, on the other hand, had implemented at least eight emergency programs by that date.

The various emergency measures taken by states in response to the gasoline shortage and the number of states involved follow: minimum- or maximum-purchase plans, 16; odd-even license plate fuel purchase plans, 11; flag system to indicate fuel availability at service stations, 10; staggered hours or weekend openings of service stations, 14; emergency hotlines concerning fuel availability, 31; expansion of carpool and vanpool programs, 34; reduced travel by state employees, 34; and increased enforcement of the 55-mph speed limit, 37. This information was derived from a telephone survey conducted by the National Governors Association in June 1979 (4). Unfortunately, data are not available regarding the actual effectiveness of any of these programs in reducing fuel demand or queues at the pumps in particular states. (Research conducted by the Massachusetts Institute of Technology since the shortage indicates that minimum-purchase plans have little effect on gasoline demand. Odd-even plans, on the other hand, appear to reduce gasoline demand by 1-2.5 percent.)

Virtually all states also used their set-asides of gasoline and diesel fuel to combat the fuel shortage. Some states (e.g., Massachusetts) directed much of this fuel to retail service stations in particular regions of the state in order to maintain key local economies such as tourism. Other states apportioned their set-aside supplies among retail stations, mass transportation services, and other fuel users on a case-by-case basis (1).

Though there is no list of all the other actions that states took in response to the shortage, it is clear that additional measures were undertaken by individual states. Colorado, for example, allowed the sale of discounted bus tokens and transit passes at state employment centers and started a voluntary carless-day program under which residents were urged not to drive one day per week.

Local Response

A variety of organizations participated in local efforts to minimize the impact of the 1979 fuel shortage. These organizations included city and county governments, MPOs, transit authorities, private transportation providers, ridesharing organizations, and employers. It must be emphasized, however, that these actors did not participate uniformly in local emergency efforts.

The U.S. Conference of Mayors conducted a telephone survey of 100 cities during the last week of June 1979 to determine (a) the impact of the shortage on these cities and (b) the responses of these cities to the shortage (5). Almost every city surveyed was affected by the shortage either because of substantial increases in the price of fuel or because of reduced allocations of diesel fuel and gasoline for city government operations. Of the cities surveyed, 81 percent did take emergency actions. In the area of passenger transportation, cities took actions such as the following:

1. Reducing travel in city-owned vehicles,
2. Reducing parking rates for carpooling employees,
3. Subsidizing bus passes for city employees,
4. Instituting variable work-hour programs,
5. Implementing restrictions on gasoline sales (e.g., minimum- and maximum-purchase plans), and
6. Expanding city-operated carpool and vanpool programs.

Again, it should be emphasized, however, that these actions were not implemented in any consistent or comprehensive manner.

No national data are available on the emergency programs that were implemented by county governments, MPOs, transit authorities, private transportation providers, ridesharing organizations, and employers. What information is available, however, indicates the following:

1. County governments frequently participated in discussions of alternative regional strategies for reducing queues at service stations and lowering demand for gasoline and diesel fuel. Some county governments played a

coordinating role in regional efforts to respond to the shortage. MPOs generally assumed similar functions, although some actually took the lead in organizing emergency programs.

2. Although a few transit authorities and ridesharing organizations had contingency plans ready for implementation when the shortage struck, the vast majority of these organizations did not. Consequently, most transit authorities and ridesharing organizations had to take action on an ad hoc basis to accommodate sharply increased demand for their services. Some of these organizations did nothing more than attempt to maintain their current service levels.

3. In areas where the shortage was severe (e.g., the Northeast and California), some employers assumed new responsibilities for employee commutation. In general, these employers were those with large work forces. Emergency actions taken by these employers included the introduction and expansion of carpool or vanpool programs, shuttle or subscription bus services, and transit subsidy programs.

Summary

The federal government's response to the 1979 fuel shortage generally included initiatives to increase the supply of fuel rather than to reduce the demand for fuel. (Congress rejected DOE proposals to reduce fuel demand through implementation of national contingency plans or a gasoline-rationing plan.) On the state level, the mandatory programs (e.g., minimum-purchase plans) that were implemented focused on controlling queues at retail service stations rather than on controlling demand for fuel. It is unclear if state government implementation of various voluntary programs (e.g., expansion of carpool and vanpool programs) had any significant effect on fuel demand. Local-level emergency actions varied enormously, although virtually all of them concentrated on lowering fuel consumption.

Finally, it should be stressed again that, with few exceptions, state and local responses to the fuel shortage were not based on detailed contingency plans. Instead, they were the result of ad hoc decisions made with limited information in the midst of the shortage. In this environment, it is hardly surprising that major institutional actors did not react consistently and comprehensively to the shortage.

CURRENT PROBLEMS AND FUTURE OPPORTUNITIES

Although the 1979 fuel shortage had some significant impacts on travel and the national economy, it was relatively brief, geographically dispersed, and only sporadically severe. Moreover, the shortage may have been partly a blessing in disguise, because it refocused federal attention on the need for transportation energy conservation and contingency plans as responses to an environment of rapid inflation, spiraling fuel prices, and uncertain fuel supplies.

Today, interest in conservation and contingency planning remains high within certain parts of the federal government, particularly DOE and DOT (although support for emergency planning is limited even within these two agencies). As part of its statutory responsibilities under the Emergency Energy Conservation Act of 1979, DOE is urging states and localities to prepare transportation energy conservation and contingency plans to achieve voluntary targets established by DOE. DOT is asking MPOs to undertake contingency planning as part of their unified work programs.

In partial response to these federal recommendations, some state energy and transportation departments have prepared or are preparing conservation and contingency plans. Some MPOs, transit authorities, and local providers of paratransit and ridesharing services have written or have begun to write such plans.

Despite these efforts, serious problems remain in the nation's approach to transportation energy conservation and contingency planning. There is confusion and uncertainty within all levels of government as to the relative importance of conservation and contingency planning in the amalgam of problems that beset the nation. There are still a large number of state governments and localities that have not yet grappled with the difficult issues presented by a fuel-short energy future. There is a serious lack of comprehensiveness, coordination, and consistency among conservation and contingency planning efforts that have been undertaken by different government agencies. In short, there is still no general understanding of the proper way to prepare for a decade that almost certainly will be marked by continually rising fuel prices, occasional fuel shortages, and consequent losses in personal mobility.

Four basic problems currently impede government efforts to prepare comprehensive transportation energy conservation and contingency plans. These problems are

1. Insufficient integration of the federal government's approach to conservation and contingency planning,
2. Decentralized decision-making process for the selection and funding of transportation services,
3. Insufficient state attention to the need for and development of conservation and contingency plans, and
4. Weak local institution (i.e., the MPO) that has some difficulty in focusing on and in coordinating conservation and contingency planning programs.

Insufficient Integration at the Federal Level

As stated earlier, DOT and DOE have begun to focus on transportation energy conservation and contingency planning as issues of critical national importance. To date, however, these issues have received the close attention of only a small number of officials within these two agencies. For the most part, DOT and DOE transportation programs are still being operated as though the 1974 and 1979 fuel shortages were momentary aberrations rather than harbingers of the energy environment of the next decade and beyond. Consequently, DOT and DOE are not prepared to institute prompt, comprehensive, and appropriate responses to future fuel shortages. They are also not in a position to require localities to undertake broad transportation energy conservation programs.

Because DOT and DOE have not organized their own approaches to the energy problem, they may have difficulty urging strong energy-related actions by other federal agencies whose policies and programs affect opportunities for reducing energy consumption and managing fuel shortages. Clearly, though, coordination with other federal agencies is urgently needed. The U.S. Department of Housing and Urban Development through its urban development action grant program, for example, provides public funds for the construction of parking garages in downtown areas, but DOT funds programs to constrain the use of the automobile in these areas.

Decentralized Decision-Making Process

The second key problem is that for more than a decade, it has been a basic tenet of federal policy that state and local actors should establish their own transportation priorities and programs. DOT and other federal agencies have retained review powers and have established general regulations regarding service development and compliance with existing laws; state and local actors, however, have generally been allowed to implement those programs that they feel are more appropriate for their own political, economic, social, and environmental circumstances.

Federal funding practices have followed this general federal policy. The Federal Highway Administration (FHWA), which has the largest transportation budget of any federal agency, allows its funds to be used for highways, ridesharing programs, or as capital for mass transit projects (through the interstate transfer program). The Urban Mass

Transportation Administration (UMTA) also has substantial funding that may be used for any project that is defined as mass transportation. Much smaller amounts of monies from the U.S. Environmental Protection Agency are available for transportation programs that promise reductions in air pollution. In the same way, DOE's small budget for transportation programs may be devoted to any project that helps to reduce energy consumption.

Although this decentralized decision-making process has permitted localities to choose among a wide range of service options related to transit, paratransit, and ridesharing and of federal funding programs, it has also led to several major problems. First, though the process is designed to encourage local debate, the executives of individual transportation agencies have frequently adopted a hands-off approach regarding funding. In this environment, retention of the status quo is unavoidable.

When debate has occurred, it has often seemed interminable. More important, it has often created tensions between constituencies competing for limited funds that may be used for a variety of purposes. Highway interests, for example, have opposed the use of FHWA funds for ridesharing. Transit providers have opposed the use of UMTA funds for paratransit services that would be operated by privately owned entities. Inaction rather than decision has been the common result of this conflict.

These problems are not the only consequences of the current decentralized decision-making process. This process also makes it difficult for states and localities to address new problems such as the need for transportation energy conservation and contingency planning. New problems are often ignored because they are poorly understood, they have no immediately identifiable constituency, and there are no clear federal requirements and priorities for action.

DOT's transportation system management (TSM) initiative provides one example of a new program that has had many difficulties that are, in part, the result of a decentralized decision-making process. TSM theoretically has been a vehicle for low-cost projects designed to improve air quality, conserve energy, expand mobility, and increase the efficiency and coordination of transportation systems. Local planners and decision makers, on the other hand, have often perceived the TSM program as one that contains a wide range of possible actions, no federal preference for any of these actions, and no federal requirements for success. With these perceptions, they have frequently chosen to implement those TSM actions that are least expensive, least controversial, and least experimental, as opposed to those actions that promise to be most effective in reducing vehicle miles of travel or vehicle hours of travel. In many cases, their motivation is only to ensure that federal highway funds continue to flow for local transportation projects. For all these reasons, the TSM program has had only limited success since 1975.

Insufficient State Focus on Emergency Planning

The federal government is not wholly responsible for the lack of state and local attention to conservation and contingency planning in the transportation sector. States are also somewhat responsible for this situation.

At the outset, it must be noted that a variety of factors discourages states from tackling new complex problems. (It must also be said that a few states have surmounted these obstacles. California, for example, succeeded in implementing a strict air pollution control program that requires automobile manufacturers to alter their vehicles in order to sell them in the state. On the other hand, California is big enough to be a fair-sized independent nation. It is not likely that other states could adopt the California approach.) The press of daily business obscures the importance of attending to these problems before they affect society. The lack of hard data on the effectiveness of various approaches to new problems makes it politically risky for state political leaders to adopt one approach instead of another. A dearth of state funding for research, experimentation, and demonstration programs forces states to leave such efforts to the federal government.

Another key obstacle to state action in the area of transportation energy conservation and contingency planning is the fact that the beneficiaries of such planning are not immediately identifiable or powerful. Indeed, when fuel is plentiful, strong transportation energy conservation programs may hurt many people, businesses, and government agencies, at least in the short term. Service station operators, automobile dealers and manufacturers, oil companies, and other persons who are engaged in the sale of products and services for automobile travel may lose revenues. State highway departments may lose revenues needed for their programs (because of reduced gasoline tax receipts). Individuals may lose mobility (if increased fuel prices, for example, force people to travel less because alternative transportation modes do not exist). In this environment, strong conservation programs are accompanied by enormous political risk.

Finally, states have historically viewed fuel shortages as national problems that deserve national solutions. State governors, legislatures, and the executives of state agencies have always assumed that in the event of a serious shortage, the federal government would intervene to increase fuel supplies and/or restrain fuel demand.

The Problems of MPOs

On the local level, MPOs are the natural choice for leadership of local and regional conservation and contingency planning programs. Yet MPOs clearly face serious problems in assuming this function. MPOs historically have served as technical organizations that provide analysis of major regional capital investments such as highways and rail transit lines. They have also undertaken generalized regional transportation planning under federal requirements.

The focus of MPOs on capital investments has forced them to give less attention to service-planning issues. This focus has also made it difficult for MPOs to alter their priorities as local circumstances change. Put another way, capital investments are long-term projects that are hard to stop or modify once they are begun. Consequently, money and attention continue to be given to these investments even if it appears that other projects should assume higher priority as a result of external events. Debate between interest groups and the lack of MPO authority for final decisions have caused new ideas to languish in the face of obvious needs for action.

When MPOs do wish to give attention to service-planning and other noncapital issues, a variety of pressures combines to force MPOs to focus on short-term rather than on long-term questions. Constituent agencies of the MPO want the planning body to examine immediate issues (e.g., the impacts of new federal regulations) so that staff of the constituent agencies can continue to work on day-to-day operating problems. Problems with the existing public- and private-sector transportation system (e.g., a lack of funding and intermodal competition) take precedence over long-range issues. Long-term questions such as changes in land use patterns are difficult to study because they involve sweepingly controversial issues for which there may be many right answers or few hard data. In addition, efforts to answer long-term questions are often frustrated by elections, new appointments, and other changes in the political environment that may eradicate the institutional consensus for action on these questions.

Another problem is that MPOs have no leverage to bring new actors into local efforts to respond to new regional problems. Major employers, for example, should be key participants in local conservation and contingency planning programs. Yet many of these employers are national corporations that may not wish to alter their companywide policies to suit local priorities. In the absence of pressure from higher levels (i.e., the federal government), these actors may well choose to do nothing.

In the area of transportation energy conservation and contingency planning, the job of MPOs is made particularly difficult by the fact that there are no tangible and immediate incentives or rewards for these types of efforts. Conservation and contingency programs frequently involve modifications to and regulation of individual travel behavior—unpopular acts in any environment. They may require shifting money from programs that are popular but have no energy benefits to programs that have no visible constituency but will have benefits apparent only in the event of a fuel shortage. In addition, conservation and contingency programs are not supported by substantial funding specifically designated for energy-related transportation programs. (DOE's transportation budget is minuscule in relation to the funding available from other federal agencies for other transportation projects.)

MPOs should lead local efforts to develop strategies (for transit, paratransit, and ridesharing) for energy conservation and future fuel shortages. They should coordinate the conservation and contingency planning efforts of various providers of such services as well as local governments. However, the current institutional environment does not encourage these approaches. On the contrary, these activities are specifically discouraged by existing institutional realities.

Future Opportunities

Current federal policies and the recent passage of the Emergency Energy Conservation Act (EECA) of 1979 may help to remedy some of the state- and MPO-based problems described above. Since this act gives states first-line-of-defense responsibilities in the event of future fuel shortages, state political leaders may perceive that it is in their political self-interest to ensure that both state and local actors have strong contingency plans ready at all times. (The act requires each state to implement a contingency plan in the event of a fuel shortage. This plan must meet an energy conservation target established by the President. If a state fails to implement a contingency plan, or if the state plan fails to achieve the conservation target, a federal contingency plan may be imposed on that state.) Equally important, these officials may conclude that the presence of comprehensive state and local energy conservation programs is essential to the success of contingency plans based on the 1979 act. Finally, state leaders may realize that they can benefit themselves and their constituents if they support or implement positive programs now (e.g., expansions of transit service and state carpool and vanpool programs), while the federal government is introducing negative programs (e.g., oil import fees, import quotas, and decontrol of oil prices).

All of these factors may spur states to undertake conservation and contingency planning programs. These factors may also encourage states to give their MPOs (or other local agencies) clear responsibility to prepare coordinated local responses to future energy shortages. None of this activity, however, is guaranteed because DOE is not currently mandating the preparation of EECA plans by the states.

If DOE does make the EECA process mandatory in the near future, DOT might take several steps to reinforce the EECA process and ensure that transit, paratransit, and ridesharing strategies receive full attention in each state's development of an EECA plan. If DOE does not make the EECA process mandatory, however, other federal approaches will be needed to ensure that states develop comprehensive plans. In this event, DOT should lead the federal effort.

DOT might adopt several strategies regardless of DOE action concerning EECA. At a minimum, DOT should make the development of state transportation energy conservation and contingency plans a condition for its funding of state-sponsored transportation projects. In addition, DOT should require states to designate lead agencies at the local level to coordinate the design of locally based plans for individual transit, paratransit, and ridesharing services.

With new statutory authority, DOT could require that each state prepare a conservation and contingency plan that includes a basic package of actions to reduce energy consumption. Possible elements of this mandatory package might include the following:

1. A broad public information program to encourage energy-efficient automobile travel and encourage public use of transit, paratransit, and ridesharing services;
2. Programs to ensure that carpools, vanpools, transit, and paratransit vehicles have access to fuel during shortages (assuming, of course, that DOE's fuel allocation program expires on schedule in September 1981); and
3. Programs to expand public use of transit, paratransit, and ridesharing services during shortages (e.g., state implementation of a network of park-and-ride lots, high-occupancy-vehicle lanes, as well as a state carpool and vanpool program).

DOT might also urge states to develop a comprehensive program to reduce transportation energy consumption by state employees as well as programs to reduce automobile travel and queues at the pump (e.g., increased parking and toll charges, sticker plans, and employer-based travel reduction strategies). DOE, however, probably is the proper source of a federal requirement that states adopt these strategies.

Federal pressure on the states by either DOE or DOT will not be adequate for the task of preparing the nation for future fuel shortages in the transportation sector. For this reason, it is recommended that DOT take steps to require local conservation and contingency planning efforts regardless of DOE actions concerning the EECA process. Specifically, it would seem wise for DOT to mandate that all MPOs and federally funded transportation providers develop conservation and contingency plans. DOT should make the preparation of these plans a condition for its funding of local transportation projects. If DOT wished to take particularly strong action, the agency might require that the plans of local transportation providers include actions that will enable these providers to accommodate specified increases in demand that could result from fuel shortages of different severity (e.g., increases in demand of 10, 20, and 50 percent).

To encourage states and localities to prepare high-quality plans and to ensure that these plans can be implemented, DOT might ask Congress to appropriate new monies that are specifically designated for energy-related efforts. Some of this money could be devoted exclusively to planning. Equally important, however, is the creation of a federal emergency fund that states and localities can tap during a fuel shortage to expand their transit, paratransit, and ridesharing services and to operate other contingency programs.

Finally, it would seem wise for DOT to continue its efforts to publicize the most effective types of contingency strategies and the best examples of state and local conservation and contingency plans.

All of the preceding recommendations explicitly involve strong federal action to ensure that energy planning in the transportation sector receives high priority from both state and local officials. More important, the top-down approach that is recommended here is designed to eliminate many of the institutional impediments to conservation and contingency planning that currently exist at state and local levels. Through the substitution of strong federal requirements for a decentralized decision-making process, state and local debate over program priorities can be reduced and the focus can be shifted to action. Such an approach will force states and localities to extensively analyze service planning and restructuring issues instead of only major capital investments. A requirement that states and localities prepare conservation and contingency plans before DOT will approve funding proposals almost certainly will generate a constituency for the development of these

plans. Finally, this approach will add to the EECA message that states and localities are expected to play the leading role in future government responses to energy shortages.

DOT and DOE are not the only federal agencies that might play major roles in promoting or requiring emergency planning by states and localities. Others could also assume substantial responsibilities in this area. As noted earlier, however, major institutional obstacles to conservation and contingency planning exist at the federal level as well as within states and localities. The lack of a coordinated federal approach to energy emergency issues, however, poses a serious threat to the success of state and local planning efforts.

To achieve this coordination, several steps may be necessary. First, it may be highly desirable for DOT and DOE to conduct internal reviews of their own policies, programs, and regulations to isolate obstacles to coherent emergency action. DOT, for example, might review its current emphasis on providing new capital rather than operating assistance funds to transportation providers. The agency might examine its policies toward ridesharing and other low-capital transportation projects to determine if a separate funding category is needed for these projects. DOT might analyze the substantial number of planning requirements that MPOs and transit authorities must currently satisfy to determine which of these requirements makes sense in an environment characterized by unstable petroleum supplies and rising fuel prices. Various DOT regulations (e.g., Section 504, Section 13c, and Buy American requirements) deserve study with regard to their application during energy shortages.

For its part, DOE's funding of state and local energy projects may warrant some review to determine if these projects promote emergency preparedness. The agency might examine means by which essential activities, including mass transportation services, can be assured of access to fuel during shortages if DOE's fuel-allocation program is terminated in 1981. Various kinds of line-control measures should be studied to identify those that deserve particular DOE support in the event of another shortage.

If DOT and DOE can reach agreement on in-house changes that are needed to respond to the energy problem, they will be in a good position to ask other federal agencies to join with them in efforts to promote or require transportation energy conservation and contingency planning. At a minimum, the policies and programs of other federal agencies should be coordinated with those of DOT and DOE.

As one example of the usefulness of coordination, large private employers could be encouraged to develop conservation and contingency programs as part of broader local energy activities if (a) the Office of Management and Budget provided tax credits to employers who fund such programs, (b) the Internal Revenue Service determined that these programs do not constitute taxable fringe benefits for employees, (c) the Environmental Protection Agency required employers to prepare these programs in conjunction with local efforts to reduce air pollution, (d) the U.S. Department of Defense required its major contractors to develop these programs, (e) the U.S. Department of Housing and Urban Development funded only those land use developments for employers (e.g., industrial parks) that minimize energy consumption, (f) DOE encouraged states to require employers to implement conservation and contingency plans as part of state-sponsored EECA plans, and (g) DOT and DOE provided special funds to states and localities so that they could provide transportation services or technical assistance to employers.

Of course, coordination of federal policies and programs (and revision of these policies and programs where necessary) will be a lengthy process. Since the arrival of a fuel shortage will leave no time for extended deliberations, it would be most beneficial if the federal government began this coordination effort immediately.

REFERENCES

1. R. Shriver Associates. Evaluation of the Gasoline-Allocation Program. Office of Policy and Evaluation, U.S. Department of Energy, Draft Final Rept., Dec. 1979.
2. Emergency Stockpiling of Buses. Urban Mass Transportation Administration, U.S. Department of Transportation, Notice 9300.1, June 20, 1979.
3. Interim Guidelines, Bus Rehabilitation Program. Urban Mass Transportation Administration, U.S. Department of Transportation, July 9, 1979.
4. State Energy Emergency Response Measures: A Recent Survey. National Governors Association, Washington, DC, July 6, 1979.
5. The Gasoline Shortage and the Cities. U.S. Conference of Mayors, Washington, DC, June 27, 1979.

Background Information: Gasoline-Rationing Plan

Edwin J. Curle

To better enable the United States to deal with future energy shortages, the U.S. Congress passed the Emergency Energy Conservation Act of 1979. This act requires that a gasoline-rationing plan be developed. The gasoline-rationing plan would not be put into effect unless a serious energy supply crisis occurs.

After the plan is formally submitted to Congress, Congress has 30 days to review it. Unless a joint resolution of disapproval is enacted, the plan would be considered approved and would then remain in standby status.

Rationing would not be imposed unless the President finds that a 20 percent shortfall exists or is likely to exist for at least 30 days. The President must notify the Congress of his finding together with a request to implement rationing. Either house of Congress may then disapprove the President's decision within 15 days. If the President finds it necessary to impose rationing with a less than 20 percent shortfall, both houses of Congress must approve its implementation.

The President, by executive order, has delegated the authority to develop the standby gasoline-rationing plan to the U.S. Secretary of Energy. DOE has issued a proposed plan for public comment. Features of the proposed plan are discussed here briefly.

RATION ENTITLEMENTS

Eligibility for ration allotments would be determined on the basis of motor vehicle registration records. The calculation of ration coupons issued within each state would be in proportion to the state's base-period use of gasoline; thus, the degree of shortfall would be equally shared among the states. Supplemental allotments would be granted for certain priority activities to ensure the maintenance of essential public services. Supplemental allotments would also be granted to businesses and government organizations with significant off-highway gasoline requirements.

Although initial allotments to firms would be vehicle-based, supplemental allotments that reflect historic use would be provided as soon as practicable after the start of rationing. State and local rationing offices, established by state and local governments, would provide supplemental

allotments to hardship applicants. Responsibility for providing supplemental allotments that take into account the mobility needs of the handicapped would be delegated to the state and, in turn, to local offices by the states.

PRIORITY CLASSES

Priority status would be limited to activities that provide for national security, public transportation, protection of public health, safety and welfare, energy production, and maintenance of telephone and telecommunications services. Special status would also be given to farmers, who would receive sufficient allotments adequate to fully meet food and fiber production goals approved by the President.

RESERVES

State ration reserves would be established in each state for use by state and local offices in issuing hardship allotments. States would have considerable discretion in the use of their ration reserves, subject to limited DOE standards and guidelines. The responsibilities of state and local governments would increase in accordance with their capability and willingness to handle them, with the state ration reserves increased accordingly. DOE would establish and maintain a National Ration Reserve for use in meeting special national emergency needs and for such other purposes as DOE found necessary.

ISSUANCE OF RATION ALLOTMENTS

Ration allotments would be issued in the form of government ration checks, which would be exchanged for ration coupons at designated coupon-issuance points. These checks would be issued in advance of each ration period, with the allotment amount printed on the check. DOE or the states would issue supplemental allotment checks for priority activities, farms, and other eligible firms. Checks would also be issued to states for their ration reserves.

COUPONS

DOE might adopt simplified procedures for establishing coupon eligibility (such as accepting walk-in applications) if it were necessary to impose rationing before the necessary preparatory measures had been completed. DOE would enlist the participation of a variety of qualified organizations as coupon-issuance points. These organizations would be supplied with coupons by DOE and would serve as ration-check-cashing points for recipients of government ration checks. Different series of coupons would be distributed. For each series, DOE would establish the date at which it becomes valid. Coupons would be valid until used, or until the end of the rationing program.

DOE would permit the sale or transfer of ration coupons on a voluntary basis. DOE would impose no price controls or other controls on this market, except as may be necessary to prevent activities disruptive to the rationing program.

RATION BANKING

Individuals and organizations would open ration banking accounts at participating ration banks, subject to DOE regulations concerning these accounts. Account holders could deposit valid coupons or ration checks to their accounts and could write ration checks against their accounts. Gasoline suppliers could open redemption accounts at ration banks. These redemption accounts would be used for deposit of redeemed (or canceled) ration coupons and ration checks received by the supplier in gasoline sales. These suppliers in turn would write checks on their redemption accounts to pay their suppliers for resupply of gasoline.

Economic Allocation of Gasoline Shortages

Carmen Difiglio

The purpose of this paper is to evaluate ways of restoring economic allocation of gasoline supplies if severe interruptions of U.S. petroleum imports occur. Cost and benefits of gasoline price controls, taxes, rationing, and the time required to implement each approach will be estimated. Each plan will be defined and evaluated in terms of its likely impact on the gasoline market and the equity provided for gasoline consumers. The costs and benefits provided in this paper are necessarily based on certain assumptions, especially in terms of the degree of shortfall, the price elasticity of demand for gasoline, and other aspects of consumer behavior in the face of a shortage. However, the conclusions reached would survive a wide variation of assumptions used to calculate the various costs and benefits. In addition, the waste implied by mismanaging a severe gasoline shortage is enormous—at least $75 billion annually or more. Therefore, we cannot afford to be casual about how gasoline shortages are dealt with. As discussed below, existing public opinion on this issue and the conclusions reached in this paper are entirely at variance with each other.

Much of the controversy regarding gasoline problems results from a wide difference of views as to what causes them and who is responsible. However, since the Iranian and Afghanistan crises, there is a growing realization that our future supply of Persian Gulf petroleum is not secure and that some external and uncontrollable event could interrupt or terminate a significant proportion of U.S. petroleum imports.

Approximately 25 percent of the petroleum consumed in the United States is imported from Persian Gulf suppliers (1, pp. 5-9 and 5-22). If the supply of Persian Gulf oil were interrupted, considerably more than 25 percent of our normal oil supply would be unavailable because of increased worldwide demand for the exports still produced by suppliers outside of the Persian Gulf. If supplier countries rationed out the remaining petroleum, the United States could experience up to a 40 percent reduction in available petroleum (1, pp. 5-9 and 5-21).

Political scenarios that result in a substantial proportion of Persian Gulf oil being withdrawn from the world market are all too easy to imagine. These scenarios can involve domestic upheavals similar to what has occurred in Iran or can involve aggression as in Afghanistan (although not an oil producer, it is in the same geographic area). In addition, foreign intervention may help destabilize existing supplier-country governments by supporting revolutionary movements. Regardless of exactly how such upheavals may occur, future events could result in a loss of oil exports from major supplier countries. Also, the supply interruptions may not be of short duration. Changes in political regimes could result in an indefinite reduction of production (while providing more than adequate foreign exchange). Any serious violence in the area could result in the destruction of production or transshipment facilities that would eliminate exports for several years, possibly even a decade.

The possibility of a severe drop in petroleum supply concerns the transportation sector more than any other component of the economy because transportation is an

energy-intensive activity that depends almost completely on petroleum as an energy source. Consequently, about 54 percent of total U.S. petroleum demand is used by the transportation sector (1, p. 2-15). About 30 percent of this petroleum demand is used as gasoline in passenger cars (1, p. 2-15). The message is clear: If a severe interruption in petroleum supply occurs, one of the most significant policy problems facing the United States is how to allocate scarce supplies of gasoline and diesel fuel to consumers. If this policy problem is solved for the transportation sector, only 46 percent of the problem is left to the remaining economic sectors. Also, the remaining sectors have a substantial capacity to switch from one fuel to another—for example, from oil to natural gas for buildings, from oil to coal for electric utilities, and from oil to coal or natural gas for industrial processes. Opportunities for fuel switching in the transportation sector are relatively limited and are virtually nonexistent in the short term.

In order to calculate various costs and benefits, a 30 percent shortfall of gasoline is assumed—a level that could correspond to a major catastrophe in the Middle East. Only gasoline will be considered in this paper because the focus of the analysis will be on the private automobile and not on the commercial sector. A more precise and comprehensive analysis would include both gasoline and diesel fuel use by the private and commercial sectors. The number of private automobiles that use diesel fuel is increasing, and the commercial sector uses a substantial amount of gasoline. However, for the level of analysis to be presented here, we will assume that preemergency consumption is 7 million bbl/day of gasoline by private end-users (i.e., cars and trucks) and that only 4.9 million bbl/day will be available within two or three months after some precipitating event (2).

GASOLINE SHORTAGES

A gasoline shortage results from a specific chain of events that would normally begin with a major reduction of petroleum supply. However, any given reduction in petroleum supply is insufficient in and of itself to cause a gasoline shortage. As is illustrated by the gasoline shortages of 1973-1974 and 1979, interference with market-clearing processes is required before shortages of gasoline result. A severe reduction in petroleum availability results in reduced gasoline production at the refinery. In the past, DOE regulations have caused larger declines in gasoline production than might have otherwise occurred because the public policy was based on ensuring adequate heating oil reserves. Sharp decreases in gasoline production result in allocation of motor fuel to jobbers and retailers in accordance with DOE allocation regulations. When gasoline supplies are sufficiently tight, retailers either start running out of their monthly quotas of gasoline or restrict their hours of operation. Consumers are unable to purchase the gasoline they want at the controlled price (according to DOE price regulations), and queuing occurs as a way of rationing the shortage of gasoline. Service stations are not legally able to increase the price of gasoline to allow sales of supplies without queues. Otherwise, increases in the retail price of gasoline would suppress demand until queues and the gasoline shortage disappeared.

A gasoline shortage represents an imbalance of supply and demand at the controlled price. The purpose of the controlled price is to significantly reduce the windfall profits that would accrue to the petroleum industry when shortage conditions occur. If price controls were not used, a sharp reduction in gasoline availability would cause substantially increased revenues to the petroleum industry. (The effects of the Windfall Profits Tax are not discussed in this paper in order to simplify the analysis. However, the tax is considered in Appendix D.) The reduction in the volume of gasoline sales that results from a supply interruption would cause a loss in gross revenue if the price of gasoline did not change. However, the change in the price of gasoline is so severe that supply interruptions cause a dramatic increase in revenue from gasoline sales. A review of several models of gasoline demand (3-9) suggests that the short-term price elasticity of demand for gasoline is between -0.10 and -0.30. An elasticity of -1.0 would be required in order for sales revenue to remain constant after a supply interruption. Assuming the midpoint price elasticity (i.e., -0.20), the petroleum industry would receive $101 billion more annual revenue without price controls than with price controls on their domestic gasoline sales. My calculation also assumes that U.S. price controls are set to maintain an unchanged gross revenue from gasoline sales before and after a supply interruption of 30 percent. This assumption is used to approximate the DOE price control set after consideration of postemergency crude oil acquisition costs and the allowable cost and profit margins for refining, wholesaling, and retailing of a significantly reduced supply of product. It is not suggested as a criterion for establishing price controls.

With these assumptions, the price of gasoline would be $1.34/gal higher without price controls than with price controls. (See Appendixes A and B for a discussion of price elasticities.) Therefore, the immediate benefit of price controls to consumers is to sharply reduce their expenditures for gasoline. Of course, because price controls prevent an income transfer, there is also an income loss to the petroleum industry equal to the consumer benefit that results from lower prices. Unfortunately, price controls have not only effected an income transfer of $101 billion from producers to consumers but have also caused a shortage of gasoline—an imbalance of supply and demand. As the recent and relatively minor shortages of gasoline have demonstrated, the consumer is hardly immune to the consequences of a shortage and must also assume a substantial cost in addition to the substantial benefits provided by price controls.

COST OF SHORTAGES

The cost of a gasoline shortage is represented by the loss of the market-clearing process that is inherent to uncontrolled markets. This is not to say that a perfectly competitive market exists for gasoline or for any other commodity. It is simply a theoretically sound and empirically verified observation that uncontrolled markets are characterized by product availability to all consumers who wish to purchase at the available price. Although specific instances of product shortage have occasionally occurred in uncontrolled markets, they are generally the result of a price control imposed by manufacturers in anticipation of increasing production to meet unexpected product demand. This behavior results from the desire of a manufacturer to maintain relatively stable prices during a temporary period in which product demand and anticipated demand are seriously imbalanced. Product introductions provide several examples of these voluntary shortages such as those that occurred in 1970 and 1971 after the introduction of the Datsun 240Z sports car.

Although uncontrolled markets are characteristically in balance (i.e., market clearing), controlled markets are characterized by conditions of shortage when the controls result in lower-than-market-clearing prices. Rent controls provide the classic example of the controlled market in which shortage conditions are indefinitely perpetuated. As the rental market has amply demonstrated, price controls are a mixed blessing to renters. Apartments under rent control are typically hard to find and waiting in line becomes the prevailing requirement to get one. The product is rationed by one's willingness to wait rather than by what one is willing to pay.

We have already calculated the benefit to consumers of not having to pay higher prices. But what about the cost? Something tangible has been lost when markets do not clear. One either waits or pays some black-market price to move up in line. Based on the recent gasoline shortages of 5-10 percent that occurred in many urban areas, an across-the-board 30 percent shortage is estimated to result

in an average waiting time of 2 h. If personal time were valued at $4.00/h, approximately $60 billion of time will be lost in queues waiting to buy gasoline.

In addition to lost time, there will also be lost gasoline: 325 000 bbl/day will be used up idling in queues (10). (No data exist regarding the waiting times experienced during the 1973-1974 and 1979 gasoline shortages. My personal observation was that, while Washington, D.C., experienced a 10 percent shortage, waiting times of about 1 h were typical. A 30 percent shortage is conservatively estimated to produce an average 2-h wait time, all other things being equal. The $60 billion estimate of the lost value of waiting time is offered as a conservative estimate of the economic loss to individuals represented by the opportunity cost of the time lost waiting in queues.) To put this loss into perspective, the mandatory fuel economy standards are estimated to provide a saving of 380 000 bbl/day by 1985 (11). Therefore, the likely waste of gasoline from a gasoline shortage is nearly equivalent to the fuel saving in 1985 provided by the most significant transportation conservation program in place in the United States. In addition, the estimated market value of the wasted fuel is $16 billion annually.

The full cost of gasoline shortages is hard to quantify. Thus far, estimates have been made of the easiest costs to quantify. They are summarized in the following list, which identifies the annual costs and benefits to consumers, producers, and society that result from price controls after the assumed supply interruption:

1. Benefit to consumers resulting from lower, controlled gasoline prices, $101 billion/year;
2. Loss to petroleum industry resulting from controlled gasoline prices, $101 billion/year;
3. Value of waiting time lost in gasoline queues, $60 billion/year;
4. Value of wasted gasoline, $16 billion/year;
5. Net social cost, $76 billion/year; and
6. Percentage of income transfer to consumers lost in waiting lines, 75 percent.

The direct benefits to consumers and losses to producers resulting from gasoline price controls are exactly equal. However, because the loss of the market-clearing process has caused additional consumer costs, the net social cost of gasoline price controls implied by the above list is $76 billion annually. This figure is conservative and does not include these potential costs: (a) the loss in capital value of the automobile stock as a result of shortage conditions, (b) the opportunity costs of activities that could no longer be planned due to uncertainties in acquiring gasoline, and (c) the economic losses to individuals who depend on automobile transportation for their work. It is entirely possible that inclusion of these costs could raise the cost of a shortage to more than 100 percent of the income retained by consumers and kept from the petroleum industry. The loss of the market-clearing process causes costs that are so large that one need not have a precise estimate of them to realize how unacceptably high they are. A transfer of $101 billion of wealth from oil producers to oil consumers can be more efficiently accomplished than at a higher-than-75 percent deadweight loss. The U.S. economy cannot afford the waste of $76 billion or more annually in gasoline queues. In order to prevent such waste, it is necessary to restore the market-clearing process.

REESTABLISHING ECONOMIC ALLOCATION

There are several scenarios that would restore an economic allocation of the shortfall and avoid the waste associated with a severe gasoline shortage. Decontrol of gasoline and petroleum would restore the market, but gasoline consumers would lose an additional $101 billion. Many would, doubtless, prefer to pay their money and get their gasoline, while others would rather pay less and put up with the inconvenience of the shortage.

Alternatives to these two scenarios are only vaguely understood. We have learned about price controls and gasoline shortages and can readily envision higher prices without lines, but ways of avoiding shortages and preventing the petroleum industry from reaping a huge windfall profit in the midst of a national emergency are available. Policies to prevent windfall profits without the loss of the market process to distribute gasoline include the following:

1. Administratively determined gasoline tax ($1.34 estimated for a 30 percent reduction in gasoline availability)—Revenues from this tax would be used to reduce other taxes;
2. Administratively determined gasoline tax with rebate—Revenues from this tax would be rebated to the public according to some entitlement criteria (e.g., equal distribution to all persons 16 years or older, equal distribution to all licensed drivers, proportional—i.e., one share per vehicle—distribution to all vehicle owners, and other variations); and
3. Gasoline rationing with white market—This plan would have the same entitlement criteria as the administratively determined gasoline tax with rebate.

There are also policies that can eliminate gasoline lines. However, these do not restore the market process to gasoline distribution: (a) strict gasoline rationing (no white market), (b) restrictions on motor fuel purchases (e.g., use of license digit schemes), (c) still days for automobiles (the sticker plan), and (d) other contingency plans that restrict the use of the automobile. These four policies can prevent queues but only by strictly allocating gasoline entitlements to individuals or by imposing other restrictions on personal behavior relating to the use of the automobile. Instead of restoring the market process, they shift the control of gasoline prices to direct control of gasoline purchasing (strict rationing) or employ proscriptions on behavior that reduce gasoline demand. The sticker plan is a good example of this. Automobiles would have windshield stickers that identify the days of the week on which the vehicle is permitted to operate. Thus, gasoline demand can be reduced sufficiently to eliminate gasoline queues even though a market process is not really functioning. For example, under the sticker plan individuals who value or require more-than-average driving cannot buy extra traveling privileges, as they would be able to buy extra ration coupons or to pay increased excise taxes—two actions that would permit the "purchase" of extra travel. Therefore, while gasoline lines would be eliminated, new inefficiencies would have been introduced by directly mandating personal behavior. Individuals who require an automobile for their livelihood either have to reduce travel and therefore income or have to appeal to the bureaucracy to receive special privileges not accorded others. Therefore, the impact of these policies on personal income can be significant, whereas market processes always insulate such individuals from a monetary disadvantage larger than the increased price of gasoline. A plan that simply eliminates mobility causes direct personal losses that are often larger than the waste caused by waiting in line. As bad as gasoline queues are, they do provide an upper limit on the cost of the gasoline shortage to individual users. The monetary losses to individuals who are denied access to transportation in specific situations can be far larger than from waiting in line.

A detailed analysis of plans that do not restore market processes will not be provided in this paper. Because one or more alternative public policies can restore market processes while providing a wide range of desired income-distribution objectives, plans that shift the shortage from one arena (purchase of gasoline) to another (use of the vehicle) are not required and are not constructive.

Before exploring the aggregate economic benefits of alternative gasoline-allocation plans, it is important to address the income and equity objectives that the plans should fulfill. The three plans reviewed here include two

types of gasoline rationing and a gasoline tax with rebate. Rationing is often perceived as a nonmarket mechanism for providing a fair share of gasoline to all users. In order to achieve this objective, rationing would somehow allow each driver to still travel a constant percentage of his or her current travel level at no increase in cost. However, ration coupons could never be distributed in such a way as to achieve this objective. In order to do so, all drivers would have to be surveyed and some procedure developed for verifying their responses. Any feasible distribution scheme will result in some individuals receiving far too many coupons for their needs, while others receive far too few. Therefore, a market is required that allows drivers to purchase extra coupons or realize income on coupons that individuals do not want to spend on travel.

The equity of this market ultimately depends on how resources with which to participate in the market are distributed. Under rationing, coupons are negotiable whether permitted or not. If this is accepted and coupons are openly allowed to be negotiable, then ration coupons and money would become close substitutes for each other in that they would function as currencies or negotiable assets. Therefore, the resources that individuals have to participate in the gasoline market are the income and assets they normally have plus the additional distribution of gasoline ration coupons or gasoline tax rebates. No gasoline-allocation scheme can change the fact that high-income people will have the resources to maintain travel if they choose to, while low-income people will be substantially more constrained and will face more difficult trade-offs between travel and other needs. The impact on equity derived from alternative gasoline-allocation plans is completely dependent on how they affect the net-income position of individuals. Allocation plans cannot be evaluated in terms of the fairness of the distribution of gasoline because they do not distribute gasoline but rather the economic resources with which to purchase gasoline. Both the rationing and tax with rebate plans provide recipients with purchasing power either in the form of ration coupons or gasoline tax receipt rebates. The ultimate distribution of gasoline to consumers depends on their original purchasing power, the extra purchasing power derived from the allocation plan, and the trade-offs consumers will make among their demands for mobility, other goods and services, and savings. Therefore, the equity of the plans to be reviewed is independent of all their characteristics except how they affect the purchasing power of individuals. The gasoline tax with rebate is neither more nor less equitable than the rationing of negotiable coupons unless coupons and tax rebates are distributed differently. The equity of alternative-distribution criteria will be reviewed in the following section of this paper.

GASOLINE TAX WITH REBATE

Gasoline taxes can be used to suppress the demand for gasoline. When shortage conditions occur, large gasoline taxes would be required to suppress gasoline demand sufficiently in order to reduce the market price received by retailers to levels that prevent large windfalls to the petroleum industry. Large gasoline taxes are required because of the low price elasticity of demand for gasoline. This is illustrated in Figure 1. Before a shortfall occurs, consumers are using Q_1 gasoline (107 billion gal/year) at price P_1 ($1.25/gal). Before shortfall conditions occur, the gasoline market is providing equilibrium between supply and demand without imposing any nonprice costs on consumers (gasoline lines).

When a shortfall occurs, the supply of gasoline shifts from S_1 to S_2. The new market-clearing price is now P_2, substantially above the allowed price P_c ($1.79/gal). The quantity of gasoline available at price P_1, P_c, or P_2 is approximately Q_2 because the supply curve of gasoline is assumed to be quite inelastic. Although the supply of gasoline would be larger at P_2 than at P_c or P_1, the differences are not likely to be large enough to affect the analysis and Q_2 is assumed to be the quantity of gasoline supplied at price P_1, P_c, or P_2. (Appendix E discusses the elasticity of the supply of gasoline.) Therefore, all of the market-clearing process has to occur on the demand side. In an uncontrolled market, this would occur with a price rise to P_2 ($3.13/gal) where the amount supplied and the amount demanded were both equal to Q_2. However, with price controls, only P_c can be charged and Q_c-Q_2 more (22.6 billion gal/year) is demanded at price P_c than is supplied (a 23 percent shortfall).

A large tax on gasoline that results in an after-tax price of gasoline of P_2 would just eliminate the shortage of demand (Q_c-Q_2) and force the market-clearing price to P_c at quantity Q_2. This is illustrated in Figure 2. The demand curve D_1 is lowered to D_T by the vertical distance P_2-P_c, which equals the gasoline tax. By using the midpoint estimate of the price elasticity of gasoline (-0.20) and by assuming that $P_1 = \$1.25$/gal, a $1.34/gal tax would be required to reduce the amount demanded from Q_c to Q_2. The gasoline retailer receives P_c.

The gasoline tax has restored the market-clearing process and has prevented a transfer of $101 billion from gasoline consumers to the petroleum industry. Instead, consumers have paid their government $101 billion more in federal gasoline taxes. The original objective of the price control of P_c was to prevent the $101 billion income transfer to the petroleum industry from gasoline consumers. Imposition of a $1.34/gal gasoline tax would shift the income gain of the petroleum industry to the federal treasury instead of gasoline consumers and simultaneously eliminate the consumer costs of the gasoline shortage by doing away with the shortage itself.

Rebates of gasoline tax revenues can be used to shift the income transfer from consumers to the federal treasury back to consumers. However, the income received by the treasury cannot be distributed back to consumers in exactly the way it was received. If it were, the tax would not have any demand-reducing effect. The rebate must be distributed to consumers by using some criteria that is independent of the amount of gasoline tax that individual consumers pay. Therefore, the marginal cost of the first and last gallon of gasoline purchased by individuals is independent of any rebate received.

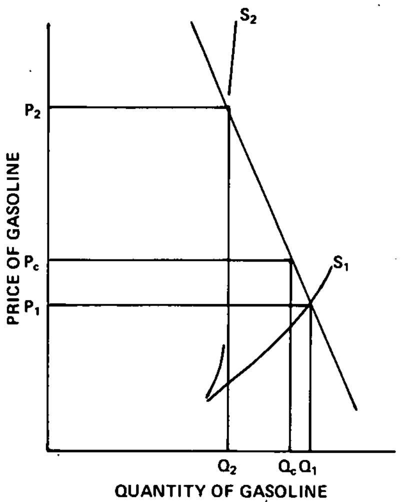
The use of rebates with a gasoline tax can accomplish the overall objective of gasoline price controls without the huge deadweight loss caused by gasoline shortages. Consumers as a group would receive the increased gasoline tax payments in the form of rebates. Although gasoline users will have to pay a much higher price at the pump (P_2 in Figure 2), the average consumer will also receive his or her increased gasoline tax payments in rebates. Consumers face a market-clearing price and avoid the costs of shortage but do not experience any loss of net income. Specific consumers may receive more rebates than taxes paid or less rebates than taxes paid. The exact relation between taxes paid and rebates received will depend on the rebate-distribution scheme and how much gasoline a person uses.

Rebates can be provided in several ways. The more obvious approaches include an equal distribution of rebate revenues to all—persons over 16 (potential automobile users), licensed drivers, and vehicle owners. In addition, rebate revenues can be increased to residents of high-use states so that the revenues generated within a state are distributed there. The usefulness of the gasoline tax with rebate is independent of the particulars of rebate distribution so long as the particular method chosen is workable and can be implemented without unnecessary costs and delays. Therefore, complicated rebate schemes that attempt to make rebates proportional to a specific need for gasoline by consumers are not recommended. Such action would require unavailable data regarding the specific circumstances of all individuals. In addition, consumers as a group do not benefit by rewarding high-volume gasoline users with extra shares of tax rebates—more tax rebates for

high-volume users mean less tax rebates for moderate- and low-volume users.

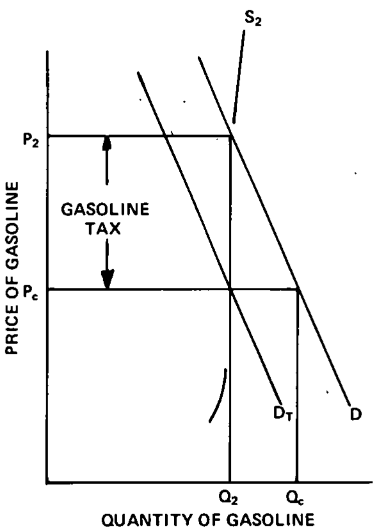
Of the three rebate mechanisms identified above, equal rebates to all adults would be the simplest to administer and would be the most progressive scheme among consumers by income groups. For these reasons, it is used to estimate the costs and administrative requirements of a gasoline tax rebate system. However, other rebate systems could be used if there were some compelling reasons to do so.

Figure 1. Relation between gasoline price and quantity.



Q_1 = 107 x 10^9 gal/year P_1 = \$1.25/gal
Q_c = 98 x 10^9 gal/year P_c = \$1.79/gal
Q_2 = 75 x 10^9 gal/year P_2 = \$3.13/gal

Figure 2. Impact of gasoline tax on price and availability.



GASOLINE TAX = P_2-P_c = \$1.34/gal
Q_c = 98 x 10^9 gal/year P_c = \$1.79/gal
Q_2 = 75 x 10^9 gal/year P_2 = \$3.13/gal

Equal rebates to all adults would tend to transfer income from high-income consumers to low-income consumers. A \$1.34/gal gasoline tax would result in a \$382 rebate (annually) to each adult and a \$932 rebate to each household. (It is assumed that 70 percent of gasoline taxes is collected from noncommercial users and rebated to households.) As shown in Table 1 (derived from unpublished data from the 1977 nationwide personal transportation survey conducted for FHWA by the U.S. Bureau of the Census), low-income households pay substantially less in increased taxes than high-income households. Households in the lowest income category (\$0-\$5999) will gain \$329 net annual income, while the highest income category (more than \$50 000) will lose \$978 net annual income. High-income households are paying more in increased taxes than they are receiving in rebates, while low-income households are paying less in increased taxes than they are receiving in rebates. This is not to say that all low-income households will benefit and all high-income households will lose. Specific instances of hardship or windfall will occur in all income groups or within almost any other socioeconomic classification. More-complicated rebate-allocation schemes would not eliminate these instances but would distribute them differently.

The administrative requirements of a gasoline tax and rebate program are very modest. Gasoline taxes are currently collected by state and federal bureaucracies that are in place. No significant cost could be incurred by increasing the federal tax from \$0.04/gal to \$1.34/gal. The proposed gasoline tax would have to be administratively determined, and occasionally changed, to maintain a given level of income to the petroleum industry under prevailing market conditions. Therefore, some increase in the tax-collection bureaucracy may be required in order to change gasoline taxes every month or so. While the level of income transfer cannot be assured in any particular month due to the uncertainties of estimating supply and demand, the errors accumulated over a year could be averaged out by using a sequential tax-setting strategy. The annual income allowed the petroleum industry can be controlled by adjusting gasoline taxes—and without any gasoline price controls and the costs of shortages created by them. (This issue is explored further in the section on Accounting for Uncertainty and Appendix B—Reliability of Price Elasticity Estimates.)

The rebate system will require substantially more administrative effort than the imposition of a gasoline tax. Fortunately, new bureaucracies do not have to be created. The U.S. Internal Revenue Service (IRS) can be used to distribute gasoline tax rebates. If the withholding system is used by the IRS, most rebate recipients would be paid without any additional check-distribution expenses. Tax forms would be slightly modified, and each taxpayer would establish rebate status in the context of his or her annual tax return. Approximately 85 percent of eligible rebate recipients can be served via the withholding system (12). Some 50 percent of the remaining rebates could be handled

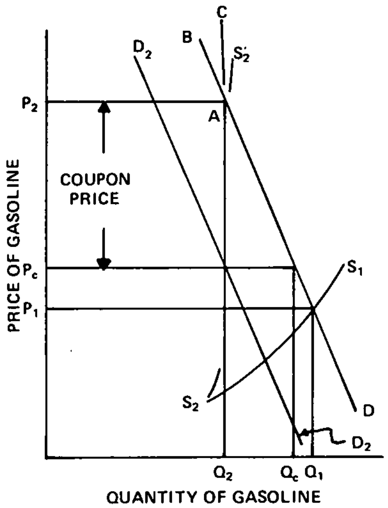
Table 1. Net annual income effects of a \$1.34/gal tax on gasoline with an equal rebate of revenues to all adults.

	Net Annual Income Effect by Income Group (1977 dollars)					
Factor	0-5999	6000-14 999	15 000-24 999	25 000-34 999	35 000-49 999	50 000+
Tax paid per household	382	1016	1570	1895	2055	2059
Rebate received per household[a]	711	917	1085	1150	1127	1081
Income transfer per household	+329	-99	-485	-745	-928	-978

Note: Adult persons are defined as all individuals 16 years or older. It is assumed that 70 percent of gasoline taxes is collected from noncommercial users and distributed to all adult persons.

[a]Average rebate per household = \$932/year.

Figure 3. Illustration of the prevailing market condition that results from a successful gasoline-rationing system.



DEMAND CURVE FOR GASOLINE		SUPPLY CURVE FOR GASOLINE
Without Rationing:	BD	$S_2(S_2')$
"Fixed-Quantity" Rationing:	BAQ_2	S_2AC
"Fixed-Price" Rationing:	D_2	$S_2(S_2')$

$Q_1 = 107 \times 10^9$ gal/year P_1 = \$1.25/gal
$Q_c = 98 \times 10^9$ gal/year P_c = \$1.79/gal
$Q_2 = 75 \times 10^9$ gal/year P_2 = \$3.13/gal

by using other federal disbursements, such as Social Security or Health and Human Resources accounts (12). This would leave less than 10 percent of rebate recipients who would have to establish new reporting relations in order to receive rebate checks. This group could do so simply by filing an amended 1040A short form.

Based on the above-described distribution system, full implementation of rebates would require less than six months. Approximately 85 percent of adults would receive rebates within one month (via modified withholding), 93 percent within three months (via Social Security and Health and Human Resources payments), and the remaining group within six months (via new reporting relations). If interest were paid on delayed rebates, the equity of such an approach would be improved.

The estimated cost of the gasoline tax and rebate system outlined above is less than \$100 million annually and is as close to being administratively certain as possible (13). That is, the tax-rebate scheme requires bureaucratic operations that are very similar to ongoing activities and do not require substantial increases in the size of existing bureaucracies.

GASOLINE RATIONING

Another approach to reestablishing market equilibrium is to institute gasoline rationing. The term gasoline rationing can cover several systems that appear very similar but actually are substantially different. One immediate distinction is between white-market gasoline rationing and the rationing of nonnegotiable coupons. The latter system does not reestablish market processes. Consumers who wish to travel more than their coupon allotment allows cannot enter a market and buy more gasoline. At least that is the official position. In actuality, an illegal market (black market) would provide consumers with market-clearing opportunities. If the inevitability of this illegal market is accepted, little is to be gained by imposing strict rationing. It will merely result in a market that is more costly and excludes individuals who are unwilling to purchase gasoline coupons illegally. A substantial motivation to purchase illegal coupons would often exist for individuals who require more-than-average amounts of gasoline for work-related travel or other travel thought to be essential. Therefore, such a system would probably criminalize a significant portion of the current law-abiding population.

If a disruption of gasoline supply occurs, gasoline rationing (white market) can prevent a transfer of income from consumers to the petroleum industry without resulting in shortage conditions (i.e., gasoline queues). However, certain conditions must be met in terms of bureaucratic accuracy and efficiency for rationing to be successful in reestablishing market-clearing processes.

The prevailing market condition resulting from a successful gasoline rationing system is illustrated in Figure 3. As in Figures 1 and 2, the interruption in gasoline supply is represented by the shift of supply from curve S_1 to curve S_2. The market-clearing price P_1 existed before the supply interruption, and the use of price controls would result in a 23 percent shortage of gasoline. If gasoline rationing that made Q_2 coupons available were implemented, the demand for gasoline would shift from D to BAQ_2, resulting in price P_2.

Because a white market exists for gasoline coupons, individuals can either purchase gasoline or sell their coupons for the prevailing price. If the white market were perfectly efficient, the cost of gasoline coupons would be P_2-P_c, which is \$1.34 according to our midrange price elasticity estimate. Note that under the assumed conditions, the coupon price under market-clearing rationing is identical to the gasoline tax that allows a market price to gasoline sellers of P_c (Figure 2). Therefore, the marginal cost of gasoline to consumers is identical (\$3.13) with either a gasoline tax or gasoline rationing; both satisfy the conditions identified in Figures 2 and 3. (Departures from these conditions are discussed in the next section, Accounting for Uncertainty.)

There are two important variants of negotiable coupon rationing. In the usual system, the government allocates all coupons to users and lets a private market handle the transactions of coupons among individuals. The supply of coupons is fixed at Q_2, resulting in a market-clearing price of gasoline to users of P_2. An alternative system is to have the government offer to buy and sell coupons at coupon price P_2-P_c in Figure 3 (\$1.34). Instead of moving the demand curve from D to BAQ_2, the latter rationing system establishes demand curve D_2. The government is prepared to sell or buy as many coupons as consumers want at price P_2-P_c. According to the assumed data, a coupon cost of \$1.34/gal would shift the demand for gasoline to D_2 and result in a market price to retailers of P_c (\$1.79/gal). [This second variant of rationing will be referred to in later sections of this paper as fixed-price rationing (demand curve = D_2) and the first type as fixed-quantity rationing (demand curve = BAQ_2). As with the gasoline tax, fixed-price rationing does not require any gasoline price controls. The level of income provided to gasoline suppliers is controlled by setting the price of coupons. Note that consumers would receive the same number of free ration coupons under either system.]

Gasoline rationing as shown in Figure 3 has established a marginal cost of gasoline P_2 (\$3.13/gal) and a price for retailers of P_c (\$1.79/gal). Often it is not realized that the true cost of gasoline is P_2, not P_c. Because coupons are negotiable and worth \$1.34/gal, their use to purchase gasoline raises the marginal cost of gasoline (i.e., price) from the pump price of \$1.79/gal to \$3.13/gal.

The price of gasoline has risen to the market-clearing level of P_2. Because of this, gasoline rationing has eliminated the shortage and its associated costs. The \$101 billion income transfer to the petroleum industry does not occur because its revenue per gallon is held at P_c—the price allowed by price controls. As with the above-described gasoline tax with rebate system, gasoline rationing restores market processes and achieves the desired withholding of windfall profits to the petroleum industry.

The equity impacts of gasoline rationing depend on the entitlement criterion used to distribute gasoline coupons. If gasoline coupons are distributed in the same manner as

Table 2. Net annual income effects of a gasoline-rationing system based on providing coupons ($1.34/gal) to vehicle owners on the basis of number of vehicles owned.

Factor	Net Annual Income Effect by Income Group (1977 dollars)					
	0-5999	6000-14 999	15 000-24 999	25 000-34 999	35 000-49 999	50 000+
Value of coupons used by households to purchase gasoline	382	1016	1570	1895	2055	2059
Value of coupons received by households[a]	482	915	1240	1421	1505	1571
Income transfer per household	+100	-101	-330	-474	-550	-488

Note: It is assumed that 70 percent of gasoline coupons is distributed to private households and the remainder to owners of commercial vehicles.

[a]Average value of coupons received by households = $932/year.

gasoline tax rebates, the equity impacts of gasoline rationing and the gasoline tax-rebate system are identical. For example, Table 1 indicates the estimated impact on households of a $1.34/gal tax redistributed equally to all adults. If, under gasoline rationing, coupons were made equally available to all adults, the income impact of rationing on households is also evident in Table 1. All households would receive an average value of $932/year because each coupon is negotiable at $1.34/coupon. Low-income households gain $329 net income annually, while high-income households lose $978 net income annually.

The current DOE standby gasoline-rationing plan provides ration coupons for each registered automobile. The distributional impact of this entitlement criterion tends to favor higher-income households somewhat more than does an equal adult entitlement. As shown in Table 2 (derived also from unpublished data in the 1977 nationwide personal transportation survey), the average value of coupons distributed to households is also $932/year. Low-income households gain $100 net annual income, while the high-income category will lose $488 net annual income. High-income households tend to buy gasoline coupons from lower-income households in order to sustain higher-than-average gasoline consumption. Of course, specific low- and high-income households could either be net purchasers or net sellers of coupons. On average, the per-vehicle coupon entitlement criterion is less progressive than a per-adult criterion but still results in a transfer of income from high-income households to low-income households.

The administrative requirements of gasoline rationing are not fully understood. An important uncertainty concerns the time required to authorize, appropriate, plan, hire, organize, and begin implementation of a ration-coupon-distribution system. One critical difference between gasoline rationing and gasoline taxes is that gasoline taxes can be implemented immediately but rationing cannot. Also, rebates of gasoline tax revenues can be rebated to 85 percent of the eligible population within a month by using withholding adjustments. In comparison, rationing requires that a coupon-distribution network be established before the system can be implemented. DOE is currently estimating that the standby gasoline-rationing plan will require one year to complete preimplementation after authorization and appropriation of $100 million. Once preimplementation is completed, DOE has established a 90-day mobilization goal. The estimated cost of the rationing system is between $2 billion and $4 billion per year and will involve 40 000 to 50 000 federal, state, and local employees (14). The reader can evaluate whether a 90-day period will prove sufficient to authorize and appropriate the funds, plan the bureaucracy, hire employees, establish procedures, procure contract services, and train 40 000 to 50 000 federal, state, and local employees. Every month of delay will result in an estimated $6 billion loss to consumers from waiting in gasoline queues.

ACCOUNTING FOR UNCERTAINTY

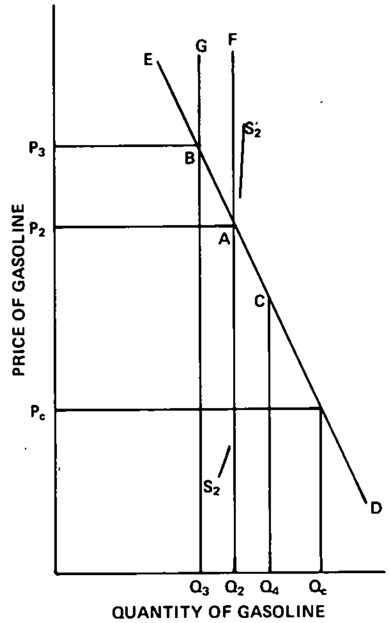
Gasoline taxes and gasoline rationing appear to produce identical market impacts. Each was estimated to result in a market-clearing price of $3.13/gal for 75 billion gal/year of gasoline sales. Each resulted in the same level of gross income to the petroleum industry as under price controls ($134 billion annually). Each prevented $101 billion additional revenue from accruing to the petroleum industry if gasoline price controls were eliminated without also implementing the tax-rebate or rationing systems. For gasoline-allocation plans to have the above-described market-clearing characteristics, it was assumed that the markets possessed perfect information, had zero transaction costs, and were in static equilibrium. In addition, the quantitative estimates of the market-clearing gasoline tax or coupon price depended on specific estimates of gasoline supply (Q_2 and Q_1), price (P_1), and the price elasticity of demand for gasoline (assumed equal to -0.20). Our purpose in this section is to acknowledge uncertainty, transaction costs, and disequilibrium, as well as their effects on the market-clearing process provided by each approach. Three specific approaches are defined:

1. Gasoline rationing with a fixed allocation of coupons, maintenance of price controls, and an uncontrolled white market for coupons (i.e., fixed-quantity rationing);
2. Gasoline rationing with government sales and purchases of ration coupons at an administratively determined price and elimination of price controls (i.e., fixed-price rationing); and
3. Administratively determined gasoline tax with revenue rebate and elimination of price controls.

The first uncertainty faced in managing a motor fuel shortage involves the magnitude of the shortage and the actual amount of gasoline available for distribution. Under fixed-quantity rationing, DOE would be required to issue ration coupons that allow the available gasoline to be purchased. As shown in Figure 4, Q_2 gasoline remains available after some supply-interrupting event occurs. Let us assume that Q_2 allows gasoline consumption of 4.9 million bbl/day (75 billion gal/year). However, let us also assume that DOE estimates Q_2 to be 10 percent lower and higher than it actually is. Under fixed-quantity rationing, instead of distributing coupons with which Q_2 gasoline can be purchased, DOE distributes coupons that permit Q_3 (10 percent less than Q_2) and Q_4 (10 percent more than Q_2) gasoline to be purchased at the controlled price P_c ($1.79/gal). As shown in Figure 4, these errors would result in a supply of coupons that allows either 67 billion gal/year to be purchased (Q_3) or 83 billion gal/year to be purchased (Q_4). Looking at the low-side error, Q_3 coupons would mean that only Q_3 gasoline would be legally sold. The cost of gasoline to consumers would rise from P_2 ($3.13/gal) to P_3 ($4.70/gal), resulting in a 50 percent increase in the price of gasoline. If gasoline production continued at Q_2 while only Q_3 could be purchased, transshipment and storage facilities would eventually fill up; this would force a reduction of gasoline refining to Q_3. The 10 percent DOE low-side error results in (a) making the economic cost of the gasoline shortage worse by allowing only Q_3 worth of mobility instead of Q_4 worth of mobility and (b) raising the price of gasoline by 50 percent. A 10 percent DOE high-side error would result in Q_4

worth of coupons being made available. The issued coupons would permit the purchase of 83 billion gal/year, even though only 75 billion gal/year is available—a shortage of 10 percent. The immediate result of this shortage would be gasoline queues. The ration coupon system would not reestablish a market-clearing process but would reduce the shortage from 23 percent of Q_c (23 billion gal/year) to 10 percent of Q_c (8 billion gal/year). The monthly cost of this error would be approximately $2 billion due to lost time and gasoline wasted in queues. Under the high-side error, the price of gasoline is indeterminate. The demand curve ECQ_4 intersects the supply curve S_2 at price P_2 and quantity Q_2; however, the coupon price P_2-P_c could not be sustained because there are Q_4-Q_2 more coupons available at P_2 than are required to purchase Q_2 gasoline (75 billion gal/year).

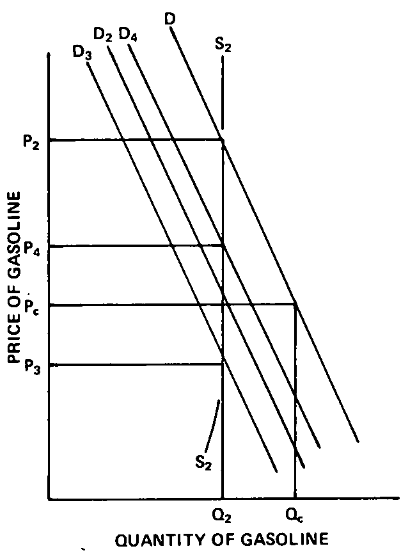
Figure 4. Incorrect coupon allocation based on fixed-quantity rationing.



DEMAND CURVE FOR GASOLINE		SUPPLY CURVE OF GASOLINE
Without Rationing:	ED	S_2 (S'_2)
With Q_2 Ration Coupons:	EAQ_2	S_2AF
With Q_3 Ration Coupons:	EBQ_3	Q_3BG
With Q_4 Ration Coupons:	ECQ_4	S_2 (S'_2)

Q_c = 98 x 10^9 gal/year P_c = \$1.79/gal
Q_2 = 75 x 10^9 gal/year P_2 = \$3.13/gal
Q_3 = 67 x 10^9 gal/year P_3 = \$4.70/gal
Q_4 = 83 x 10^9 gal/year

Figure 5. Incorrect price of gasoline given the fixed-price rationing or gasoline tax-rebate approaches.



P_2-P_c = \$1.34/gal P_2 = \$3.13/gal
P_2-P_3 = \$1.61/gal P_c = \$1.79/gal
P_2-P_4 = \$1.07/gal P_3 = \$1.52/gal
P_4 = \$2.06/gal

With fixed-price gasoline rationing or the administratively determined gasoline tax with rebate, DOE would not decide what quantity of gasoline could be purchased as is required under fixed-quantity rationing. With the gasoline tax, the policy instrument is instead the amount of the tax. Under fixed-price rationing, the policy instrument is the price that DOE would set to buy and sell coupons. As illustrated in Figure 5, setting the coupon price or tax at P_2-P_c shifts the demand curve for gasoline from D to D_2 and results in a market-clearing price of P_2, with P_c being received by retailers. However, establishing the coupon price-tax at P_2-P_c requires even more information than setting the quantity of coupons at Q_2 under fixed-quantity rationing. S_2 must be known as well as the shape of D (the elasticity of demand for gasoline between P_c and P_2). In considering this increased uncertainty, let us assume that DOE makes a 20 percent error in estimating P_2. Instead of setting a coupon price (or tax) of $1.34, let us assume that low-side and high-side errors are made that result in a coupon price-tax of $1.61/gal and $1.07/gal--i.e., 20 percent higher and lower, respectively, than P_2-P_c.

As illustrated in Figure 5, the high-side error results in shifting the demand curve from D to D_3 instead of to D_2. The marginal cost of gasoline remains P_2 because the nontax demand curve D still intersects the supply curve at P_2 and Q_2. However, the price that retailers receive drops to P_3 instead of P_c--a drop in revenue from $1.79/gal to $1.52/gal. Therefore, the consequence of a high-side coupon price-tax error of 20 percent results in a 15 percent decline in gross revenue to the petroleum industry. Note that consumers still purchase Q_2 gasoline at a market-clearing price of P_2 despite DOE's high-side error.

The low-side coupon price-tax error results in a $1.07 price-tax instead of the correct $1.34 price-tax (20 percent lower). As before, the market-clearing price and quantity remain unchanged at P_2 and Q_2, but the price to retailers increases to P_4 or $2.06/gal. Therefore, the consequence of DOE's low-side error is to increase gross revenues from gasoline sales to the petroleum industry by 15 percent. In either case, market-clearing processes have not been interrupted, and the total cost to society of the DOE error is zero. If DOE established the correct coupon price-tax of $1.34/gal, the petroleum industry would maintain a gross revenue from gasoline sales of $101 billion/year or $8.4 billion/month. The DOE high-side error would decrease monthly revenue to $7.2 billion, and the low-side error would increase monthly revenue to $9.7 billion. It is important to realize that the only impact of the price error is to change the income distribution between consumers and the petroleum industry, while the impact of quantity error (fixed-quantity rationing) is to result in real economic losses to consumers only or to both consumers and the industry. These losses can never be recovered because they represent real losses in queues (too many coupons) or in reduced mobility (too few coupons). The transfers between consumers and industry can always be recovered or readjusted simply by monitoring the price that gasoline retailers receive and by adjusting the tax or coupon price to achieve an average value of P_c over the year.

Another issue, which was not accounted for in the static-equilibrium analysis, concerns transaction costs. There is no transaction cost for the gasoline tax with rebate implied by establishing a tax because it is collected at the pump. The transaction cost for fixed-price rationing

depends, however, on the arrangements made by DOE to buy and sell coupons and the cost of arbitrage provided by private entrepreneurs. Transaction costs for fixed-quantity rationing depend on the behavior of speculators who buy and sell coupons.

It is difficult to estimate transaction costs of either fixed-price or fixed-quantity rationing. Further analysis of fixed-price rationing transaction costs is required to develop workable institutional arrangements and to determine the costs associated with them to the government and the consumer. An analysis of fixed-quantity transaction costs would require estimating the profits and behavior of speculators. Speculators could consistently operate at a high profit and tend to significantly raise transaction costs for purchasers of extra coupons. Also, speculators could lose money and subsidize either sellers or purchasers of coupons, or both. Either way, price variations under fixed-quantity rationing could be large, and the white market might be characterized by a high degree of uncertainty for coupon sellers and purchasers.

Therefore, although there is no attempt to quantify transaction costs, it can be concluded that the gasoline tax with rebate has the least (none) transaction costs, fixed-price rationing would add consumer transaction expenses, and fixed-quantity rationing would add a speculator's losses or profits to the costs incurred in fixed-price rationing. Transaction costs under fixed-quantity rationing would be potentially large and inherently uncertain.

A final consideration in this section on uncertainty concerns the availability of data required to administer rationing or a tax plan. Total gasoline sales volume data are available from DOE (as reported in DOE's Monthly Energy Review) and FHWA. However, these data sources often differ by more than 5 percent (15). Of the two, FHWA data are more reliable because of its end-of-year accounting requirement to validate gasoline tax receipts. But, at any given time in a year, the FHWA data can be up to a year out of date for the United States as a whole. States are not required to report sales to FHWA except at the end of each calendar year. In contrast, DOE data are available with only about a three-month time lag. In order to administer a fixed-quantity gasoline-rationing system, DOE would have to rely on forecasts of gasoline availability of three months to one year, and these forecasts would necessarily be based on a data source of questionable accuracy. Therefore, errors in estimating Q_2 (available supply) are likely to be substantial.

If price is used as the controlling variable, neither the price elasticity of gasoline nor the quantity of gasoline need be known. DOE would establish a gasoline tax or coupon price and monitor its effectiveness by observing the market price of gasoline received by retailers (P_4, P_c, and P_3 in Figure 5). If DOE uses an iterative price-setting procedure, it can set the coupon price-tax, observe return to retailers, reset the coupon price-tax, reobserve the return to retailers, and so forth, until, over a longer time period, the return to retailers is fine-tuned to achieve the same income-transfer objectives for which gasoline price controls were established. The price of gasoline to retailers can be monitored with little lag time by using a sample of retail outlets to estimate the prevailing national price of gasoline. (It is estimated that a weekly sample of the gasoline prices charged at 20 percent of all service stations would cost less than $15 million annually or about $0.0002/gal of gasoline sold, as shown in Appendix B.) Therefore, the fixed-price rationing system and gasoline tax with rebate are much more practical to administer because they require information that is relatively available (gasoline prices). On the other hand, the fixed-quantity rationing system requires information that has to be forecasted (quantity available).

CONCLUSIONS

Three distinct approaches to avoiding gasoline shortages have been evaluated. All of them can provide the same equity to gasoline consumers in that they keep the average net cost of gasoline equal to the controlled price of gasoline. All of them raise the marginal cost of gasoline (price) to a market-clearing level that is substantially higher than the controlled price. All of them cause high-volume consumers to pay low-volume consumers either by purchasing their coupons (rationing) or by financing their rebates with higher-than-normal gasoline tax payments (tax with rebate). The differences among the plans do not relate to how fair they are but to how effectively they will work.

The fixed-quantity gasoline-rationing plan has been found to rely on information that must be forecast at least three months ahead of the most recent data available. If the forecasts of gasoline availability are wrong, substantial inefficiencies are imposed on gasoline users. A 10 percent high-side error results in approximately $2 billion/month lost in gasoline queues, while a 10 percent low-side error reduces gasoline availability and forces the market-clearing price to be 50 percent higher.

Both the fixed-price rationing and gasoline tax with rebate do not require precise estimates of gasoline availability. Both systems require that price controls be eliminated and use the pump price of gasoline as an observed variable to set future gasoline taxes or coupon prices. Although achieving the exact desired pump price in the first month of operation may be as difficult as identifying the exact number of coupons to distribute, the average revenue to the petroleum industry over several months can be precisely controlled by using an iterative price-tax-setting scheme. In any month for which the pump price does not equal the controlled price, consumers still face the same market-clearing price and will not have to wait in lines. Instead, their rebates or coupon subsidies will be somewhat larger or smaller than they would have been if the pump price and controlled price were equal. Over a year of operation, the average net cost to consumers and gross revenues to the petroleum industry can be fine-tuned simply by monitoring current pump prices and by using an effective iterative tax-price-setting scheme.

Comparison of the fixed-price rationing system and the gasoline tax with rebate reveals that they are almost identical in the way they work. However, fixed-price rationing imposes several operations on the government (DOE) and consumers that serve no purpose. For example, with rationing, consumers who wish to purchase more than their coupon allotment allows must make a trip to some coupon purchase-sales outlet or buy them from some individual who has some to sell. With the tax-rebate system, this is unnecessary because the extra cost is paid at the pump. With rationing, DOE must physically distribute ration coupons to approximately 140 million recipients, but the tax-rebate system will require physical distribution of rebate checks to only 21 million recipients. The remaining recipients would receive their rebates via reduced withholding payments. Rationing has, in effect, created a second national currency and requires new bureaucracies to manage it. The tax-rebate system uses the existing national currency and, therefore, requires only a slight increase in responsibility for existing bureaucracies (IRS, Health and Human Services, and Social Security).

Two final considerations are lead time and availability. Rationing is likely to require significantly more than three months to begin to function, and it may require significantly more time to iron out the bugs once it is implemented. A gasoline tax-rebate system can be operational within one month. If some event terminates the supply of oil from the Middle East, gasoline lines are likely to begin within two, and certainly three, months of the cutoff. For each month that the gasoline-rationing plan is not available, consumers will lose more than $6 billion in wasted time and gasoline.

What does gasoline rationing offer to compensate for the increased bureaucratic cost and uncertainty that it implies? The answer is very little. The gasoline tax with rebate system is in almost every regard identical or superior to either fixed-price or fixed-quantity rationing.

There are some differences, however, that favor gasoline

rationing. Because of accounting conventions, a tax with rebate would impact the Consumer Price Index (CPI) and appear inflationary while rationing would not. However, any excise tax that rebates revenues back to consumers should not be counted in the CPI for the same reason that the cost of gasoline ration coupons should not be accounted for in the CPI.

Coupon rationing also differs from the gasoline tax with rebate system with regard to macroeconomic impacts that result from temporary federal surpluses or deficits. The surpluses or deficits in the tax-rebate system are caused by differences between the total rebate payments and the total gasoline tax payments that will inevitably result. In the fixed-price rationing system, even larger deficits or surpluses are likely to occur in the government coupon market. The surpluses or deficits will be larger because the government's transactional surpluses or deficits are not disposed of through a rebate mechanism. In the fixed-quantity rationing system, direct federal surpluses and deficits do not occur because the coupons are given away and the government has no further involvement with the white market in which they are traded. The coupons represent a second currency whose exchange rate with dollars is determined by the white market. However, despite the absence of a federal surplus or deficit with fixed-quantity rationing, significant macroeconomic disruptions can still occur because a significant amount of purchasing power will be changing hands in the white market. Because the true purchase price of gasoline (pump price plus coupon price) and the mobility available vary considerably more with fixed-quantity rationing than with fixed-price rationing or the tax with rebate plans, the macroeconomic disruptions of fixed-quantity rationing can be even more significant than the other alternatives. Therefore, considerably more study is required to better understand the macroeconomic implications of all proposed contingency plans.

Despite the detailed differences outlined among alternative gasoline-allocation plans, there are many substantive similarities. It has been shown that a type of rationing (fixed-price rationing) is operationally more similar to the gasoline tax with rebate system than it is to fixed-quantity rationing. In particular, the equity impacts of each plan are identical because coupon allocation criteria and tax rebate criteria need not be different. Yet there is a strong public antipathy toward the gasoline tax with rebate system. For example, one survey found that consumers preferred gasoline rationing to higher prices by a more than five-to-one margin (16). I am not aware of any survey data that contrast the popularity of rationing and the gasoline tax with rebate scheme outlined in this paper. However, it is clear that consumers associate rationing with fairness and associate gasoline taxes with being "ripped off". Unless the rebate scheme is carefully explained to a receptive audience, the distinction between a gasoline tax and a gasoline tax with rebate will likely be obscure to most consumers. Likewise, Congress has twice prohibited (through passage of the Energy Policy and Conservation Act of 1975 and the Emergency Energy Conservation Act of 1979) DOE from using any tax or user fee in developing a plan to deal with gasoline shortages.

Although the numerical estimates in this paper can vary substantially if different gasoline price elasticity estimates and other assumptions were used, the conclusions remain unaltered. A gasoline tax with rebate system (a) provides equity equal to that of any rationing system, (b) operates at a fraction of the cost, (c) provides consumers with a simpler system and no transaction costs, (d) is virtually certain of working as described, and (e) is the only system available soon enough to prevent a severe gasoline shortage following a significant interruption of imported petroleum.

APPENDIX A—Glossary of Elasticity Concepts

Demand function. The demand function is the relation between the demand for some commodity or service and one or more demand-influencing variables. The most ubiquitous demand-influencing variable is price, and demand is often stated simply as a function of price. However, other variables besides price can also be included in a demand function. Regardless of how many variables a demand function possesses, the relation between any one of them and demand can be graphed by holding the values of all others constant. This relation is often called the demand curve, especially when price is the variable graphed, as illustrated in Figure 6. The price-quantity demand curve (which need not be curved) usually slopes downward. This indicates more demand as price decreases.

Elasticity. Elasticity is a measure of the sensitivity of demand with respect to changes in a variable that influences demand. If this variable is price, the elasticity is called a price elasticity. For example, a price elasticity of -1 implies that a 1 percent reduction in price will result in a 1 percent increase in quantity demanded. There are, however, three ways by which elasticity can be measured.

Point elasticity. A point elasticity measures the instantaneous proportional rate of change between demand and a demand-influencing variable at a specific point on the demand curve. The definition of point elasticity requires that the demand curve be differentiable around the specific point at which it is calculated. For any demand-influencing variable x and demand variable q, point elasticity is defined as

$$(\partial q/\partial x)x_1 \cdot (x_1/q_1) \qquad (1)$$

where x_1 and q_1 are the ordinates of the point in question (Figure 7).

Shrinkage ratio. A shrinkage ratio is the proportional change in demand that results from a given change in a demand-influencing variable. Two points on the demand curve are involved (Figure 8). Assume that at time period 1, demand = q_1 and price = x_1. Assume a price increase to x_2 with a resulting decrease of demand to q_2. The shrinkage ratio is defined as

$$[(q_2 - q_1)/q_1]/[(x_2 - x_1)/x_1] = (\Delta q/\Delta x) \cdot (x_1/q_1) \qquad (2)$$

where x_1 and q_1 are the price and quantity levels before the change in price.

Arc elasticity. An arc elasticity is also calculated from two points on the demand curve (Figure 8). It is defined as

$$[(\log q_1 - \log q_2)/(\log x_1 - \log x_2)] = \Delta \log q/\Delta \log x \qquad (3)$$

The arc elasticity is often preferred to the shrinkage ratio because it comes much closer to preserving an important property of point elasticity. That is, when the point price elasticity is equal to -1, gross revenue is maximized. When the point elasticity is numerically greater than unity, gross revenues may be increased by reducing price. Similarly, when the point elasticity is numerically less than unity, gross revenues may be increased by increasing price. This relation does not hold true for the shrinkage ratio unless Δx approaches zero. However, this revenue-maximizing relation is approximately true for the arc elasticity under all conditions.

Sign of elasticity. As defined above, for the normal downward-sloping relation between price and quantity demanded, price elasticities have negative values. The more sensitive demand is to price, the more negative the elasticity will be.

Income elasticity. Income elasticity is a measure of the sensitivity of demand with respect to changes in income. Such an elasticity implies that the income of the consuming group or individual is included as one of the

Figure 6. Example of demand curve when price is the variable.

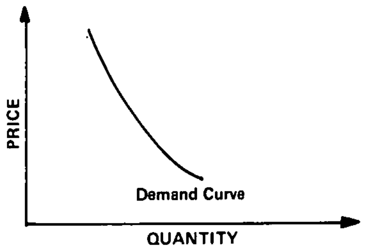


Figure 7. Example of point elasticity—a measure of proportional rate of change on a demand curve between demand and a variable.

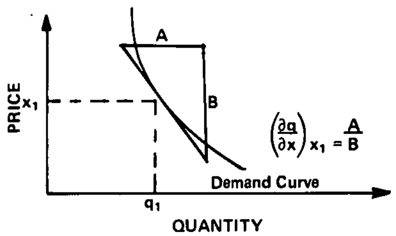
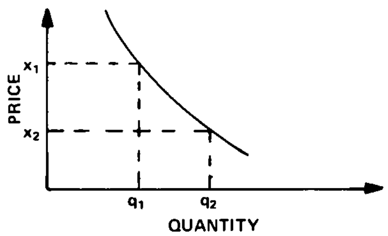


Figure 8. Example of shrinkage ratio or arc elasticity that is estimated by observed changes in demand and price.



demand-influencing variables in the demand function. Income elasticity can either be positive, negative, or zero. A good that has a negative income elasticity is called an inferior good. As income increases, an individual will spend less on inferior goods and purchase more-desirable substitutes.

APPENDIX B—Reliability of Price Elasticity Estimates

As described in Appendix A, there are three different ways of calculating the change in price implied by movement along a demand function characterized by a price elasticity. The point elasticity characterizes the elasticity relation at a particular point on the demand function and, in general, it is only valid for the region around that particular point. The shrinkage ratio and arc elasticity are methods of calculating changes in price or quantity implied by given elasticity relations applied over a discreet interval. The larger the interval, the more imprecise these elasticity calculations become in estimating either changes in price or quantity unless the demand function has particular characteristics. Also, the larger the interval used, the divergence between estimates derived from using the shrinkage ratio or the arc elasticity is increased. If the demand function is a constant elasticity (exponential) relation between quantity and price—that is, $Q = aP^e$ or $\ln Q = \ln a + e \ln P$—then the arc elasticity should be used to estimate changes in price or quantity implied by a price elasticity. If the demand function is not of the exponential variety, little guidance can be provided because any application of a constant elasticity will produce the wrong result unless applied only to small percentage changes in price or quantity. A review of gasoline demand models presented or reviewed elsewhere (3-9) reveals that the demand for gasoline has a complex relation to price that cannot be effectively characterized by a log-linear relation or any other single-equation approach. Therefore, price elasticities that characterize the behavior of these models cannot be reliably used to forecast price-quantity relations except over the range of data used to calculate the price elasticity employed. Indeed, the models themselves cannot be employed to forecast price-quantity relations far beyond the range of data used to estimate model parameters.

To illustrate the divergence implied by shrinkage ratio or arc elasticity calculations, recall that a market-clearing price of \$3.13/gal of gasoline was estimated if the supply of gasoline were reduced from 107 billion gal/year to 75 billion gal/year—a \$1.87 increase over the original \$1.25/gal price. This calculation was based on an elasticity estimate of -0.2 by using the shrinkage ratio method of calculation. If, instead, the arc elasticity had been used, the new market-clearing price would have been \$7.17/gal. I chose the shrinkage ratio largely because I used shrinkage ratio calculations to determine that -0.1 to -0.3 was a reasonable range of elasticities characterizing several demand models. However, there is little certainty achieved when applying such a low price elasticity to a 30 percent reduction in gasoline availability.

The estimates provided in the paper are meant to illustrate the size of income transfers implied by alternative gasoline-shortage strategies and to illustrate the likely range of coupon values or gasoline taxes that would be associated with particular policies. The conclusions in the paper do not depend on those particular estimates.

In addition, the suggested fixed-price rationing or gasoline tax with rebate plans do not administratively depend on knowing the price elasticity relation that would actually occur. Even if the price elasticity relation were known, one still does not know the change in gasoline supply until well after the fact. The suggested approach depends on monitoring an uncontrolled pump price to provide the required information needed to set the appropriate level of tax or coupon value for the tax-rebate or fixed-price rationing plans. If the established tax or coupon value results in an observed pump price of gasoline that is below the desired pump price (P_c), then the tax or coupon value should be reduced. Likewise, if the observed pump price is above P_c, it should be increased. Knowledge of price elasticities could aid this process only if detailed movements in the available supply of gasoline were known shortly after they occurred. Since the estimated lag time of acquiring these data is three to six months, price elasticity data cannot alone suggest at what levels to establish taxes or coupon values. Therefore, perfect knowledge of the price elasticity relation would not alleviate the need to use an iterative tax-setting (coupon value) scheme based on the observed pump price of gasoline in relation to the desired price that the petroleum industry should receive (P_c). The variable P_c is a policy variable set to minimize windfall benefits while accounting for increased costs incurred by the petroleum industry. The same variable (P_c) is set by using identical criteria when administering gasoline price controls.

P_c is a variable that can be observed with great accuracy within a very short time period (one week). The bureaucratic cost of pump price data is modest because there are less than 180 000 service stations nationwide, and a relatively small sample of their prices for gasoline would yield a statistically reliable average price. Government observers could simply visit their assigned sample of service stations and record their pump prices. While I cannot offer tested estimates, it is likely that an observer can easily record the prevailing prices of 10 service stations daily. That modest requirement would imply that 720 observers could provide a 20 percent weekly sample of the prices of all service stations nationwide. That is a small personnel requirement in relation to other aspects of administering

either a gasoline-rationing or gasoline tax with rebate program. At a salary of $17 000/year for each observer, price data would be available for $12.2 million/year or a 0.012 percent share of the estimated tax collected ($101 billion/year) or $0.000 16/gal. It is likely that a substantially smaller sample than 20 percent will prove statistically reliable and, if so, would reduce estimated data costs proportionately.

APPENDIX C—Sample Calculations

Assumptions

1. Preemergency price of gasoline = $1.25/gal = P_1.
2. Preemergency consumption of gasoline = 7.0 million bbl/day = 107 billion gal/year = Q_1.
3. 30 percent shortfall reduced available consumption to 4.9 million bbl/day = 75 billion gal/year = Q_2.
4. Price elasticity of gasoline (shrinkage ratio calculation) = -0.2 = e.
5. Controlled price of gasoline (P_c) set to maintain an unchanged gross revenue resulting from gasoline sales before and after the supply interruption.
6. Average waiting time associated with a 30 percent reduction in petroleum supplies = 2h (11).
7. Average fill-up of gasoline = 10 gal.
8. Value of time = $4.00/h.

Calculations

1. Market-clearing price of gasoline:

Market-clearing price of gasoline after 30 percent shortfall of supply = P_2.

$[(Q_2 - Q_1)/Q_1]/[(P_2 - P_1)/P_1] = e$

[(75 billion gal/year - 107 billion gal/year)/(107 billion gal/year)]/[(P_2 - $1.25/gal)/$1.25/gal] = -0.2

$1.25/gal • (-0.30/-0.2) + $1.25/gal = P_2

P_2 = $3.13/gal

Note: Gasoline price and quantity relations, identified in Figures 3, 4, and 5, are determined as shown above.

2. Controlled price of gasoline:

Controlled price of gasoline = P_c. Unchanged gross revenue requires the following calculation.

$Q_1 P_1 = Q_2 P_c$

$P_c = Q_1 P_1 / Q_2$

P_c = (107 billion gal/year x $1.25/gal)/75 billion gal/year

P_c = $1.78/gal

3. Income transfer of price controls:

(a) Gross petroleum industry revenue from gasoline sales after a shortage without price controls = $P_2 Q_2$.

$P_2 Q_2$ = $3.13/gal x 75 billion gal/year

$P_2 Q_2$ = $235 billion/year

(b) Gross petroleum industry revenue from gasoline sales after a shortage with price controls = $P_c Q_2$.

$P_c Q_2$ = $1.78/gal x 75 billion gal/year

$P_c Q_2$ = $134 billion/year

(c) Income transfer to consumers implied by price controls = $P_2 Q_2 - P_c Q_2$.

$P_2 Q_2 - P_c Q_2$ = $235 billion/year - $134 billion/year

$P_2 Q_2 - P_c Q_2$ = $101 billion /year

4. Economic waste implied by gasoline shortage:

Assumed waiting time associated with a 30 percent reduction in petroleum supplies = 2 h. Assumed average fill-up of gasoline = 10 gal. Assumed value of time = $4.00/h.

Number of fill-ups per year = Q_2/10 gal = 75 billion gal/year/10 gal = 7.5 billion/year

Total excess wait time = 2 h x 7.5 billion/year = 15 billion h/year

Value of total excess wait time = $4.00 /h x 15 billion h/year = $60 billion/year

Excess idle time = 15 billion h/year

Average fuel consumption at idle (10) = 0.33 gal/h

Amount of fuel wasted by idling = 15 billion h/year x 0.33 gal/h = 5.0 billion gal/year

Value of wasted fuel = P_2 x 5.0 billion gal/year = $3.13/gal x 5.0 billion gal/year = $16 billion/year

Estimated cost of shortage due to lost time and gasoline waiting in queues = $60 billion/year + $16 billion/year = $76 billion/year

The calculations in Appendix C do not account for the opportunity cost of activities that could no longer be planned due to uncertainties in acquiring gasoline, the economic losses to individuals who depend on automobile transportation for their income and the loss in the capital value of the automobile stock that results from shortage conditions.

APPENDIX D—Effect of the Windfall Profits Tax

The recently passed Windfall Profits Tax (WPT) Act of 1980 will have a dramatic effect on the disposition of windfall profits resulting from gasoline sales during a petroleum emergency. Approximate base prices are established for three classifications of domestic crude petroleum, and a fixed percentage of the difference between the selling price and base price is taxed by the federal government. The percentage of tax varies with the classification of petroleum as shown below (base price is adjusted for inflation):

Oil Classification	Base Price (1980 $/bbl)	Tax (%)
Lower- or upper-tier oil if the pre-June 1979 price controls had remained in effect	13	70
Stripper production and oil produced from a national petroleum reserve	15	60
Newly discovered oil, certain heavy oil, and incremental tertiary oil	17	30

The WPT will be phased out after a 33-month period after December 31, 1987, or when cumulative revenues raised by

the tax reach $227.3 billion, whichever is later.

The WPT was not accounted for in the discussion of gasoline shortage for several reasons. Althouth the WPT strongly implies that there will be no price controls on crude petroleum, it is unclear if petroleum product prices would be used during emergency conditions. If gasoline price controls were used, the price of crude petroleum would be allowed to be passed through at 100 percent. However, the relation between the market-clearing price of gasoline, other petroleum products, and crude oil are not well understood under emergency conditions. The products with the smallest price elasticities will have the highest increases in market prices and the greatest potential for shortages if price controls are used.

The estimated market-clearing price of gasoline of $3.13/gal was determined strictly from demand-side considerations, assuming a perfectly inelastic supply of gasoline at 4.9 million bbl/day. The increased price per gallon compared to preemergency conditions is $1.88. On the supply side, much of this increased price could be accounted for in higher crude petroleum costs. However, the price of crude petroleum would have to increase by $79/bbl or reach a total price of almost $110/bbl in order to absorb the increased windfall of gasoline price increases under emergency conditions. It is likely that a significantly higher price elasticity of demand for crude petroleum could be encountered than for gasoline. It is a matter for speculation without a comprehensive model of the supply and demand of all petroleum products, but I would guess that equilibrium world petroleum prices could be far less than $110/bbl under emergency conditions during a period when U.S. gasoline prices would have to be $3.00 or higher to avoid gasoline shortages.

Without employing a complex, comprehensive, and accurate petroleum products supply-and-demand model, the gap between the windfall implied by the increased price of gasoline that is not absorbed by the windfall profits tax is highly uncertain. (The uncertainty is complicated by the possibility of direct government control of refinery output; see Appendix E.) If an oil price increase of $50/bbl of oil is assumed, an $0.83/gal price increase for petroleum can be passed through to gasoline to pay for WPT liabilities. This represents 44 percent of the estimated increase in gasoline prices required to prevent or eliminate gasoline shortages after an emergency occurs (as defined). But this implies a controlled price of gasoline that is only $0.34/gal more than already assumed. Recall that the estimated controlled price of $1.79/gal assumed that oil revenues would remain constant before and after the emergency. Therefore, by using the very rough assumption of a $50/bbl increase of the world price of petroleum, the estimated windfall of $101 billion that would accrue to the petroleum industry without price controls would be reduced to $76 billion by the WPT. With the WPT, instead of a controlled price of $1.79/gal, a controlled price of $2.13/gal would be permitted, a smaller shortage would exist and $76 billion of income transfer between consumers and the petroleum industry would shift if price controls were or were not used.

In summary, large uncertainties in the market environment are introduced by the WPT, depending on the relation between market-clearing crude oil prices and market-clearing gasoline prices. If the market-clearing price of gasoline does not move up any faster than implied by the market-clearing price of petroleum, the WPT would itself capture much of the windfall (up to 70 percent) resulting from the increased price of gasoline required to prevent gasoline shortages under emergency conditions. If the uncontrolled price of gasoline moves up much faster than petroleum prices, then the WPT will capture only a small proportion of the windfall generated after a petroleum emergency.

APPENDIX E—Elasticity of the Gasoline Supply

The static equilibrium analysis used to analyze gasoline markets assumes that the supply of gasoline is perfectly inelastic after a petroleum emergency occurs. In referring to Figure 1, the supply curve S_1 shifts to S_2—a straight vertical line above Q_2 between gasoline price P_1 and P_2. As stated in the text, the supply of gasoline would be larger at P_2 than at P_c or P_1, but the differences are not likely to be large enough to affect the analysis and Q_2 is assumed to be the quantity of gasoline supplied at price P_1, P_c, or P_2. This is more likely to be true in the short term rather than the long term. For example, refineries can be technically modified to process a larger percentage of heavy petroleum into gasoline and distillate. Also, the supply of crude oil available for gasoline production will be dependent on the market for all petroleum products and the actions DOE takes in regulating the price and availability of any petroleum products. Therefore, it is impossible to draw a supply curve for gasoline without knowing the specific market environment for all petroleum products and the technological changes that can be made in refining processes. Under emergency conditions, the market environment will prove particularly important if DOE allocations control the inputs and outputs of refineries. The supply function of gasoline will depend on how much gasoline DOE allows to be refined, the economics of alternative uses of petroleum, and refinery capacity as affected by allocations and regulations that pertain to alternative petroleum products.

In summary, we do not really know how elastic the supply of gasoline will actually be. In the short term, the supply of gasoline will be inherently inelastic. In the longer term, government behavior may contribute to a very inelastic supply of gasoline in order to prevent the percentage of gasoline production to increase at the expense of other petroleum products. Also, national policy may allow more gasoline to be refined from each barrel of crude oil at the expense of less-valuable petroleum products (residual oil) as alternative energy sources (coal and natural gas) are used to replace them. This would contribute to a more elastic supply of gasoline.

REFERENCES

1. Transportation Energy Conservation Data Book, 3rd ed. Oak Ridge National Laboratory, Oak Ridge, TN, Feb. 1979.
2. Monthly Energy Review. U.S. Department of Energy, Oct. 1979, p. 36.
3. Charles River Associates. Price Elasticities of Demand for Transportation Fuels. Federal Energy Administration, May 1976.
4. C. Difiglio and D. Kulash. Methodology and Analysis of Ways of Increasing the Effectiveness of the Use of Fuel Energy Resources: Increasing Automobile Fuel Economy via Government Policy. Paper presented at U.S.-USSR Joint Energy Committee Meeting: Information and Forecasting, Washington, DC, Dec. 1977.
5. G. R. Schink and C. J. Laxley. The Wharton EFA Automobile Demand Model. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, DOT-TSC-1072, Final Rept., 1977.
6. Preliminary Projections of Fuel Savings and Revenues Associated with Increased Taxes on Motor Fuel. U.S. Congressional Budget Office, Tech. Note, Dec. 12, 1979.
7. J. Sweeny. Gasoline Demand Model. Energy Information Administration, U.S. Department of Energy, 1979.
8. D. L. Greene. The Demand for Gasoline and Highway Passenger Vehicles in the United States: A Review of the Literature, 1938-1978. Oak Ridge National Laboratory, Oak Ridge, TN, 1979.
9. R. E. Mellman. A Critical Analysis of Automobile Demand Studies. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, Rept. WP-210-02-84, 1975.

10. W.J. Schultz, E.E. Miesiak, A.E. Hamilton, and D.E. Larkinson. Credibility of Diesel over Gasoline Fuel Economy Claims by Association. Society of Automotive Engineers, Tech. Paper Series No. 760047, Feb. 1976.
11. C. Difiglio, R. Dulla, and K.G. Duleep. Cost-Effectiveness of 1985 Fuel Economy Standards. Society of Automotive Engineers, Tech. Paper Series No. 790930, Oct. 1979.
12. R. White. Standby Gasoline Tax. Federal Energy Administration, National Energy Plan Issue Paper, April 1977.
13. Mechanisms to Allocate Gasoline in an Emergency. U.S. Department of Energy, June 1980.
14. Managing Motor Fuel Shortages. U.S. Department of Energy, National Energy Plan (II) Issue Paper, March 6, 1980.
15. Differences Between Estimates of Gasoline Supply. Energy Information Administration, U.S. Department of Energy, Memorandum EI-523, Dec. 5, 1979.
16. F. Linden. How Much Could We Cut Back on Our Driving? Consumers, Feb. 1980.

Household Characteristics and the Determinants of Travel Behavior

Robert Gorman

Due to the existing energy situation, there is a distinct possibility that motor fuel may be rationed. DOE is currently in the process of developing a standby fuel-rationing plan. Under the proposed plan, motor fuel will be allocated primarily on the basis of vehicle registrations. Fuel will first be allocated to individual states on the basis of current or recent fuel consumption, and the states will then allocate their supplies to consumers in accordance with the number of vehicles registered. How much discretion a particular state will have in developing a final allocation procedure is uncertain at this time.

The purpose of this paper is to present an analysis of household travel characteristics that may aid in the understanding of the reasons for and extent of such travel. Currently, although considerable discussion on how rationing should be accomplished has taken place, much of this discussion has occurred with limited factual data to support the various positions. If some of the data that we already possess becomes more widely known, a more rational discussion and allocation can take place.

The following analysis is based on the 1977-1978 National Personal Transportation Survey, which was conducted for the U.S. Department of Transportation by the U.S. Bureau of the Census. (Some of the figures used may differ from those of the Federal Highway Administration—a result of classifying data by slightly different categories or definitions.) This was the second survey of household travel; the first took place in 1969-1970. The 1977-1978 survey interviewed approximately 18 000 households throughout a 12-month period. Information was collected on household characteristics, each person within the household, all trips taken on the travel day, as well as all trips over 75 miles in length taken during the preceding two-week period, and on each vehicle available for use in the particular household. Although none of the summary findings from this survey has yet been published, a series of reports will be available in the near future.

VEHICLE TRAVEL BY PLACE

People have argued that rural areas should receive more fuel than urban areas, or that suburbanites are more dependent on automobiles than are residents of the central city. Table 1 shows the annual vehicle miles of travel (VMT) per household by area population and the number of vehicles the household owns. Among households owning only one vehicle, there is little variation in the amount of travel, regardless of whether they live in rural areas, small towns, or large cities. In fact, the range in values is less than 1800 miles. It is interesting that the households in the largest cities (with more than 1 million population) travel more than residents of small towns and rural areas.

Although the range in values is slightly higher for two- and three-vehicle households, the distribution of average annual VMT is also very compact. Regardless of the number of vehicles owned, residents of small towns and rural areas travel less than the average. Since this refutes some commonly held ideas on the subject, a further explanation of the reasons is appropriate.

Vehicle ownership rates are lowest (1.24) in the central cities and the average number of vehicles a household owns is higher (1.71) in rural areas. This factor is the most significant reason for higher fuel consumption outside central city areas. In small towns, the ownership rate is 1.54 and in the suburbs, 1.68. Although the data for 1977-1978 could not be segregated by state or region, previous analysis of the 1969 survey revealed little differences between states and regions after automobile ownership was considered.

Another surprising result is that travel seems to be linearly related to the number of vehicles a household possesses. Two-car households travel a little more than two times, and three-car households three times, as much as one-car households. One might have expected that travel would increase with the number of vehicles owned, but at a decreasing rate. This is true, but the breakpoint exists at a level above three vehicles.

If a rationing scheme seeks to replicate existing travel patterns, a vehicle registration plan would probably be the least disruptive. However, a plan that allocates fuel on the basis of registered vehicles may encourage households to obtain additional vehicles. Evidence suggests that, once a household obtains an added vehicle, it is used. Thus, such a plan might encourage travel behavior that is contrary to the national goal of fuel conservation. Also, it might have disruptive effects on central-city neighborhoods by fostering additional car ownership.

VEHICLE OWNERSHIP

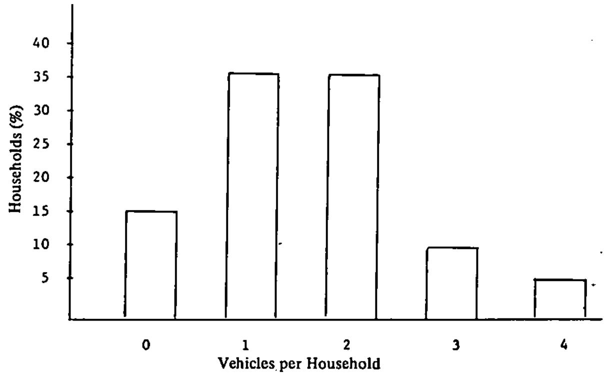
On average, there are 1.5 vehicles per household. The distribution of households by number of vehicles owned is shown in Figure 1. There are almost as many two-vehicle households as there are one-vehicle households. Approximately 85 percent of the households owns at least one vehicle. The number of households owning three or more vehicles exceeds 15 percent of the total households.

The extraordinary number of multivehicle households will have some important implications concerning allocating fuel on the basis of registered vehicles. Almost 16 percent of households has more vehicles than drivers. This relation, as well as the percentage of households with matching drivers and vehicles, is indicated by these data: households without licensed drivers, 13 percent; more licensed drivers than vehicles, 19 percent; equal number of licensed drivers and vehicles, 52 percent; and more vehicles than licensed

Table 1. Annual VMT per household based on area population and number of vehicles owned.

Area	Population (000s)	Number of Vehicles 1	2	3	>4
Rural	<5	8 260	17 618	25 071	35 157
Small town	5-50	8 119	17 083	25 787	31 629
City	50-100	17 723	36 277	51 762	65 944
	100-250	16 900	35 120	52 110	74 560
	250-500	15 556	35 722	50 529	69 970
	500-1000	16 594	36 826	53 825	70 381
	1000-3000	18 312	36 612	52 169	74 609
	>3000	17 527	36 665	53 453	88 312

Figure 1. Distribution of households according to number of vehicles owned.



drivers, 16 percent. A possible improvement in the existing vehicle registration plan would be a requirement that each vehicle have a matching driver. To do otherwise would reward profligate fuel consumers at a time when energy must be conserved. Such requirements might also discourage households from acquiring excess vehicles simply to obtain additional allotments.

VEHICLE CHARACTERISTICS

The average annual miles a household vehicle was driven is 8677. The following table analyzes this figure according to different vehicle types:

Vehicle Type	Average Annual Miles Driven	Percentage of Total Vehicles
Car	8 678	72.1
Station wagon	9 713	8.4
Van bus	10 412	2.0
Other van	11 152	0.8
Pickup truck	8 708	11.7
Camper	9 270	0.8
Other truck	10 131	1.1
Motorized camper	7 146	0.4
Motorcycle	2 372	2.4
Other	-	0.3

The average miles per vehicle does not vary significantly by vehicle type unless motorcycles are included. It must be remembered that these characteristics are for vehicles that are household based. A significant number of vehicles (15 percent) are public vehicles or are based at businesses and rental agencies. Furthermore, distribution of vehicles by the mileage driven appears to be highest in those categories related to low numbers of miles driven.

DAILY TRIP CHARACTERISTICS

The National Personal Transportation Survey collected data for all trips the household had taken on the travel day. The following table shows the percentage of daily travel for various trip purposes and average car occupancy:

Trip Purpose	Percentage of Total VMT	Average Car Occupancy
Work	34.6	1.47
Shop	9.7	2.17
Family business	16.9	2.14
Recreation	27.7	2.67
Other	11.1	2.47

More than one-third of daily VMT is for work or work-related purposes. The next most prevalent trip purpose is for recreation. It is interesting to note the corresponding car occupancy for the various purposes. The lowest occupancy rate, by far, occurs for the work trip, while the highest occupancy rate is for recreation. These figures were weighted by trip distance. Average occupancy proved to be higher for long trips than for short ones. Although some people view the recreation trip as the target for conserving fuel because most of this travel is discretionary, likewise the work trip can also be considered discretionary. The work trip may be necessary; however, the occupancy rate is so low that many of these trips could be potential candidates for ridesharing.

Besides varying with trip purpose, travel varies on a daily and a monthly basis. This is shown by the following index figures (average = 100): Sunday, 0.94; Monday, 0.87; Tuesday, 0.94; Wednesday, 0.98; Thursday, 0.98; Friday, 1.15; and Saturday, 1.15. On a monthly basis, the index figures are January, 0.87; February, 0.83; March, 1.00; April, 1.05; May, 1.01; June, 1.06; July, 1.07; August, 1.14; September, 1.05; October, 1.04; November, 0.93; and December, 1.00. These figures become more relevant as the possibility nears of restricting travel on one or more days of the week. It should be noted that a ban on travel or a restriction on gasoline sales probably would not reduce travel by the same amounts noted here because some portion of the travel on any given day could be shifted to another day.

Table 2 shows a breakdown of travel by purpose and day. Although almost one-half of the travel occurring on weekends is recreation related, 15 percent of Saturday's and 8 percent of Sunday's travel is also work related.

Person miles of travel for various modes and trip purposes are noted in Table 3. The amount of travel by transit is less than 3 percent of the total. It seems unlikely that improvements in transit will make a significant reduction in energy use. The biggest payoff from an energy standpoint will come from more efficient use of personal vehicles.

HOUSEHOLD CHARACTERISTICS

Analyzing the amount of household travel by mileage increments reveals that an extraordinary amount of travel is accounted for by relatively few households. Table 4 shows the percentage of households and the percentage of travel by varying annual mileage ranges. Less than 16 percent of all households travels more than 25 000 miles/year, yet these households account for more than 45 percent of total vehicle travel. This same phenomenon also exists when one analyzes licensed drivers. The table below shows that only 13 percent of the drivers traveled more than 20 000 miles/year, yet they account for more than 40 percent of the total travel:

Annual VMT	Percentage of Drivers	Percentage of Total Travel
0-4999	33.7	6.3
5000-9999	23.2	15.3
10 000-14 999	20.9	23.2
15 000-19 999	9.1	14.5

Annual VMT	Percentage of Drivers	Percentage of Total Travel
20 000-24 999	5.8	11.9
25 000-29 999	2.4	6.0
>30 000	5.0	22.8

Therefore, households that travel more than 25 000 miles/year and drivers who travel more than 20 000 miles/year are traveling more than three times the average and accounting for 40-45 percent of total travel.

The immediate question that one might ask is, "Who are these high-mileage travelers?" It is difficult to find any one reason why they should travel so much, but some generalized characteristics do emerge. As a group, they report needing their vehicle for work on one or more days each week, much more frequently than the lower-mileage group. More than 40 percent of these drivers report needing their car for work versus 10 percent of lower-mileage drivers. However, only 4.5 percent of this group's travel is for work-related purposes.

The higher-mileage group, on average, travels much more for each trip purpose. The disparity is greatest for work-related and work trips and least for recreation. Thus, it would be misleading to claim that high-mileage households result from work needs or recreation preferences. All that can be said is that work-trip needs are more significant.

Some of the other factors that tend to cause higher levels of travel are longer distances to work, income, age, sex, higher vehicle ownership rates, and greater number of drivers per household. (Sex was found to be an extremely important variable. Men travel almost twice as much as women even when they are disaggregated by work status. However, because it is unlikely that either sex or age would ever be used as a factor for rationing fuel, further analysis has been omitted.) The income factor is very important because income is closely related to vehicle ownership; once vehicle ownership is considered, the income effect tends to diminish.

Previously, this paper showed how the number of vehicles owned by a household explains travel variations between places. Because the number of vehicles owned is the most important determinant of vehicle travel, average VMT can be classified by vehicles, income, and the number of drivers to see how much additional variation these factors explain. Although annual VMT increases almost linearly with the number of vehicles owned, the average VMT for all drivers within a vehicle class is at most 7 percent more than for the single-driver household in that class. The effect of income is more pronounced. The average VMT for a vehicle class ranges from 16 to 44 percent higher than the lowest income group. A vehicle-based allocation scheme will not discriminate against the poor because for each class of vehicles owned, they drive less than the average. Therefore, they will not have to reduce their travel as much.

Most of the discussion has revolved around vehicle travel rather than fuel consumption. But do lower-income households have fewer fuel-efficient vehicles? Although it is not possible to determine this precisely, one measure of the efficiency of vehicles is their number of cylinders. In this respect, lower-income households have approximately the same proportion of eight-cylinder vehicles, about 4 percent more six-cylinder vehicles, and 3 percent fewer four-cylinder vehicles than the rest of the population. Thus, lower-income households do not significantly differ from everyone else with respect to the vehicles they drive.

EXCEPTIONAL CASES

Much of the discussion concerning fuel rationing has evolved around who should receive supplementary rations based on some form of necessity. This section will shed some light on the subject, but it should not be considered a comprehensive analysis.

The table below indicates the number of vehicles selected by type of ownership and percentage of travel for work:

Type of Ownership	VMT (%) Work	Work Related	Nonwork
Household	28	6	66
Company	32	30	38
Leased	24	22	54

Households that have use of company vehicles use these vehicles for a substantial amount (38 percent) of nonwork travel. Considering that company vehicles are only used to travel to work a little more than household vehicles, it is only the work-related travel that stands out. In fact, company vehicles are used for business purposes less than one-third of the time (this refers to company vehicles that are based at the household, not at the business site).

A much higher proportion of the individuals who traveled 20 000 miles or more annually reported needing their car for work at least once a week. On average, drivers who use their vehicles for business-related purposes three or more times a week travel 35 percent more than the rest of the population. When this figure is broken down by trip purpose, about two-thirds of this increase is explained by work-related travel. Thus, on average, such individuals travel only 24 percent more than the rest of the population because of work-related reasons. This may be considered an upper bound on supplementary rations for drivers who need their vehicles for work. On the other hand, since their jobs do not require them to travel that much, they could easily

Table 2. Percentage of VMT by purpose and day.

Day	Purpose: Work	Shopping	Family Business	Recreation	Other
Sunday	8.1	7.2	18.7	48.6	17.4
Monday	48.6	8.1	17.9	18.3	7.1
Tuesday	45.2	8.7	17.6	17.9	10.6
Wednesday	48.2	8.1	17.6	16.8	9.2
Thursday	44.7	8.3	17.6	19.9	9.3
Friday	38.1	9.6	16.1	24.8	11.3
Saturday	15.1	16.5	13.8	43.6	10.9

Table 3. Person miles of travel by purpose and mode.

Mode	Purpose: Work	Shopping	Family Business	Recreation	Other	Total
Personal vehicle	87.6	99.1	90.8	95.9	83.2	91.3
Transit	3.0	0.6	6.6	1.3	2.9	2.8
Air	7.5		1.6	2.1	12.7	4.8
Nonmotorized	0.4	0.3	0.6	0.3	0.6	0.4
Other	1.5		0.3	0.4	0.6	0.7

Table 4. Percentage of VMT and households based on VMT range.

Annual VMT	Percentage of Total VMT	Percentage of Total Households	Percentage of Households with Vehicles
0-4999	2.6	32.7	18.7
5000-9999	7.6	14.4	17.3
10 000-14 999	14.6	16.4	19.8
15 000-19 999	14.4	11.3	13.7
20 000-24 999	15.3	9.3	11.3
25 000-29 999	10.9	5.4	6.5
>30 000	34.6	10.5	12.7

purchase additional fuel on the white market without undue hardship.

SUMMARY

The findings of this paper generally support the vehicle-allocation plan selected by DOE for rationing fuel. Such a plan would allocate fuel in a manner that best replicates existing travel patterns. In that respect, the transfer of income from one group to another would be minimized. The vehicle registration plan would not be biased against the poor. Almost half of the households earning less than $6000/year do not own cars and, consequently, do not consume fuel. For the low-income households that do have cars, their average travel is less than the overall average for all households owning the same number of vehicles.

There is also no justification for providing supplementary allocations to households who reside in rural or suburban areas. Any differences in their travel are explained by the higher levels of vehicle ownership.

The major drawbacks of a vehicle registration plan are that it aids in preserving the status quo (i.e., 15 percent of the households accounts for 45 percent of the VMT) and encourages households to obtain additional vehicles that, once purchased, are used. In respect to the former drawback, it is unlikely that the trend toward multivehicle families would continue if the price of fuel were unconstrained.

Because 16 percent of all households already has more vehicles than drivers, limiting allotments to each registered vehicle matched with a specific driver would certainly aid the goals of energy conservation. Furthermore, it would place a ceiling on the number of allotments a household could obtain.

The finding that 15 percent of households is responsible for 45 percent of travel is significant. However, since many of these same households possess more than one vehicle, there does not seem to be a way of restricting their travel more than the lower-mileage households. However, government initiatives should encourage more efficient use of personal travel. Such efforts might encourage people to plan their travel and combine trips, if possible, and to improve their driving habits.

Our extraordinary dependence on private vehicles is vividly illustrated in Table 3. With less than 3 percent of personal travel on transit, it is doubtful that even major expansion of transit service will have a substantial impact on fuel conservation.

This paper has focused on household and travel characteristics that could influence the rationing of fuel. There are many additional factors that also influence travel behavior, such as age, sex, and life-style. In fact, the elements that influence how, when, and where a person travels are so numerous that it would be naive for government officials to declare that one is essential and another is not. A rationing plan that enables the individual to decide what portion of his or her travel must be reduced would be the preferable plan.

Driver- Versus Vehicle-Based Rationing and the Potential for Coupon Sales Between Different Income Groups in Michigan

Martin E. H. Lee

In June 1978, DOE released a proposed standby gasoline-rationing plan for public comment, which replaced an earlier plan. Both plans were prepared in response to the Energy Policy and Conservation Act of 1975. The primary difference between the two plans is the use of registered vehicles rather than licensed drivers as the unit of allocation for gasoline. It was asserted that this would make rationing quicker to implement and be a more realistic response to existing use than a driver-based allocation. The recent plan also emphasized the value of a white market for the unrestricted exchange of rationing rights at uncontrolled prices.

In subsequent federal legislation in November 1979, Congress renewed the President's authority to impose rationing and, in 1980, specified congressional review of standby plans. A revised standby plan was released by DOE for comment in December 1979. The main differences between this plan and that released in 1978 are an increased role for the states in resolving priority use and hardship problems and a proposal to allow the federal government to intervene in the coupon market to control the number of coupons in circulation. The vehicle-based allocation and white-market proposals together raise controversial questions about the impact of rationing on different income groups. However, to investigate distribution-related questions, it is necessary to have detailed data on the trip-making characteristics of drivers and vehicles.

SURVEY AND DATA BASE DESCRIPTION

The Michigan Driving Experience Survey (MDES), a micro data base on vehicle ownership and use, was built from 7581 personal interviews of driver's license renewal applicants conducted throughout Michigan during 1976. It used a controlled selection procedure for random selection of sites within two dimensions—level of urbanization and gasoline sales per capita (the latter was the only indicator available of gross personal travel activity). Because of the scarcity of rural trip-making data, the rural areas were deliberately oversampled. All data are capable of being weighted to compensate both for sampling rates and for variations owing to the day of week of the interview and the level of nonresponse. Overall response was very high—85 percent of those asked to participate. The number (7581) of usable interview forms represents 72 percent of the number of interviews predicted from the workload of the 30 local driver's license bureaus selected for the survey. The difference between the two percentages primarily represents some continuity gaps inevitable in the conduct of a decentralized survey operating over an entire year.

Within the 30 sites, a random number system—beyond the control of the employees—was used to select seven or eight interviewees per office per week from among all driver's license renewal applicants. Because the system used a meaningless sequence number that became a transaction identifier in an audit trail, it was possible to verify later that none of the (unannounced) eligible drivers had been missed. Follow-up procedures, which were more time-consuming than an interview done at the time the driver was in the local bureau, helped keep administrative response very high. Overall, this provided a representative sampling of the Michigan driver population, but it must be noted that drivers under the age of 19 are not represented because they are not old enough to be renewing a driver's license.

The interviews were conducted by the managers of the

local license bureaus, who generally have excellent public contact skills and who received training in the interview procedures in a seminar and on site. The emphasis of the survey was on the careful reconstruction of a recent trip day, usually the previous day, and on the complete set of vehicles to which the respondent had access.

The survey was designed primarily to yield a series of measures of the amount and type of driving undertaken, aggregated over the entire trip day. Thus, the total time and distance driven by each respondent are expressed in terms of travel under different trip regimes, purposes, light conditions, road types, vehicles used, and passenger load. The vehicles owned and used are identified at the level of make, model, and year. This information is available for each trip made during the day.

The survey data have been integrated with the individual accident and traffic conviction records from the files of the sponsoring agency (while individual identity has been deleted). Cross-reference capability has been established with selected socioeconomic characteristics of the traffic zones (used by state transportation modelers) in which the respondents resided. Certain socioeconomic characteristics are also available by zip code of residence. In addition, the interview itself provides basic biographical information on the respondent and his or her household.

Considerable effort has been completed to build two verified summary files: in a driver file, all time and distance information has been aggregated over the trip day for all trip attributes, including algorithm-assigned travel by purpose in multipurpose trips; in a second file, each trip is treated as a separate case, with driver descriptors repeated. The files were built primarily with OSIRIS.IV software for use with both the OSIRIS and the MIDAS software packages on the University of Michigan computing system.

ANALYZING THE STANDBY RATIONING PROPOSALS

The recent standby rationing plan provides for a fixed allocation of gasoline to all registered vehicles. All privately owned vehicles under 10 000 lb (4.5 Mg) would receive an allocation based on the national average consumption for an automobile, which was estimated in 1978 as 748 gal (2830 L) per year, less a percentage necessary to respond to the predicted shortfall in supply. The allocations would be made for periods of about 90 days. Ration rights would be distributed directly to the public, with an amount of additional rights distributed through state government agencies to provide relief for hardship cases. Vehicles more than 10 000 lb would receive larger allocations based on average fuel consumption and historic mileage trends. Motorcycles would receive a very small allocation and recreational vehicles none at all. The proposed plan considers, and leaves open, the possibility of placing all commercially used vehicles on a separate allocation based on historic use. The plan also discusses the possibility of adjusting allocations to entire states based on past consumption patterns.

This study examines some aspects of vehicle-based, as opposed to driver-based allocation in relation to a white market. Ration rights would be traded legally at uncontrolled prices under the latest plan, and much is claimed for the value of this white market in redistributing income to offset general inflationary effects and to benefit poorer households. A discussion of likely scenarios for the behavior of commercial companies is beyond the scope of this study, however. Thus, most analyses are confined to the 98.7 percent of the respondents who stated that the vehicle they drive most often is a private automobile, van, pickup, or recreational vehicle. (Because many vehicles registered in Michigan as recreational vehicles are primarily passenger vehicles with a camping or off-road capability, these vehicles were included despite the intention of the plan to allocate no gasoline to motor homes.) The assumption is made that a white market is most likely to operate among private-vehicle owners, despite the interest of the proposed DOE plan in a flow of money from commercial to private users.

In order to compare driver- and vehicle-based allocation methods, it is preferable to have trip-making information for individuals and for each owned vehicle in a household. The MDES data provide very detailed individual trip-making information and support a surrogate for per-vehicle trip making. As the total number of drivers and vehicles owned in the respondent's household is known, the surrogate is obtained according to the following equation:

$$VT = (PT \times DH)/VH \qquad (1)$$

where

VT = vehicle trip making (distance and time),
PT = person trips reported by respondent,
DH = total number of drivers in household, and
VH = total number of vehicles owned in household.

This provides a measure of vehicle travel adjusted for the driver-to-vehicle ratio in the household. The number of privately owned vehicles per 100 drivers is high in Michigan. The table below shows data based on the ratio between mean drivers per household and mean vehicles per household, and it is seen that they change little by income. This is of key importance to vehicle-based plans.

Household Income ($)	Number of Privately Owned Vehicles per 100 Licensed Drivers
<5000	83.4
5000-10 000	80.3
10 000-15 000	86.5
15 000-25 000	86.9
>25 000	84.4
All	85.2

In tabulating data for this study, income groups refer to household income and should be considered approximate because of the sensitivity of asking financial questions in a government survey. Vehicle size classes are used that were condensed from make and model codes. Specialty automobiles, such as luxury cars, are placed in the closest-size category. For all analyses not expressly using vehicle class as a control variable, the truck-bus and motorcycle classes were deleted in this analysis. Vehicle size in this paper refers exclusively to that which the respondent declared he or she most often drove.

Geographic location is based on a classification of the zip codes in which respondents reside. They are in six classes in descending order of housing density and should not be considered as economically homogeneous; for example, central city includes the centers of some medium-sized affluent towns, while inner ring contains both poor and wealthy neighborhoods on the outskirts of some metropolitan areas.

Costs of rationing in terms of white-market cash exchanges are, of course, subject to widely differing assumptions. However, as the value of the MDES data is in providing trip-making data, some simplistic scenarios are postulated to examine the distributional effects. The analyses use a projected gasoline supply shortfall of 25 percent for private vehicles. Costs are estimated here on the artificial basis that, if all drivers reduced their travel by the same percentage as the shortfall (25 percent in this instance), a fixed allocation of gasoline based on a similar reduction in supply would be more than sufficient for some and insufficient for others. Given that a 1978 DOE economic analysis projects a per-gallon white-market price of $0.90 under a 20 percent shortfall and inflation since then, the average cost in dollars per month is calculated by using the following formula:

$$\$/\text{month} = [(MD \times 0.75) - MR](365/12)(1.25/MPG) \qquad (2)$$

where

MD = miles traveled in one day (per driver or per household vehicle),
MR = miles allowed by ration allocation, and
MPG = miles per gallon of vehicle used.

For analyses by vehicle size, MR is adjusted to the average fuel economy of the vehicle class analyzed, and MPG is set to that figure. The fuel economy constants are based on DOT standards for 1972 vehicles (1) and are subcompact, 22 miles/gal; compact, 16 miles/gal; intermediate, 14 miles/gal; and full size, 12 miles/gal. Vans, pickups, and recreational vehicles were estimated by the driver to average 11 miles/gal. The formula used for MR is

$$MR = (\overline{MD} \times 0.75 \times MPG)/\overline{MPG} \quad (3)$$

where

$\overline{MD}$ = grand mean of miles traveled in one day for entire sample (per driver or per household vehicle),
MPG = miles per gallon of vehicle used, and
$\overline{MPG}$ = average MPG (13.5).

For analyses in which vehicle size is not differentiated, the MPG constant used is the same as that quoted in the DOE plan, namely 13.5.

Table 1. Mean distance driven in one day, by income group.

Household Income ($)	Miles per Driver	Miles per Vehicle Owned in Household
<5000	16.0	20.9
5000-10 000	19.6	25.1
10 000-15 000	24.6	30.9
15 000-25 000	29.1	37.0
>25 000	38.6	47.7

Note: Figures are based on 6605 interviews of respondents who most often drive vehicles other than trucks, buses, and motorcycles.

Table 2. Mean distance driven in one day, by size of vehicle most often used.

Size of Vehicle Used Most Often	Miles per Driver	Number of Drivers in Sample Using Vehicle Class Most Often
Subcompact	28.9	658
Compact	26.2	1058
Intermediate	24.9	1359
Full size[a]	24.7	2763
Vans, pickups, and recreational vehicles	33.0	905
Motorcycles	20.4	16
Trucks and buses	103.2	78
Total	27.3	6837

[a]The full-sized category includes luxury automobiles that have high average use.

RESULTS OF RATION PLAN ANALYSIS

A clear finding of the MDES data is the major increase in daily mileage driven with increasing household income. Table 1 shows this both per driver and for the surrogate per-vehicle variable. This suggests considerable potential for a white market to operate between high- and low-income groups and is slightly greater with a per-driver allocation basis.

There are also significant differences in the amount of daily mileage as a function of the vehicle size most often used. Table 2 shows that use of smaller cars is associated with increased mileage. Other MDES analyses have revealed that this effect generally holds true regardless of the age of the driver. The higher mileages for those driving vans and pickups reflect some degree of rural bias in the location of these vehicles, with associated longer trip lengths.

The effect of vehicle size on rationing is also influenced by this distribution of vehicle classes within each income group. Table 3 shows that the higher-income groups opt for more large vehicles and that the use of vans and pickups is an especially middle-income phenomenon. The popularity of the smallest cars, once a higher-income specialty market, is now growing in the lower-income groups.

One way of looking at a 25 percent shortfall is shown in Table 4. This gives the percentage of each income group who already drive less than 75 percent of the statewide average; for comparison, this table also shows the same data for a 50 percent shortfall. (Note that the two lowest-income groups make up about 25 percent of the statewide driving population.)

The cost analyses were performed by using mean daily travel for the various population subgroups. Summaries of the costs to each income group under a 25 percent shortfall, and postulating a 25 percent reduction in travel by all, are shown in Figures 1 and 2. (All of the results shown in the tables and the figures are based on weighted sample data.) Figure 1 examines differences by geographic location, while Figure 2 gives results according to the vehicle size most often used. Both figures compare the costs on a per-driver basis (upper graph) and a per-household-vehicle basis (lower graph). It should be pointed out that, for Figure 1, the results assumed that all household vehicles have similar fuel economy.

Of major importance are the relative effects of this scenario on different income groups. It is clear from this perspective that the per-vehicle and per-driver schemes are very similar in impact. Although this might be expected, given the high ratio of vehicles to drivers in Michigan regardless of income, it is not necessarily true that the amount of driving done is independent of numerous driver-vehicle configurations found in households.

The differences between geographic locations are of interest in that the rural towns—some of which presumably have long-distance commuters—do not seem to carry the

Table 3. Percentage distribution of vehicle classes within income groups.

Vehicle Type Most Often Used	Household Income ($) <5000 (N = 688)	5000-10 000 (N = 1418)	10 000-15 000 (N = 1826)	15 000-25 000 (N = 2113)	>25 000 (N = 1121)	All (N = 7164)
Subcompact	15.9	10.3	10.5	6.5	8.1	9.3
Compact	11.4	14.8	15.3	10.7	8.5	15.0
Intermediate	19.8	20.9	16.6	23.3	27.2	19.1
Full size	36.9	39.0	40.0	45.8	47.9	39.2
Vans, pickups, and recreational vehicles	3.7	10.7	14.1	11.7	7.8	13.0
Motorcycles	0.4	0.1	0.2	0.1	0.0	0.2
Trucks and buses	4.6	0.6	2.2	0.9	0.1	1.7
Unknown	7.3	3.6	1.1	1.0	0.4	2.5

penalty of increased driving that is conventionally assumed. One possible explanation is the concentration of retirees in the resort towns of Michigan. By far the heaviest users of gasoline on average live in the suburbs and remote areas. The inner-ring drivers have the highest income potential on a per-driver basis and a per-vehicle basis. This reflects the relatively high percentage of urban dwellers who are in the low-income groups. However, this study does not reveal anything about those people in central cities and elsewhere who would not appear in the system at all because they have no access to private automobiles.

The data on vehicle size in Figure 2 reveal that those with the smallest cars could be in a positive cash-flow situation in this scenario, regardless of income group. The lowest two income groups could potentially sell some ration rights on average in all cases except where the vehicle most used is a van, pickup, or recreational vehicle. The higher average mileage of those driving vans and pickups shows up clearly. Those in the higher income groups could spend an additional $750/year or more to maintain 75 percent of their previous mileage.

A more accurate calculation of gasoline consumption is supported in MDES by the data on vehicle type actually driven during the trip days. Figure 3 shows consumption by income group based on the average MPG estimates for the vehicles actually driven. For comparison, the average miles driven within each income group is plotted against the right-hand scale. A comparison of the shape of the curves suggests that there is a slight trend for the higher mileage of the $25 000 plus group to be associated with more fuel-efficient vehicles. Considerably more adaptation to fuel-efficient vehicles by high-mileage drivers than these analyses reveal will be necessary if conservation is sought in this way. It should be noted that the average fuel economy has improved since 1972, the year for which estimates were used and the median year of most-used vehicles in this sample.

Perhaps more significant are the characteristics of those who would or would not be able to operate with little change in travel habits under a 25 percent shortfall. In addition to the information in Figures 1 and 2, Table 5 shows some characteristics for those whose daily mileage is above or below 75 percent of the statewide mean (regardless of vehicle size). Approximately one-third of the drivers surveyed is above the 75 percent level. As expected, these figures imply the dominance of the journey to work. It should be remembered that they are based on a personal survey; therefore, the figures do not reveal the overall demand for gasoline in households. Further analyses can be

Table 4. Percentage of drivers whose daily mileage is less than the statewide average, by income group.

Household Income ($)	Less Than 75 Percent of Average Mileage	Less Than 50 Percent of Average Mileage
<5000	80.3	72.8
5000-10 000	73.4	63.3
10 000-15 000	66.6	54.7
15 000-25 000	61.1	49.6
>25 000	51.9	40.1

Figure 1. Distribution of potential white-market costs under a 25 percent gasoline shortfall for private vehicles, by income group and geographic location.

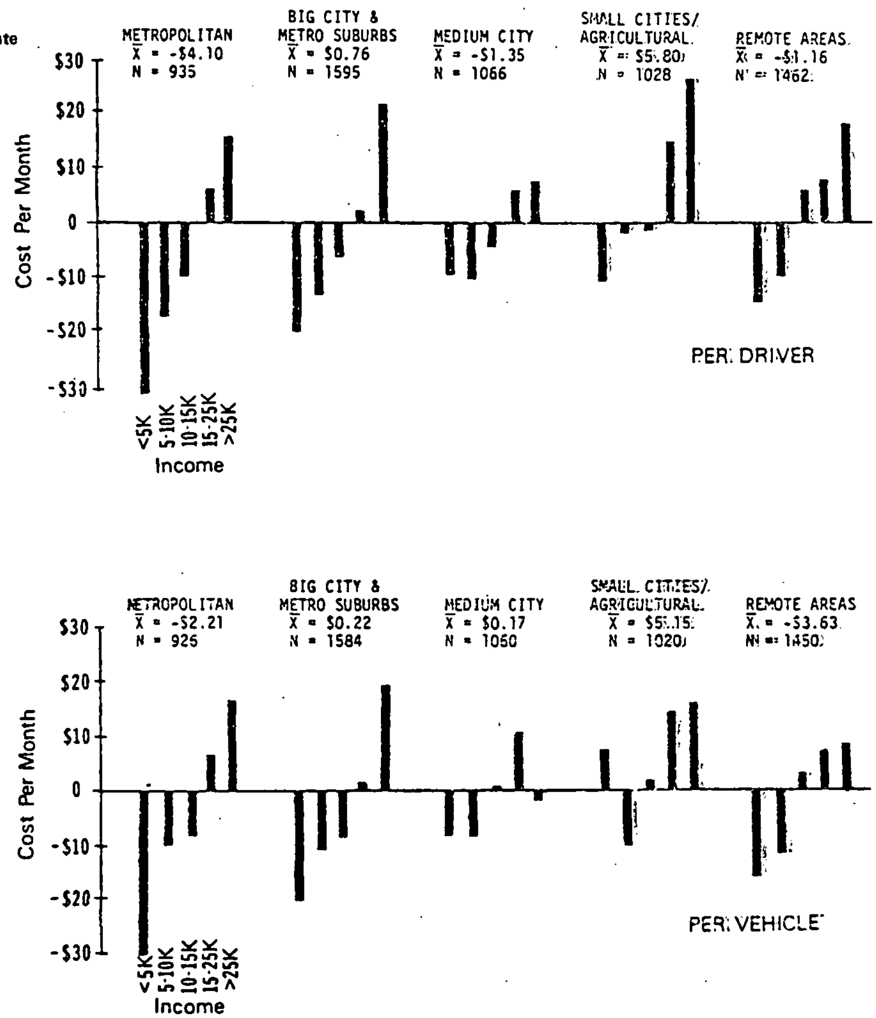
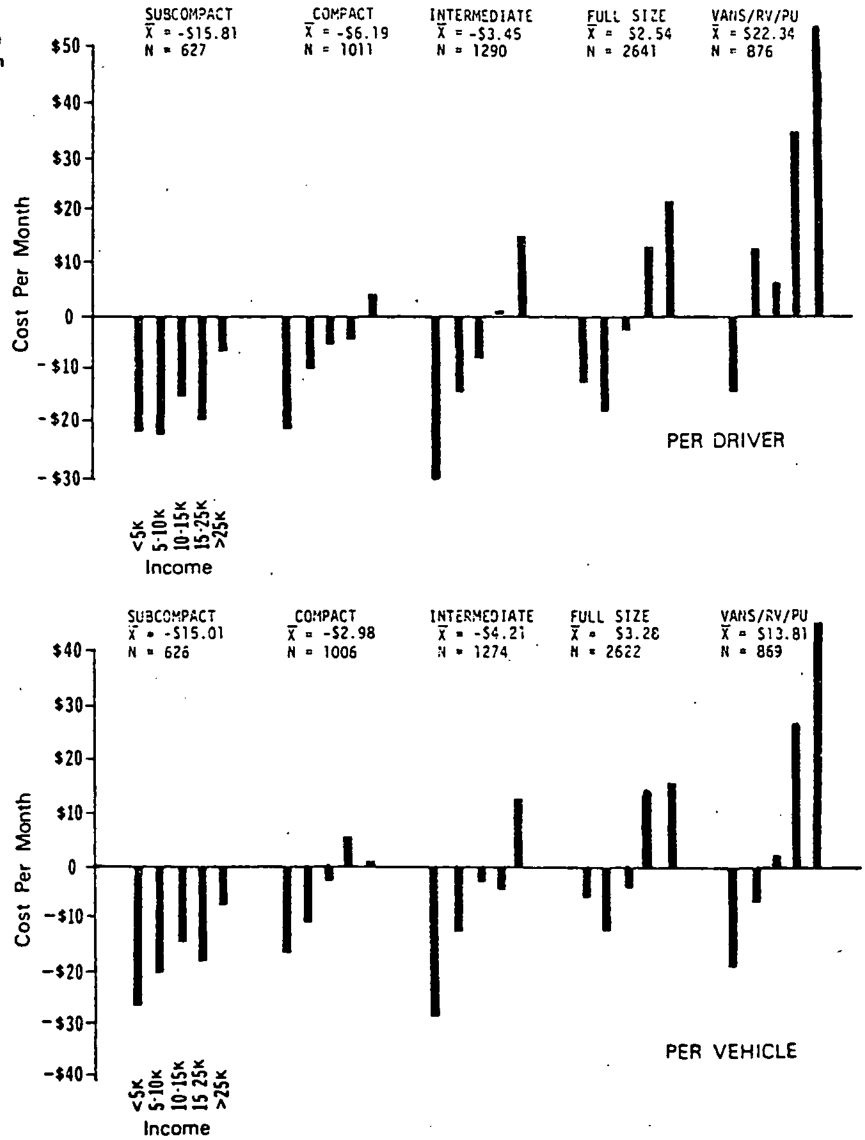


Figure 2. Distribution of potential white-market costs under a 25 percent gasoline shortfall for private vehicles, by income group and vehicle size most often used.



done to identify the characteristics of target populations for conservation strategies. Such analyses would be of particular relevance if rationing is considered on a per-driver basis.

This is a manipulation of personal travel data to examine who might be able to benefit from a white market in ration rights. It poses the highly improbable zero-sum scenario that all drivers could reduce their mileage an equal amount under rationing. Taken at face value, it does appear that wealthier vehicle users would be likely to buy available ration rights from the spare (coupon) capacity of lower income groups. Before assuming that to allow such a market to operate contributes to the general welfare, it should be asked if it is right in a shortage situation to assent to a system that reinforces existing demand patterns. Wealthier people will in all probability pay the white-market price; and at $1.25 more per gallon, the inhibition of their mileage will probably be minimal, given their inelasticity of demand for gasoline.

POST-MDES COMMENT

Since the analyses in the body of this paper were first reported in 1979, considerably more exploration of gasoline use, of the most promising targets for conservation policy, and of various conservation scenarios has occurred. An important extension of this work has been the examination of gasoline consumption by population group, not only in total gallons but also in terms of productivity (measured in occupant miles per gallon). This was calculated in a fully disaggregated manner and is based on the actual occupancy and vehicle size used for each of the 13 000 trips reported in the MDES. The results of the more recent work have given a broader perspective on the rationing policy issues raised in this paper. This section summarizes my conclusions on (a) rationing versus other measures, (b) examples of mechanisms for the use of ration rights to encourage efficient use of gasoline, and (c) some thoughts on future disaggregate data needs for energy conservation planning.

Rationing Versus Nonrationing Measures

The analyses of gasoline conservation scenarios have assumed the possibility of a major disruption in foreign oil supplies and a need for government policies to sharply reduce consumption of gasoline. Discussions of potential political instability in the Middle East have raised the possibility of gasoline supply shortfalls as high as 40 percent of normal. For the rationing scenarios, I assumed a 25 percent shortfall (5 percent more than the minimum needed to trigger presidential rationing authority).

From some of the more recent MDES analyses, it has

Figure 3. Average gasoline consumption and mileage driven per day, by survey respondent's household income.

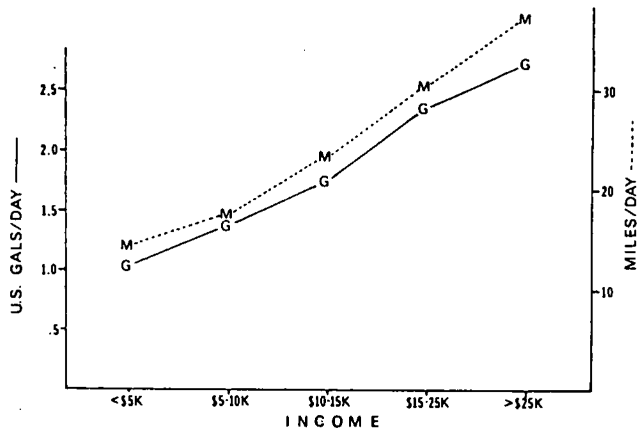


Table 5. Characteristics of drivers whose daily mileage is less than or more than 75 percent of the statewide average.

Characteristic	<75 Percent of Average Daily Mileage (N = 4593)	>75 Percent of Average Daily Mileage (N = 2310)
Male (%)	44.0	70.9
Under 30[a] (%)	34.1	37.0
Has chauffeur's license (%)	4.1	8.8
Mean number of other drivers in household	1.39	1.48
Mean number of children in household	0.87	0.99
Employed full time (%)	43.7	69.9
No education beyond high school (%)	59.5	51.1
In current residence more than 20 years (%)	20.0	15.4

[a]Survey covers drivers over 18 years old only.

been concluded that the most technically promising areas of conservation policy are commuter carpooling and the use of smaller cars (2). However, even in combination with politically favored measures—notably the 55-mph speed limit—it is estimated that the saving in the short term would not be enough to avert rationing in a 20 percent shortfall, let alone a 25 percent shortfall. By using these estimates, a policymaker might assume that there is no alternative to rationing (or a massive price increase) except to ban all nonessential driving. In fact, there is little evidence from available data to suggest that one type of driving is valued by a group more than another, that groups with higher mileages are not characterized by higher percentages of what is conventionally assumed to be nonessential (i.e., social and recreational), and that, therefore, a partial ban on driving—even if it were feasible—would not serve its implicit goal.

Nevertheless, recent estimates offer some valuable comparisons of the relative magnitude of total gasoline demand by various subgroups. For example, the fuel cost of allowing remote areas and small villages combined to continue 1976 levels of consumption, when everyone else is using 25 percent less, amounts to only 6.6 percent of the fuel being used by the suburbs. Or, if a consumption goal was set for those making under $10 000/year on the basis that they could not be expected to afford smaller cars and would therefore need a higher allocation, the fuel cost would be only 1.9 percent of the gasoline now used by those with incomes of more than $15 000/year.

The most important point of all, however, is that a policy decision made solely on the distributions of potential total gallons saved would be a decision made on incomplete information. Almost all of the policy discussions published focus on the bottom line of gallons saved and sometimes are accompanied by estimates of the income transfers that result from gasoline price. Through other disaggregate analyses not reported in this paper, it is possible to show that the efficiency with which gasoline produces occupant miles is neither constant nor a stable correlate of the amount of gasoline consumed. Thus, the potential exists to select policies not only on their potential to lower the number of gallons used but also in terms of the productivity with which different constituencies make use of these gallons. If it is acceptable to distribute ration allocations to states on the basis of historic use and to establish a white market that will reinforce a business-as-usual distribution of the available gasoline over income groups, then it should be acceptable to require that groups with special claims to normal levels of gasoline supply maximize the occupant miles produced. Thus, it might be reasonable to allow the remote areas of Michigan to continue consuming their 1976 average of 842 gal/driver, provided that they continue to produce 29.8 occupant-miles/gallon. Suburban drivers, who use almost the same amount (484 gal), would require 1003 gal to produce the same number of occupant miles as the remote-area drivers at their 1976 level of 25.2 occupant-miles/gal.

In contrast, policymakers have good reason to allocate the total available occupant miles that the nation or a state would have at its disposal based on mean occupant miles per gallon rather than on available gallons in their raw form. This simply involves an analysis of existing gasoline use to adjust the per-driver or per-vehicle allocation to a region or a user group. Historic use would remain the initial basis for allocation, but the number of gallons would be reduced by the amount of the supply shortfall and then adjusted up or down according to the region or user-group's deviation from mean occupant miles per gallon. Note that this would be much less disruptive than either a per-capita allocation, with the multitude of hardship claims that would follow, or an allocation based strictly on historic use. The latter has the effect of rewarding past wastefulness.

Another major conclusion of these studies is that, in addition to the use of existing occupant miles per gallon to normalize ration allocations, occupant miles per gallon varies enough to warrant the use of rationing to raise the efficiency of gasoline use. This implies that rationing would be modified to permit incentives or disincentives affecting behavior that changed passenger loads or the size of vehicle used.

Some Examples of Direct Incentives for Efficient Gasoline Use as Part of Rationing

Although it is impractical for rationing to be totally geared to individual driver differences in the number of occupant miles per gallon produced, some portion of a limited quantity of ration rights could be used to reward shifts to more efficient behavior. Some possible mechanisms follow that correspond to the areas of conservation identified from the data to have the greatest potential. These mechanisms differ from conventional ration allocation systems in that they use some institutional distribution points.

For commuter carpooling, a mechanism modeled after vanpooling is suggested. In many vanpooling schemes, a driver contracts with the employer to drive an established pool of employees to and from work. The driver is compensated for this with limited use of a subsidized vehicle (and such a van would itself have the potential of preferential ration rights). The nondriving members of the pool are usually charged a fixed price through payroll deduction, regardless of whether the van is used. An analogous situation could be developed in which a private automobile could be guaranteed extra ration rights (or better, gasoline supplied directly to this vehicle) if a minimum number of employees agreed to pay for a shared

ride via payroll deduction. This would require that the price of the ride be high enough to discourage bogus riders, that necessary changes to insurance practices be made, and that certain checks be made to verify the commuter-pool use of the vehicle, perhaps in connection with priority parking. Another related incentive would be to supply limited extra ration coupons as a bonus to anyone purchasing a monthly bus or rail pass for use between home and work.

For smaller cars, a large-scale mechanism would be the use of a vehicle-based allocation, but one in which more ration rights were distributed to cars getting high mileage per gallon. This is likely to be very unpopular. Perhaps more palatable would be to give a ration-rights bonus on purchase of a new small car; the bonus would be given even if a small car were replaced, as this might accelerate the release of a fuel-efficient vehicle to the used market.

For the overall speed limit, a disincentive is proposed. Especially considering the political resistance in some areas to assessing penalty points toward license suspension for energy speed, a conviction for violating the 55- or 50-mph limit would result in a partial loss of ration rights. To the extent that the driver and vehicle licensing agency would frequently update the lists for mailing ration rights, some flag for disqualification (perhaps for a limited period) is feasible.

Various recent proposals would facilitate the use of ration rights as efficiency incentives, including the possibility that the federal government would buy and sell coupons on the white market (as a regulatory mechanism), as well as the banking of ration rights (which would allow fractional distributions). Also, the trend toward group automobile insurance or leased vehicles as an employee fringe benefit may create some additional opportunities for efficiency incentives.

For organized end users, such as commercial fleets, the same principle could be applied. Instead of merely indexing distributions to historic use, efficiency targets could be established. Occupancy would be less relevant in most situations than commercial-activity vehicle miles per gallon. Thus, targets could be analogous to the corporate average fuel-efficiency standards used by the automobile manufacturing industry.

To protect favored automobile-dependent industries, such as tourism, fleet-based mechanisms could not be used. Instead, it may be feasible to allow ration rights to be distributed by tourist businesses, perhaps indexed to sales tax revenues. Although this would not directly improve occupancy, it would encourage ridesharing because a group of people could conceivably spend enough to obtain ration rights to cover a trip (especially in a small car). This has a considerable advantage over merely allocating extra gasoline supplies to tourist regions. Such a plan would give the motorist control over supply and reduce anxiety about venturing to distant resorts. This last mechanism is of special relevance to Michigan, which would prefer to assign some portion of a limited gasoline supply to support its northern regions—even at the cost of some percentage of local travel.

Finally, all of the mechanisms operate under the assumption that the cost of gasoline will not increase substantially above a free-market level, either directly by pricing or indirectly through white-market-coupon prices. This in itself implies that a shortage situation is moderate (perhaps a 10-25 percent shortfall) and that the government does not attempt to constrain demand by raising gasoline to a multiple of its preshortage price. Under severe shortages or such government intervention, most methods of improving occupant miles per gallon would be supply-constrained, and the incentive mechanism would not be needed.

Future Role of Disaggregate Data in Planning Energy Conservation

The case for a micro data base that covers the travel activity of an entire state has been amply demonstrated in these studies. It is relevant to other states, not only because Michigan covers a comprehensive range of human settlement types, but because it is the state level at which most of the allocation decisions must be made. Several points should be made about future applications of this methodology.

First, there may be problems in the relation between future survey data and future policy decisions. If gasoline allocations are known to be based on information volunteered by people about their travel behavior, the results may be biased either by the respondents or by those collecting and assembling the data. However, various checks can be made. Of the two components of occupant miles per gallon, vehicle size is relatively simple to validate from other sources, including vehicle records. Occupancy levels may be augmented by observation if required. It would in fact require considerable sophistication to circumvent data-quality checks of the type used in the MDES to detect administrative cheating.

Second, the first observation is one example of the need for the data design and collection to be controlled by someone with considerable sensitivity to the policy issues at stake.

Third, the collection of this type of data should be placed into a monitoring system that would ensure at least repeated, if not continuous, measurement of gasoline use. This would initially include a variety of measurement forms at different scales, including aggregate data such as gasoline tax revenues, and would use several different survey techniques. A major consideration here is overcoming the limitations of individual driver or vehicle data. Policymakers are accustomed to images of individuals as the decision-making units (or voters) for which they must plan, whereas it is clear that many energy-related decisions are made at the household level. A further need is to collect data that reveal behavioral trends not only for population subgroups or constituencies but also for activity in different types of space, such as corridors, sectors of conurbations, and isolated settlements. Such a multilevel system can be achieved at reasonable cost with careful sampling. This amounts to simultaneously applying several different and up-to-date research methods to the needs of transportation energy planners and policymakers.

Finally, it must be noted that the MDES data base was established for the most stable year in the last seven in terms of energy price and availability. It thus has value as a baseline of relatively unconstrained driving behavior against which assertions about normality may be tested in the future. It also demonstrates that in usable planning research, as elsewhere, luck has 51 percent of the votes.

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REFERENCES

1. Highway Travel Forecasts. Federal Highway Administration, U.S. Department of Transportation, Nov. 1974.
2. E.H. Lee and M.F. Glover. Use of Disaggregate Data to Evaluate Gasoline Conservation Policies: Smaller Cars and Carpooling. TRB, Transportation Research Record, 1980, in preparation.

Contingency Transportation Plans for Urban Areas and Their Potential Impacts

Darwin G. Stuart and Richard J. Hocking

This paper provides a broad overview of the energy-conserving actions available in urban areas to meet future transportation energy shortages. Based on transportation energy contingency plans prepared in several states and regions, as well as related literature, an inventory of both complementary and competing conservation actions is provided. The need for effective packaging of sets of reinforcing conservation actions is stressed. Illustrative estimates of both individual and cumulative impacts in reducing transportation energy consumption are also given based on the examples reviewed and the literature. The development of alternative energy contingency plans, staged to match anticipated energy shortfalls, and several key implementation-related issues are discussed.

Urban-oriented transportation energy contingency planning is interpreted largely from a short-range, quick-response point of view. Most of the energy-conserving actions considered are consequently near term in nature and can be implemented relatively quickly and at relatively low cost. These actions are to be contrasted with longer-range energy conservation planning, where more permanent and fundamental shifts in urban activity patterns--both directly and indirectly related to transportation needs—should be considered. The view has been expressed by some that significant transportation energy saving can only be achieved by pursuing such long-range solutions and that emphasis on short-range actions may represent a cosmetic, superficial reaction by the transportation planning community (1).

With this caution in mind, there nevertheless is a strongly felt need at state and local political decision-making levels for multiple-action energy contingency plans capable of addressing short-term transportation energy shortages (2-5). Recent experience has shown that such multiple-action strategies can be effective in dealing with temporary shortfalls in the 10-15 percent (and possibly higher) range.

PACKAGING OF ENERGY-CONSERVING ACTIONS

One of the critical steps in developing urban-oriented transportation energy contingency plans involves the grouping, or packaging, of related measures. Though the potential exists for such coordinated packages to provide a cumulatively greater degree of impact in reducing transportation energy consumption, these reinforcing aspects are not clearly understood. Furthermore, when it is realized that different degrees of implementation can be associated with many transportation actions, the number of alternative mix-and-match packages can become very large. Developing such alternative packages, which is another important dimension of contingency readiness, is discussed later in this paper.

In some instances, coordination between packages of measures themselves may be necessary because of associated shifts in travel demand and transportation supply among different packages. An example is the need to match increases in public transportation capability (supply) offered by one package (against the increases in transit use that may be stimulated by another package (such as automobile-use disincentives). Mixing shorter-range, immediate-action contingency actions with longer-range permanent conservation actions can also be an important aspect of developing coordinated packages. As noted above, however, this paper addresses only the shorter-range inventory of transportation-related conservation actions.

A broad approach to identifying packages of transportation-related energy conservation options is perhaps best tied to various components within the urban transportation planning process (6). Under such an approach, both short-range and long-range planning components can be addressed, as well as both publicly and privately oriented energy conservation actions. Both passenger and freight travel patterns should be covered, as well as the various structural elements of transportation supply (e.g., highways and transit). In addition to covering other travel behavior characteristics influencing transportation fuel use, such a broad approach to the inventory and packaging of conservation actions should also include nontransportation considerations. This particularly involves urban economic and institutional infrastructures that directly affect transportation demand and supply.

Table 1 (6) summarizes such a planning process-oriented classification and packaging of 75 different energy-conserving methods. Many are shorter-range in nature (indicated generally by an operations designation under the level-of-planning heading), while many others are longer-range in nature (generally indicated by a policy, systems, or regional designation). Also shown in Table 1 are energy-related influencing factors that are likely to affect each potential conservation method. These include, for example, fuel cost and availability, vehicle costs, and federal, state, and local government policy. The table suggests that, in general, shorter-range contingency-oriented packages of actions can be classed into several groups: travel of persons (including voluntary behavior on the part of individual travelers), freight transportation, transportation infrastructure (availability or price of street-parking supply), and transit infrastructure (wide variety of capacity-increasing, service-improving options).

Other classification efforts aimed particularly at short-range energy contingency planning have concentrated on the packaging of transportation supply elements (7, 8). As indicated in Table 2 (7), under this approach, as many as 10 different packaging categories for more than 50 suggested conservation methods can be identified. Although nearly all of the potential actions listed could be implemented within the space of a few months or less, several could require two to five years before significant impact is achieved. This timing-of-impact dimension in relation to the projected duration of future energy shortfalls represents a critical factor in energy contingency planning. Primary responsibility for nearly all of the actions listed in Table 2 would fall to state or local levels of government, including regional transit operators. In general, within any packaging category, where more than one level of government is indicated, coordination needs are increased.

The different packaging categories in Table 2 generally vary by mode, trip purpose, or type of modification in existing transportation supply. For example, improving traffic operations, ridesharing, and urban transit- and taxi-packaging categories all relate to actions that could be taken within specific modes and for associated transportation supply configurations. A different set of strategies relates to potential reductions in either or both work and nonwork travel.

Other packaging strategies related specifically to restrictions on urban travel supply (price or availability) or on gasoline sales practices (to stretch available supplies over a full month). The comment column in the table indicates some of the coordination and impact elements associated with the packaging of individual actions under each category. For example, reduced work-travel actions may negate transit and carpooling strategies and must also

Table 1. Potential energy conservation methods and related levels of government planning.

Group	Potential Methods for Conserving Energy	Level of Planning[a]	Influencing Factor
Travel of persons	Increase duration but decrease frequency of vacation trips	Policy	Fuel cost and availability
	Increase vehicle loading (car occupancy) by (a) building HOV lanes and (b) building carpool parking lots	(a) Systems and (b) project	Fuel cost, social factors, HOV lanes
	Increase trip chaining	Policy, regional	Fuel cost and availability
	Decrease trip production	Policy, regional	Fuel cost and availability
	Decrease trip length	Policy, regional	Distribution of opportunities
	Increase number of walking trips	Operations	Density, proximity of opportunities
	Increase use of bicycles and mopeds	Operations	Type of work, communications
	Work at home	Policy	Social factors; insurance costs
	Increase carpools and vanpools for work trips	Operations	Vehicle cost; fuel cost
	Speed purchase of fuel-efficient vehicles	Policy	Fuel cost and availability
	Increase use of transit	Policy, systems, and operations	Fuel cost; transit availability
Freight transportation	Increase or reduce truck size (for efficiency)	Policy	Fuel cost, vehicle cost
	Increase truck loading (for efficiency)	Private operations	Fuel cost, vehicle cost
	Reduce empty backhauling	Private operations	Fuel cost, regulations
	Increase efficiency of truck routing	Private operations	Fuel cost
	Consolidate urban deliveries	Private operations	Fuel cost, institutional factors
Urban infrastructure (built environment)	Increase density of residential settlement, particularly on transit routes	Policy, regional	HUD, FHA, state policies
	Increase density of nonresidential settlement; decrease scatter	Policy, regional	Economics of the firm
	Establish multiuse urban centers and subcenters	Policy, regional	State, local policies
	Provide telecommunications substitutes for travel	Policy	Economics
	Establish automobile-restricted zones	Corridor, project	Environmental, urban planning policies
Economic and institutional infrastructure	Establish four-day work week	Policy, individual	State, MPO
	Initiate Sunday store closings	Policy, individual	State, MPO
	Restrict store hours	Policy, individual	State, MPO
	Operate more, but smaller, store units	Individual	Economics; trends in transportation costs
Transportation infrastructure (streets, parking)	Install TOPICS, other signal improvements	Operations	State, federal government
	Install computerized traffic control systems	Operations	State, federal government
	Install access ramp metering	Operations	State, federal government
	Convert to one-way street systems	Operations	State, federal government
	Convert lanes to HOV lanes	Systems, operations	State, federal government
	Provide preferential HOV lanes at toll gates	Operations	State, federal government
	Build preferential access ramps	Systems, operations	State, federal government
	Provide traffic engineering improvements for buses	Operations	State, federal government
	Provide better service to pedestrians	Operations	State, federal government
	Provide bikeways and bike lanes	Operations	State, federal government
	Reduce or increase number of parking spaces	Operations	State, federal government
	Increase parking rates	Operations	State, federal government
	Provide differential parking rates	Operations	State, federal government
	Limit parking (percentage system)	Operations	State, federal government
	Provide parking for carpools and vanpools	Project, operations	State, federal government
	Provide parking for bus passengers	Project, operations	State, federal government
	Differential peak-hour tolls	Operations	State, federal government
	Create automobile-restricted zones	Project, operations	State, federal government
	Restrict trucks on routes and in certain areas	Operations	State, federal government
	Improve road surfaces	Operations, maintenance	State, federal government
	Enforce 55-mph speed limit	Operations	State, federal government
	Provide adequate arterial and expressway capacity	Systems	State, federal government
Transportation infrastructure (transit)	Improve routing and scheduling of buses	Operations	State, local government
	Provide express bus service	Systems, corridor	State, local government
	Park-and-ride service	Operations	State, local government
	Provide shuttle bus to central business districts (CBD's) with peripheral parking	Systems, operation	State, local government
	Improve passenger amenities	Operations	State, local government
	Improve fare-collection systems	Operations	State, local government
	Improve passenger information	Operations	State, local government
	Provide demand-responsive system	Systems, operations	State, local government
	Improve vehicle maintenance	Operations	State, local government
	Improve radio communications to buses	Operations	State, local government
	Install bus bays	Operations	State, local government
	Provide high-speed bus service between cities	Systems, operations	State, federal government
	Increase distances for students walking to school	Operations	Energy costs, safety, parents
	Prohibit taxi cruising	Operations	State, local government
Transportation infrastructure (rail and truck)	Implement trailer on flatcar trains between urban areas	Systems	Federal Railroad Administration
	Consolidate urban deliveries of small freight shipments	Systems, operations	State government
	Increase waterborne transportation	Private operations	State, federal government
	Require adequate urban truck-loading facilities	Private operations	MPO
	Ban truck idling	Operations	MPO, state
Vehicle fleet	Reduce automobile size and weight	Policy, individual	Cost, fuel price
	Selectively remove pollution control devices	Policy	Cost, fuel price
	Increase engine energy efficiency	Policy	Cost, fuel price
	Reduce truck sizes	Policy, individual	Cost, fuel price
	Reduce number of panel trucks and pickups	Individual	Cost, fuel price
	Use electric vehicles	Individual	Economics
Energy and economic factors	Increase fuel price	Policy	World supply, price, and cartels
	Make fuel unavailable	Policy	World supply, price, and cartels
	Ration gasoline	Policy	World supply, price, and cartels

[a]Where the decision maker is the individual or the firm, the "level of planning" indicated refers to that planning that bears on the supporting action, not the actual decision.

Table 2. Summary of potential actions that address transportation energy emergencies.

Action Area	Primary Responsibility	Time Horizon	Comment
Improve car internal operating efficiency			
Radial tires, power train, etc.	F	3 years	Most effective long-run action
Encourage small-car purchases	S	3 years	Low short-term payoff
Improve traffic operations			
Computerized traffic control	L, S	5 years	Most potential areas now in planning stage
TOPICS	L	2 years	Maximum potential not large; does not help rural areas
Access ramp metering	L	5 months	Also encourages carpooling and transit use
One-way streets	L	3 months	Requires major enforcement effort; rural areas primarily benefit
HOV lanes and ramps	L	3 years	
Enforce 55-mph limit	L, S	6 months	Requires major enforcement effort; rural areas primarily benefit
Enforce 50-mph limit	L, S	6 months	
Ridesharing			
Computer-match ridesharing	L	6 months	Very impersonal; actual carpool formation is low
Carpool coordinator program	S, L	1 year	Maximum potential in large companies; locally implemented; integrate with transit; stagger work hours
Vanpooling	F, S, L	1 year	Administrative difficulty; a second step beyond carpooling
Shared-ride taxi	L	2 months	Potential may be high
Reduce nonwork travel			
Encourage reduced discretionary travel	S (information); L (implementation)	1 year	Does not help low-income people; popular; potential is greatest over short term
Local trip-planning assistance	S, L	1 year	Helps public cut discretionary travel in palatable ways
Transportation audit program	S, L	1 year	Provides basic information to families to cope better
Bicycle and pedestrian promotion	L, T	1 year	Promote as alternative to out-of-town travel
Reduce work travel			
Work-hour policies	L, S, F	3 months	May negate transit and carpooling
Four-day work week	L, S, F	3 months	Must be coordinated with reduced weekend travel
Communications in lieu of travel	S, F	2-4 years	Potential is unclear
Urban transit and taxi			
Reduced off-peak fares	L	3 months	May encourage discretionary travel; may divert few riders from peak hour
Routing improvements and transit	L	6 months	Gains counter extra service
Express bus and park-and-ride	L	2 years	Park-and-ride has more potential
Downtown shuttles	L	3 months	Costly; low impact
Amenities	L	3 years	Attracts passengers
Passenger information	T	1 year	Essential step
Demand-responsive service	T	2 years	Uses more energy than is saved
Integrate client-agency services	L, T	1 year	Ensures service to clients of social service agencies; reduces hardship cases; no impact on general public
Fare collection	T		
Maintenance of buses	T	2 years	Marketing combined with information has the most potential
Transit and intercity links to CBD	T	1 year	Can enhance intercity promotion
School bus and charter taxi use	S, L	2 months	Need is unclear; potential unknown
Taxi-idling restrictions		3 months	Difficult to enforce
Diesel taxis	L	5 years	Diesel cab operation is up to 50 percent more efficient than gasoline operation
Urban travel restrictions			
Reduce parking spaces, increase time of day rates	L	2 years	Major negative impact is on commerce
Automobile congestion tolls	L	?	Politically unpopular
Automobile free zones	L	?	Politically unpopular
Urban truck restrictions	L	?	Major benefit is congestion reduction
Intercity travel			
Promote intercity air, rail, and bus	S	4 months	Weekend omitted travel may be reduced substantially
Electrify all trains	S	5 years	Business traffic; encourages increased load factors; short-term potential is low
State, parks, transit services	S	6 months	Could have major impact if tied to incentives (e.g., campsite reservations)
Freight			
Empty backhaul eliminations	S	1 year	Promotes freight competition
Air service rationalization	F, S	2 years	Promotes freight competition
Joint freight and passenger train operations	F, S	?	Generally improves railroad efficiency
Ban truck idling	S	2 months	
Gasoline sales restrictions			
Odd-even, one-half tank	S	2 months	An extreme step; does not conserve per se but reduces travel and prevents panic
Weekend closing of stations	S	2 months	Negative impact on recreation and businesses causes fillup problems during the week
Reduced station hours	S	2 months	May create panic buying and long lines
Rationing plans	F	6 months	Requires congressional approval; plans not available yet
No-drive day	S	2 months	Should be combined with ridesharing or transit actions to increase results

Note: F = federal government; S = state government; L = local government; T = transit.

be coordinated with reduced weekend-travel actions.

Another approach to the delineation of packages of energy-conserving actions focuses more specifically on constraints or restrictions that could be placed on existing transportation supply and demand (9). Such an approach is given in Table 3 (9), which lists seven different policy packages. The time dimension (short range versus long range) of these policy options is not specifically addressed but can be inferred from the data in Tables 1 and 2. In general, the policy emphasis of this approach is designed to indicate how government leadership in energy contingency planning might be structured. Policies are classified according to whether they restrict the cost of automobile travel, the availability of automobile travel and parking capacity, the capabilities of the automobile fleet, the capabilities of the nonautomobile transportation system (i.e., expansion rather than restriction), or in other ways. Table 3 also suggests the type of traveler-behavior response to be expected (e.g., reduction in travel, change in mix of trip purposes, and shift in mode).

Still another approach to the packaging of conservation actions is also organized around constraints on

Table 3. Classification of potential transportation energy policies.

	Potential Travel-Behavior Response					
Potential Energy Policy	Reduced Travel	Trip Purpose Change	Modal Shift	More Efficient Cars	Trip-End Relocation	Peak-Hour Shift
Increase the cost of automobile travel relative to travel by other modes	Yes	Yes	If available	For gasoline tax only	?	X
Increase fuel cost, either by tax or market rises in price						
Increase in automobile storage (parking) costs via parking fees						
Increase in automobile purchase price by tax or market price increases						
Increase in the time cost of automobile travel by enforced lower speed limits						
Reduce costs of other modes by changes in production technology or direct fare subsidy						
Limit the supply of automobile fuel (gasoline) available to travelers	Yes	Yes	If available	Yes	X	
Government-imposed fuel-rationing systems						
Market shortages (probably caused by external events or price controls)						
Restrictive queuing processes for gasoline purchase (i.e., odd and even days)						
Physically limit the use of automobiles	?	X	If available	X	Possibly	X
Enforced automobile-free zones at major trip destination zones						
Highway lanes reserved for buses only						
Drastically reduced parking capacity at major trip destination zones						
More restrictive driver-licensing regulations						
Change the characteristics of automobiles	X	X	X	Yes	X	X
Excise tax-rebate system based on fuel efficiency						
Enforced fuel-efficiency regulations on new vehicles						
Annual registration fees based on fuel efficiency						
Encouragement of new technology						
Change characteristics of nonautomobile transportation systems	Possible increase	X	Slight	X	X	X
Subsidies for expanded, improved existing transit systems						
Encouragement of vanpooling by subsidy, graduated tolls, or graduated parking fees						
Encouragement of new systems such as demand-activated minibus systems and people-movers						
Influence the geographic distribution of trip ends	Yes	X	If available	X	Yes	X
Encourage industrial parks						
Encourage large commercial centers						
Encourage higher-density residential development in close proximity to work and shopping centers						
Attempt to directly change travel patterns	?	Yes	Possibly	X	X	Yes
Modified work week (e.g., four-day week)						
Staggered work shifts						

transportation supply and demand, which are further distinguished by mode and component of travel behavior, and also by stressing two different impact time horizons (2). These time horizons involve expected time to implement—30 days or less and 6-24 months; see Table 4 (2). To reflect the fact that time required to implement could lead to different degrees of implementation, several specific conservation actions exist under both time horizons (particularly strategies that relate to ridesharing where impact can be expected to vary according to the level of government financial and promotional support and the market response of consumers over time).

Among the six action packages indicated in Table 4, an important distinction is made as to whether they related directly or indirectly to transportation fuel conservation. Direct conservation strategies generally involve ways to make the existing use of private automobiles (primarily) more efficient, while indirect strategies generally deal with improvement in nonautomobile modes designed to induce a modal shift. Direct conservation strategies might be regarded as achieving increased vehicle miles per gallon, while indirect strategies involve achieving increased person miles per gallon (and also include actual reductions in travel demand itself).

Confidence building is also singled out as a distinctly different kind of contingency "package" or action. Note also that, under direct conservation, a variety of voluntary conservation actions by individual motorists, all designed to increase fuel efficiency, is included. One of the more striking results of the 1979 fuel shortages in Illinois, for example, was the realization that a 5-10 percent transportation fuel shortfall can be accommodated relatively easily via such voluntary adjustments in personal travel behavior. Voluntary conservation measures were encouraged by Illinois' governor and by other state and local agencies, and, though data on specific travel behavior responses were not collected, it would appear that the cumulative effect of a variety of actions by individual motorists was sufficient to reduce consumption to a level consistent with reduced supplies. An important related role for confidence-building public information offices, either on the state or local levels, is consequently evident in order to encourage voluntary conservation.

Clearly, these different approaches to packaging and classifying potential energy conservation actions indicate the widely varying scale at which such actions might be taken. This scale is, in turn, reflected in anticipated time horizons of impact, time necessary to implement, and therefore potential use in short-range energy contingency planning.

Within specific urban areas, limited experience to date suggests that local and regional agencies tend to address mode-specific conservation actions whose implementation responsibilities are clear. For example, a series of five program packages was identified in Denver, with the first four of these addressing actions that could be taken (9, 10) within specific modes—ridesharing (carpool or vanpool), transit, parking, and preferential treatment (street or highway mode). Three different incremental-program package alternatives are indicated in Table 5 (11). These vary by (a) number of specific actions included and (b) degree of emphasis or investment with regard to specific actions. The sequential or incremental nature of these alternative packages, each increasing the degree of government effort over the previous package, is a particularly important feature of responsive energy contingency planning. Ideally, with an effective weekly or monthly monitoring program, public agencies could move

from one set of conservation packages (i.e., one program) to another in response to monthly shifts in the degree of energy shortfall.

Table 4. Implementation time horizons for selected energy conservation measures.

Conservation Measure	Implementation 30 Days	Implementation 6-24 Months
Confidence building		
Public information office	X	
Direct conservation		
Voluntary conservation	X	
Carpooling to work		
Neighborhood ridesharing (nonwork)		
Use 3 gal less per week per vehicle		
Multipurpose trips		
Reduced automobile air-conditioning		
Vehicle maintenance		
Increased transit		
Use fuel-efficient vehicle		
Public carrier for recreation travel		
Phone communication		
Nonmotorized travel		
Reduced public vehicle use	X	
Enforcement of 55-mph limit	X	
Enforcement of 50-mph limit	X	
Reduced use of transit air-conditioning	X	
Voluntary sales management	X	
Mandatory sales management	X	
Restrict weekend use of recreational vehicles	X	
Indirect conservation		
Ridesharing		
Employer-sponsored carpools	X	X
Employer-sponsored vanpools	X	X
Preferential parking for multiple-occupancy vehicles	X	X
One carless day per week	X	X
Preferential lanes for multiple-occupancy vehicles	X	X
Park-and-ride lots	X	X
Transit and land use relations		
Transit service for discretionary travel	X	
Expand transit service	X	X
School bus use	X	
Staggered work hours	X	X
Differential transit fare	X	
Four-day work week		X
Telecommunications		X
Street improvements		
TOPICS		X
On-street parking		X
Bikeways		X
Automobile-free zones		X
Economic disincentives		
Parking tax		X
Gasoline-guzzler tax		X
Registration fee (multiple automobiles)		X
Additional gasoline tax		X
Driving age		X

ESTIMATING INDIVIDUAL AND CUMULATIVE IMPACTS

The complex array of potential energy-conserving actions and the many different ways in which different levels of implementation of such actions can be combined into complementary packages present major problems in the analysis of potential impacts. In general, analysis of direct impacts (i.e., fuel savings) has followed a sequence of analyzing potential reductions in vehicle miles of travel (VMT), which may or may not reflect a preceding analysis of modal shift potentials for person travel, with further variations by trip purpose or peak- and off-peak travel periods possible. Estimated VMT reductions have typically been converted to transportation fuel-use reductions and overall petroleum-based energy consumption reductions for an urban area or state.

As a part of the shift toward transportation system management (TSM) as a major strategy for short-range transportation system improvement in urban areas, a number of federally sponsored analyses of modal shift or VMT reduction potential have already been completed (12-23). Results of these analyses are equally applicable in the analysis of energy conservation potentials for such TSM strategies. Although the general conclusion drawn from these earlier studies is that no single TSM or energy-conserving action is likely to have major impact (beyond a reduction of 1 percent or less in VMT), the literature on travel-behavior response to TSM (and related actions) indicates a limited capability to carefully analyze such responses (24-27). Few real data exist on the actual travel impact of individual TSM strategies.

The Illinois Energy Contingency Plan provides further insights into the uncertainties associated with estimating both the individual and the cumulative impacts of energy-conserving actions (2). In that project, uncertainty was reflected by the use of fairly broad ranges of potential impact for individual conservation actions only. Because our knowledge about overlapping, competing, and cumulative impacts is sparse, it is left to the reader to judge the extent to which individual actions constituting a package would reinforce one another and, particularly, to estimate net total impact. Due to the short time frame of the study itself, major reliance was placed on the TSM travel-behavior impact literature, as well as on limited sensitivity analyses of a logit modal-split model previously calibrated for the Chicago region (2).

Table 6 (2) summarizes the estimated reduction in VMT and annual fuel saving associated with 20 quick-response transportation energy conservation measures studied in Illinois (all potentially implementable within 30 days). As discussed earlier, the table distinguishes between direct conservation measures, which address the manner in which transportation fuels are used by vehicles of different types, and indirect measures, which address more fundamental changes in travel behavior that can either (a) induce

Table 5. Summary of alternative program packages developed in Denver.

Measure	Program 1	Program 2	Program 3
Ridesharing	Employer promotion and matching in all firms with 50 or more employees	Employer promotion and matching in all firms with 50 or more employees; vanpooling available in all firms with 250 or more employees; transit fare subsidy of 50 percent available to all workers; preferential carpool parking	Employer promotion and matching in all firms with 50 or more employees; vanpooling available to all firms with 250 or more employees; transit fare subsidy of 50 percent available to all workers; preferential carpool parking
Transit	Improved frequency on CBD routes	Improved frequency on CBD routes; 20 percent reduction in in-vehicle travel time for CBD routes	25 percent areawide improvement in frequency; 20 percent reduction in in-vehicle travel time for CBD routes
Parking	Increased commuter parking costs in CBD by $1/day	Increased commuter costs in CBD by $1/day; reduced parking availability so that round-trip walk times are increased by 10 min	Increased commuter costs areawide by $1/day; reduced areawide parking availability so that round-trip walk times are increased by 10 min
Preferential treatment	–	Improved areawide level-of-service for all vehicles by 5 percent	Improved areawide level of service for all vehicles by 5 percent
Pricing	–	–	Triple the price of fuel in terms of 1965 dollars

Table 6. Estimated direct impacts of 30-day transportation energy conservation measures in terms of annual fuel saving and reduced VMT.

Measure	Estimated Annual Fuel Saving				Estimated Reduction in Annual VMT			
						Percent[b]		
	Gallons per Year (000 000s)	Btu per Year (000 000 000 000s)	Reduction in Total Energy Use[a] (%)	Reduction in Transportation Fuel Use (%)	Amount (000 000s)	Statewide	Chicago Region	Peoria Region
Direct conservation								
Voluntary conservation								
Carpooling to work	15.5-116.30	1.94-14.50	0.05-0.40	0.2-1.8	216-1620	0.4-0.7	0.5-0.8	0.2-0.4
Neighborhood ridesharing (non-work)	38.80	4.85	0.10	0.6	540	1.0-2.5	1.2-3.2	1.0-2.4
Use 3 gal less per week per vehicle	194.0-775.00	24.20-96.90	1.00-2.00	3.0-2.0	2700-9180	5.0-17.0	8.0-24.0	5.6-16.9
Multipurpose trips	19.4-38.80	2.42-4.85	0.06-0.10	0.3-0.6	270-540	0.5-1.0	0.6-1.6	0.5-1.2
Reduced automobile air-conditioning	15.5-23.30	1.94-2.91	0.05-0.07	0.2-0.4	0	0	0	0
Vehicle maintenance	15.5-31.00	1.94-3.88	0.05-0.10	0.2-0.5	0	0	0	0
Increased transit	19.4-38.80	2.42-4.85	0.06-0.10	0.3-0.6	270-540	0.5-1.0	1.1	0.2
Use fuel-efficient vehicle	15.5-27.10	1.94-3.39	0.05-0.08	0.2-0.4	0	0	0	0
Public carrier for recreation travel	11.6-58.10	1.45-7.26	0.04-0.20	0.2-0.9	162-810	0.3-1.5	0.3-1.5[c]	0.3-1.5[c]
Phone communication	11.60	1.45	0.04	0.2	162	0.3	0.0-1.0[c]	0.0-1.0[c]
Nonmotorized travel	19.4-31.00	2.42-3.88	0.06-0.10	0.3-0.5	270-432	0.0-0.4	0.0-0.4	0.0-0.4
Reduced public vehicle use	7.57	0.95	0.02	0.1	105	0.2		
Enforcement of 55-mph limit	19.4-34.90	2.42-4.36	0.06-0.10	0.3-0.5	0	0	0.8[d]	0.9[d]
Enforcement of 50-mph limit	38.8-50.40	4.85-6.30	0.10-0.20	0.6-0.2	0	0	1.5[d]	1.2[d]
Reduced use of transit air-conditioning	0.04-0.07	0.0005-0.01	Negligible	0.001-0.002				
Restrict weekend use of recreational vehicles	27.10	3.39	0.08	0.400	162	0.30		
Indirect conservation								
Transit service for discretionary travel	3.90	0.48	0.01	0.060	54	0.10	0.10	NE[e]
Employer-sponsored carpools	38.80	4.85	0.10	0.60	540	1.00	1.40	1.10
Employer-sponsored vanpools	38.80	4.85	0.10	0.60	540	1.00	1.40	1.10
Preferential parking for multiple-occupancy vehicles	1.9-3.90	0.24-0.48	0.006-0.01	0.03-0.060	27-54	0.05-0.50	0.65	0.05-0.10
One carless day per week	387.60	48.50	1.20	6	5400	5.0-10.0	5.0-10.0	10.0
Preferential lanes for multiple-occupancy vehicles	38.8-116.30	4.85-14.50	0.1-0.40	0.6-1.800	540-1620	1.0-3.0	1.0-3.0	NE[e]
Temporary park-and-ride lots	1.9-3.90	0.24-0.48	0.006-0.01	0.03-0.060	27-54	0.7-0.6	0.5-1.0	NE[e]
Expand transit service	19.4-38.80	2.4-4.80	0.06-0.10	0.3-0.600	270-540	0.5-2.0	0.5-1.0	1.0-3.0
Differential transit fare	1.9-3.90	0.24-0.48	0.006-0.01	0.03-0.060	27-54	0.5-1.0	0.6-1.1	0.4-1.0

[a] For both transportation and nontransportation purposes.
[b] Percentage of automobile VMT, unless otherwise indicated.
[c] Statewide average percentage.
[d] Percentage of fuel saved.
[e] No effect.

increases in shared-vehicle transportation or (b) reduce the amount of or demand for passenger miles of travel. Both voluntary and mandatory energy conservation options are included. In some cases, the same measure may have both a voluntary and a mandatory version.

Table 7 (2) summarizes another set of energy conservation measures that, in general, have implementation time frames ranging from 2 or 3 months to 24 months. All of these measures can be classed as indirect, and most are designed to induce a modal shift to more energy-efficient means of personal travel. Many of the measures are characterized as being more permanent, involving facilities and services that are more extensive and capital-intensive than the 30-day measures. The first six measures in Table 7, all associated with some aspect of ridesharing, represent more sustained and intensive efforts of counterpart 30-day versions. The next two measures also represent more intensive versions of corresponding quick-response actions.

These tables illustrate not only the kinds of energy conservation measures that might be considered in statewide and metropolitan energy contingency plans but also the range of actual fuel-use reductions that might be associated with any individual measure.

In Table 6, a number of essentially voluntary (direct or indirect) measures show the potential for (a) significant cumulative impact on VMT, (b) immediate-action response capabilities, and (c) likelihood of general public acceptance. Nearly all such measures show a potential reduction in transportation fuel use of less than 1 percent on an individual basis, but the aggregate effect of several measures in combination can be more pronounced. Among the different voluntary conservation measures suggested, note that several involve no reduction in actual VMT but, instead, emphasize more fuel-efficient operation of the private vehicle fleet (for example, in multiple-car households, the emphasis is on the use of the most fuel-efficient vehicle). Other voluntary measures emphasize actual reduction in passenger miles and vehicle miles of discretionary travel (e.g., shopping, personal business, social, and recreational) that might be achieved, for example, by multiple-purpose trips (e.g., trip chaining).

Most of the indirect conservation measures listed in Tables 6 and 7 involve different approaches to stimulate or induce a shift from private vehicular travel to ridesharing (carpool or vanpool) or to public transit options. An overriding issue associated with desired or targeted shifts to more fuel-efficient modes consequently centers simply on the probability that such shifts can actually be achieved in the unrestrained consumer marketplace.

For all of the indirect conservation measures listed in Tables 6 and 7, the answer to this question is generally that only rather limited, purely voluntary, shifts to group travel modes should be expected. Results of most urban area travel-demand analyses indicate that, particularly within a 30-day implementation time frame, the kinds of transit or group travel service improvements and promotional campaigns that are possible should not be expected to induce modal shifts of more than a few percentage points. Perhaps the most challenging of the factors affecting implementation difficulty are associated with the modal shift issue.

Tables 8 and 9 (2) summarize judgmental estimates of indirect impact in the Illinois study for the same energy conservation measures listed in Tables 6 and 7. Such indirect impacts of energy conservation on transportation use, performance, and concomitant impacts are likely to have a limited effect on implementation decision making.

Table 7. Estimated direct impacts of transportation energy conservation measures implementable in 6-24 months in terms of annual fuel saving and reduced VMT.

Measure	Estimated Annual Fuel Saving				Estimated Annual Reduction in VMT			
						Percent[b]		
	Gallons per Year (000 000s)	Btu per year (000 000 000 000s)	Reduction in Total Energy Use[a] (%)	Reduction in Transportation Fuel Use (%)	Amount (000 000s)	Statewide	Chicago Region	Peoria Region
Ridesharing								
Carpool and vanpool	36.5	4.57	0.12	0.6	509.2	0.94	1.4	1.1
Preferential parking	13.95	1.733	0.05	0.2	193.7	0.36	0.65	0.1
Carless day	286.4-387.6	35.8-48.46	0.92-1.25	4.4-6.0	3990.0-5400.0	7.39-10.00	5.0-10.0	10.0
Preferential treatment	20.2-60.7	2.53-7.59	0.07-0.20	0.3-0.9	282.0-846.0	0.52-1.57	1.0-3.0	
Park-and-ride	1.01-2.02	0.127-0.253	0.003-0.007	0.02-0.03	14.1-28.2	0.03-0.05	0.05-0.10	
Transit and land use relations								
Transit service improvements	17.57-42.60	2.20-5.33	0.06-0.14	0.3-0.7	245.0-594.0	0.45-1.1	0.5-1.0	1.0-3.0
Staggered work hours	Up to 23.93	Up to 2.997	Up to 0.08	Up to 0.4				
Four-day work week	27.67-166.3	3.46-20.8	0.09-0.54	0.4-2.6	386-2316	0.7-4.3	1.0-6.0	1.0-6.0
Telecommunications	Up to 27.7	Up to 3.46	Up to 0.09	Up to 0.43	Up to 386.0	Up to 0.71	Up to 1.0	Up to 1.0
Street improvements								
TOPICS	Up to 23.93	Up to 2.997	Up to 0.08	Up to 0.4	Up to 334.0	Up to 0.6	Up to 1.0	Up to 0.5
On-street parking	Up to 23.93	Up to 2.997	Up to 0.08	Up to 0.4	Up to 334.0	Up to 0.6	Up to 1.0	Up to 0.5
Bikeways	Up to 13.83	Up to 1.737	Up to 0.05	Up to 0.2	Up to 193.0	Up to 0.4	Up to 0.5	Up to 0.5
Automobile-free zones	11.53-53.59	1.46-6.703	0.04-0.17	0.2-2.8	161.8-746.6	0.3-1.4	0.5-2.5	0.2-0.4
Economic disincentives								
Parking tax	87.3-125.4	10.91-15.69	0.28-0.40	1.4-1.9	1215.8-1747.4	2.3-3.2	3.5-4.5	2.2-4.6
Gasoline guzzler tax	19.3-38.8	2.42-4.85	0.11	5.4				
Registration fee (multiple automobiles)	34.9	4.36	0.06-0.12	0.3-0.6	486.0	0.9	0.9	0.9
Additional gasoline tax	68.3-145.8	8.53-18.22	0.22-0.47	1.1-2.3	951.0-2031.0	1.8-3.8	2.0-4.0	1.5-3.5
Driving age	38.7	2.32	0.12	0.6	540.0	1.0	1.0	1.0

[a]For both transportation and nontransportation purposes. [b]Percentage of automobile VMT, unless otherwise noted.

Table 8. Estimated indirect impacts of 30-day transportation energy conservation measures given certain criteria.

Measure	Criterion						Comment
	Shift to Group Travel[a]	Change in Travel Behavior[b]	Reduction in Peak-Hour Congestion[c]	Improvement in Air Quality	Improvement in Traffic Safety	Undesirable Economic Impact[d]	
Direct conservation							
Voluntary conservation							
Carpooling to work	3	1	3	2	2	1	
Neighborhood ridesharing (nonwork)	1	2	1	1	1	–	
Use 3 gal less per week per vehicle	2	3	1	3	3	2	High level of voluntary change in travel behavior required
Multipurpose trips	1	3	1	2	–	–	
Reduced automobile air-conditioning	–	–	–	2	–	–	
Vehicle maintenance	–	–	–	2	1	–	
Increased transit	2	1	1	1	1	–	
Use fuel-efficient vehicle	–	–	–	2	–	–	
Public carrier for recreation travel	2	2	–	1	1	1	
Phone communication	–	–	–	–	–	–	
Nonmotorized travel	–	1	–	1	–	–	
Reduced public vehicle use	–	–	–	–	–	–	
Enforcement of 55-mph limit	–	–	–	1	2	–	
Enforcement of 50-mph limit	–	–	–	1	3	1	Likely to be unpopular, especially with trucking industry
Restrict weekend use of recreational vehicles	–	2	–	–	–	2	Difficult to enforce; adverse effect on tourist industry
Indirect conservation							
Transit service for discretionary travel	1	1	–	–	–	–	
Employer-sponsored carpools	2	–	1	1	1	–	
Employer-sponsored vanpools	2	–	1	1	1	–	
Preferential parking for multiple-occupancy vehicles	1	–	1	1	–	–	
One carless day per week	3	3	3	3	3	2	Likely to be unpopular with motoring public
Preferential lanes for multiple-occupancy vehicles	3	1	2	1	1	–	
Temporary park-and-ride lots	1	–	–	–	–	–	
Expand transit service	2	1	1	1	1	–	
Limited staggered work hours	–	–	3	1	–	–	

Note: 1 = minor effect; 2 = moderate effect; 3 = major effect.

[a]Transit, carpool, or vanpool.
[b]Reduced frequency or length of nonwork-related (discretionary) travel.
[c]Transit or highway.
[d]Increased unemployment or disruption to economic activity patterns.

Table 9. Estimated indirect impacts of transportation energy conservation measures implementable in 6-24 months given certain criteria.

	Criterion						
Measure	Shift to Group Travel[a]	Change in Travel Behavior[b]	Reduction in Peak-Hour Congestion[c]	Improvement in Air Quality	Improvement in Traffic Safety	Undesirable Economic Impact[d]	Comment
Ridesharing							
Carpool	3	1	3	2	2	1	
Vanpool	2	–	1	1	1	–	
Preferential parking	1	–	1	1	–	–	
Carless day	3	3	3	3	3	2	
Preferential treatment	3	1	2	1	1	–	
Park-and-ride	1	–	–	1	–	–	Suburban station area impacts; more automobile congestion
Transit and land use relations							
Transit service improvements	2	1	1	1	1	–	
Staggered work hours	1	3	3	1	–	2	Change pattern of business
Four-day work week	3	3	2	–	–	3	Major shifts in business activity patterns
Telecommunications	–	3	2	2	1	–	Stimulates some business growth
Street improvements							
TOPICS	–	–	3	1	3	–	
On-street parking	–	–	1	–	1	1	Curb parking important to certain businesses
Bikeways	–	2	2	3	–	–	
Automobile-free zones	1	–	1	3	–	1	Could be major benefit as part of redevelopment
Economic disincentives							
Parking tax	2	2	–	1	–	2	Uneven distribution effects are problems
Gasoline-guzzler tax	1	1	–	2	–	2	Reduced sales of larger vehicles and recreational vehicle business
Registration fee (multiple automobiles)	1	2	–	–	–	1	Reduced automobiles sales and services
Additional gasoline tax	2	2	1	1	–	3	Regressive tax; impact on low-income groups
Driving age	2	3	2	–	2	3	Retards employment; negative impact on drive-ins and other automobile-oriented businesses

Note: 1 = minor effect; 2 = moderate effect; 3 = major effect.

[a]Transit, carpool, or vanpool
[b]Reduced frequency or length on nonwork travel.
[c]Transit or highway.
[d]Increased unemployment or disruption to economic activity patterns.

For one thing, two areas of indirect impact—improvements in air quality and traffic safety—are likely to be beneficial. The reductions in VMT that can help achieve energy conservation are the same VMT reductions associated with reduced air pollutant emissions and lower accident statistics. Although related changes in travel behavior—for example, shift to group travel and reduced frequency or length of nonwork travel—may be viewed as undesired travel hardships by some participants, such feelings of dissatisfaction are not likely to be strong.

Two other kinds of indirect impacts listed in these tables are, however, significant in nature. These impacts—undesirable economic disruption and reduction in peak-hour congestion—should perhaps receive more attention as decision-making criteria for assessing energy conservation options. Undesirable economic impacts that could affect lower-income families, and automobile-oriented commercial enterprises particularly, are generally associated with economic disincentives aimed at the automobile traveler. In addition to these kinds of distributional impact questions within urban areas, some of the stronger energy conservation options aimed at private automobile travel could also impact automobile-purchasing patterns, thus reinforcing the general trend toward smaller and more fuel-efficient vehicles.

In the longer term, reductions in peak-hour automobile congestion are likely to offer continuing and strong incentives for a return to automobile travel. This kind of return-to-normal risk in sustained energy contingency programs should not be underestimated.

STAGING OF ALTERNATIVE CONTINGENCY PLANS

In the Illinois contingency plan, the delineation of packages of energy conservation measures was accompanied by the definition of four alternative scenarios of energy emergency. These scenarios were defined quite simply in terms of the percentage reduction in transportation fuels (primarily gasoline) expected on a month-to-month basis. The four levels ranged from 10 percent to 25 percent shortfall, in five-percentage-point increments.

Figure 1 summarizes an initial attempt to match several quick-response energy conservation packages against the level of energy shortfall for which they seem most appropriate. While such a match was found to be of value at a conceptual or organizational level, participants in the study were not able to reach agreement on the extent to which some individual conservation measures were more or less appropriate for different shortfall levels. In fact, because the level of effort associated with a particular conservation strategy might itself vary with the degree of shortfall, one-step definitions of energy conservation measures tend to be overly simplistic.

Different energy shortfall scenarios should consequently not be expected to have only a single set of applicable energy conservation options. Rather, not only are different individual conservation measures likely to be applicable (at varying levels of effort or public and private commitment), but such individual measures could be combined in different ways to reinforce one another and to reinforce other packages. Full exploration of this kind of multiple matching of conservation measures against shortage scenarios was not possible within the time frame established for the Illinois study. Nevertheless, it should form an important part of more detailed energy contingency planning. As indicated above, the number of alternative actions that have a bearing on energy conservation appears to be quite numerous.

Preliminary analysis of alternate energy shortfall scenarios has also been an important part of transportation energy contingency planning in New York State (7, 8). Four

Figure 1. Illustration of the staging required for 30-day program packages directed toward energy conservation.

Package A–Information (Voluntary Conservation)

1. Public Information
2. Voluntary Conservation
3. Reduce Public Vehicle Use

Package B--Operating Efficiency

4. Enforcement of 55 mph
5. Enforcement of 50 mph
6. Reduce Use of Transit Vehicle A/C

Package C-Sales Management

7. Voluntary Sales Management
8. Mandatory Sales Management
9. Restrict Weekend Use of Recreation Vehicles
10. Transit Service for Discretionary Travel

Package D–Ride-Sharing (Personal Transit)

11. Support Employee Car Pools
12. Support Employee Van Pools
13. Preferential Parking for MOV
14. Carless Days
15. Preferential Lanes and Traffic Control for MOV
16. Temporary Commuter Park-N-Ride Lots

Package E–Public Transportation (Mass Transit)

17. Travel Service Improvements (Work Trip)
18. Use of School Buses
19. Limited Staggered Work Hours
20. Differential Transit Fare

RELATIONSHIP TO TRANSPORTATION FUEL SHORTAGE

△ LEVEL NO. 1 MEASURE (UP TO 10% SHORTFALL)

□ LEVEL NO. 2 MEASURE (10-15% SHORTFALL)

○ LEVEL NO. 3 MEASURE (15-20% SHORTFALL)

✱ LEVEL NO. 4 MEASURE (20-25% SHORTFALL)

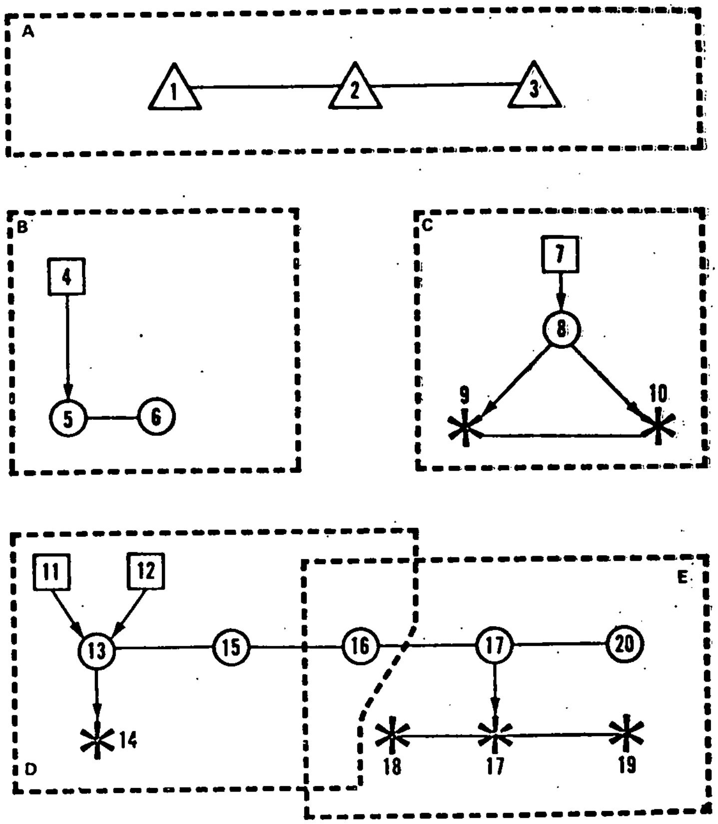

Table 10. Transportation energy contingency scenarios developed for New York State.

Scenario	Gasoline Price ($/gal)	Gasoline Shortfall (%)	Time Horizon	Probability of Occurrence	Immediate Characteristic
Level 1 (relax)	0.95-1.05	1-3	1 year	0.3	Some reduction of nonwork travel, slight shift to transit and ridesharing, trip chaining (multipurpose trips), continued surge in small-car purchasing
Level 2 (muddle)	1.00-1.05	5-10	15-18 months	0.5	Level 1 responses plus increase in commuter transit travel, reduction in weekend travel, further reductions in discretionary travel
Level 3					
Crisis A	0.92-0.98	8-14	Unknown	0.2	Level 2 responses plus long lines at service stations, odd-even rationing, shorter station hours
Crisis B	1.05-1.10	10-20	Unknown	0.2 (after Crisis A)	Level 3-A responses plus transit ridership up another 15-30 percent, summer vacations curtailed, rapidly rising gasoline prices

different scenarios on three levels were identified and are summarized in Table 10 (8). Although clearly speculative in nature, the relative differences among the scenarios are indicative of some of the important indicators that bear monitoring. These include price increases (although price increases since May 1979 have already outstripped each of the scenarios), degree of supply shortfall compared to previous years, time horizon, changes in hours and practices of service stations, observable changes in travel behavior, and modal shifts to transit and shared ride. Though probabilities of occurrence in Table 10 are largely judgmental, such scenarios as "muddle" (probability of occurrence = 0.5) may help put other more optimistic or pessimistic scenarios in perspective. This kind of multiple contingency response to varying energy shortfall scenarios has also been explored at the regional level (5, 28).

UNCERTAINTY REGARDING EFFECTIVENESS

As discussed earlier, the comparison of recent energy contingency plans indicates high levels of uncertainty associated with forecasted travel impacts. Not only is uncertainty associated with the individual and cumulative impacts of different energy-conserving actions, but compounding uncertainties are associated with the timing and duration of transportation fuel shortfalls, as well as with the timing and extent of the implementation of any individual conservation action.

One useful way to summarize these uncertainties is to focus specifically on the types of travel most likely to be affected by different actions. Returning to the broader long-range and short-range inventory of potential energy conservation methods discussed earlier (6), it is possible to identify seven different types of urban-oriented trip making that represent high-priority targets for energy conservation. Table 11 (6) matches these different targets against the various potential energy conservation methods, thus indicating which type of travel is most likely to be affected by a given strategy. The lack of specific quantitative estimates of impact in Table 11 is a corresponding reflection of the uncertainty associated with degree of impact, not only for any given conservation action but also with regard to the differential impact on different types of trip making.

Table 11. Impact of potential methods for conserving energy on urban travel components.

Group	Potential Method for Conserving Energy	Impact of Energy-Conserving Method: Long Trips (All Purposes)	Work Trips	Shopping	Social, Recreational	Trips Within One Mile	Transit Trips	Freight Transportation
Travel of persons	Increase duration but decrease frequency of vacation trips	X						
	Increase vehicle loading (car occupancy) by (a) building HOV lanes and (b) building carpool parking lots		X	X	X			
	Increase trip chaining			X	X			
	Decrease trip production			X	X			
	Decrease trip length	X						
	Increase number of walking trips					X		
	Increase use of bicycles and mopeds					X		
	Work at home		X					
	Increase carpools and vanpools for work trips		X					
	Speed purchase of fuel-efficient vehicles	X	X	X	X	X		
	Increase use of transit		X				X	
Freight transportation	Increase or reduce truck size (for efficiency)							X
	Increase truck loading (for efficiency)							X
	Reduce empty backhauling							X
	Increase efficiency of truck routing							X
	Consolidate urban deliveries							X
Urban infrastructure (built environment)	Increase density of residential settlement, particularly on transit routes	X	X	X	X	X	X	
	Increase density of nonresidential settlement, decrease scatter	X	X	X	X		X	X
	Establish multiuse urban centers and subcenters	X	X	X	X		X	X
	Provide telecommunications substitutes for travel	X	X				X	
	Establish automobile-restricted zones							
Economic and institutional infrastructure	Establish four-day work week		X				X	
	Initiate Sunday store closings			X	X			
	Restrict store hours			X	X			
	Operate more, but smaller, store units		X	X				
Transportation infrastructure (streets, parking)	Install TOPICS, other signal improvements							
	Install computerized traffic control systems		X	X				
	Install access ramp metering	X						
	Convert to one-way street systems	X						
	Convert lanes to HOV lanes	X						
	Provide preferential HOV lanes at toll gates	X						
	Build preferential access ramps	X						
	Provide traffic engineering improvements for buses		X					
	Provide better service to pedestrians					X		
	Provide bikeways and bike lanes					X		
	Reduce or increase number of parking spaces							
	Increase parking rates		X	X				
	Provide differential parking rates		X	X				
	Limit parking (percentage system)		X				X	
	Provide parking for carpools and vanpools		X					
	Provide parking for bus passengers		X				X	
	Differential peak-hour tolls		X					
	Create automobile-restricted zones						X	
	Restrict trucks on routes and in certain areas							X
	Improve road surfaces							
	Enforce 55-mph limit	X						
	Provide adequate arterial and expressway capacity	X						
Transportation infrastructure (transit)	Improve routing and scheduling of buses		X	X			X	
	Provide express bus service		X				X	
	Park-and-ride service		X				X	
	Provide shuttle bus to CBDs with peripheral parking		X	X			X	
	Improve passenger amenities		X	X			X	
	Improve fare-collection systems		X	X			X	
	Improve passenger information		X	X			X	
	Provide demand-responsive system			X			X	
	Improve vehicle maintenance						X	
	Improve radio communications to buses						X	
	Install bus bays						X	
	Provide high-speed bus service between cities	X					X	
	Increase distances for students walking to school					X		
	Prohibit taxi cruising							
Transportation infrastructure (rail and truck)	Implement TOFC trains between urban areas							X
	Consolidate urban deliveries of small freight shipments							X
	Increase waterborne transportation							X
	Require adequate urban truck-loading facilities							X
	Ban truck idling							X
Vehicle fleet	Reduce automobile size and weight	X	X	X	X	X		
	Selectively remove pollution control devices							
	Increase engine energy efficiency	X	X	X	X	X		
	Reduce truck sizes							
	Reduce number of panel trucks and pickups							
	Use electric vehicles							
Energy and economic factors	Increase fuel price	X	X	X	X	X	X	X
	Make fuel unavailable	X	X	X	X	X	X	X
	Ration gasoline	X	X	X	X	X	X	X

Note: X indicates positive impact of energy-conserving action on urban travel component.

Table 12. Energy policy testing based on key UTPS variables.

			Short-Term Forecast			
Policy	Key UTPS Variable	Other Essential Element	S	E	Difficulty[a]	Overall Capabilities to Test Now
Speed reductions	Distribution (nonwork) modal split		H	L	1	Good
Increased fuel efficiency	Assignment, evaluation	Base (mile/gal)	H	–	1	Good
Transit fare reductions	Distribution modal split		H	M	2	Good
Carpooling	Automobile occupancy		H	L	2	Medium
Increased parking charges	Distribution modal split		H	L	2	Medium
Tax on gasoline	Generation, distribution, and modal split	Gasoline price elasticity	M	L	2	Medium
Staggered work hours, four-day week	Generation and modal split		M	L	3	Medium
Transit use increase due to gasoline price increase	Modal split	Gasoline price forecast; elasticity	M	L	2	Medium
Automobile-restricted zones	Distribution modal split	Redistribution activities	M	M	2	Fair
Gasoline price increase (general)	Generation, distribution, and modal split	Gasoline elasticity by trip purpose; disposable income reallocation	M	–	3	Poor
Gasoline at higher price if car gets low mileage per gallon (gas guzzler)	Generation, distribution, and modal split	Selective trip priorities, frequencies	M	L	3	Poor
Fixed-ration ceiling	Generation, distribution, and modal split (location)	Trip priorities	M	L	3	Poor
Sunday driving ban		Weekend travel patterns, behavior	L	L	4	Poor
Urban activity redistribution	Land use activity	Long-term elasticity; redistribution of activities	L	L	5	Poor

Note: S = sensitivity; E = estimate; H = test can be done; M = some elements possible; L = weak test possible.

[a]Ranked in ascending order of difficulty from 1 (easy) to 5 (very difficult).

The high-priority targets include the following (6):

1. Long trips—all trips more than 6 miles in length and particularly those more than 12 miles in length, without regard to purpose;
2. Work trips—longer-than-average trips that generate approximately 38 percent of daily automobile VMT, or 43 percent of business trips related to work;
3. Social or recreational trips—trips that generate approximately 15 percent of daily automobile VMT;
4. Shopping trips—trips that generate approximately 15 percent of daily automobile VMT;
5. Travel and trip making in exurban and rural areas—especially long trips and to the extent that they are made in panel or pickup trucks and consume extra amounts of gasoline;
6. Trips of less than 1 mile in length—trips that create only a small percentage of total VMT (approximately 3 percent), but walking and bicycles or mopeds can substitute for them if proper facilities are available; and
7. Truck transportation—trips that make up 12-14 percent of VMT daily and probably consume 19-23 percent of available daily gasoline or diesel fuel supply because of trucking's higher energy requirements.

Lack of hard empirical data documenting observed travel-behavior changes for most energy conservation actions and a dearth of knowledge regarding complementary impacts of conservation action packages provide for most of the forecasting uncertainty that should be recognized. Though this uncertainty is consequently significant, existing transportation-demand-modeling capabilities do provide methods for estimating likely modal shifts. As summarized in Table 12 (7), demand-forecasting models within the urban transportation planning system (UTPS), which covers trip generation, distribution, modal split, and assignment, provide a reasonable capability for testing those kinds of conservation policies listed at the top of Table 12 (i.e., service levels) but relatively poor capability for testing those policies listed at the bottom (i.e., broader policies).

Continuing research with sketch-planning level-of-detail demand-forecasting models has further improved our capability to conduct sensitivity analyses of energy conservation actions (1, 11, 29-31). Though the capabilities and limitations listed in Table 12 for UTPS-based models are still applicable, such analytical capabilities as the Short-Range Generalized Policy (SRGP) analysis modeling package provide a strengthened capability to test a wider range of area-specific conservation actions with relatively quick turnaround time and limited staff and data requirements.

When accommodating the stratification of households by geographic location and socioeconomic level, such sketch-planning models provide an improved ability to estimate the relative incidence of conservation action impacts. Interrelated model linkages between steps in travel-behavior decision making (e.g., automobile ownership, work-trip modal choice, non-work-trip generation, and non-work-trip distribution and modal choice) are an important feature of the SRGP package (11, 29). This package has also been used to examine the synergistic (and competing) interactions of energy conservation actions. Further application of such sensitivity-analysis tools consequently represents a major area for continued work in impact analysis for a wide range of energy-conserving actions.

IMPLEMENTATION ISSUES

One of the confusions created by the multiplicity of potential energy conservation measures is the tendency to overlook the aggregate effect of any significant success for those measures—especially those oriented toward encouraging modal shift—on existing transit capacities.

As an example, for medium-sized regions, a shift of only 7 percent of former automobile users to public transit during peak hours of travel could mean as much as a doubling of transit ridership volumes (given a typical peak-hour regional modal split to transit of 5 percent today). Tables 6 and 7 indicate that such a 7 percent modal shift is not unreasonable under a number of different combinations of energy conservation options. Major operational, cost, and funding problems will obviously be created for already hard-pressed bus transit systems in nearly every medium-sized urban area across the country (though relative impacts on the six larger U.S. regions with rail transit systems would be somewhat less).

Some additional capacity expansion might be possible by accelerating maintenance practices and by maximizing the number of spares and reserve bus vehicles actually in revenue service (including reclamation of older buses). In some cases, new vehicle purchases on order might be delivered early, but, on an industrywide basis, limited vehicle production schedules for transit rolling stock are

already being observed. Temporary mobilization of often large school bus fleets in private ownership offers good potential (school buses may represent as much as 30 percent of the public transit bus fleet), but scheduling (during the school year), statutory, and financing problems are significant.

Establishing the clarity of public and private responsibility will be one of the most troublesome factors affecting the implementation of energy-conserving actions in multiple-agency settings. Distinguishing between overall coordination responsibility and project component responsibility will be part of the problem here; it will be further compounded by multiple funding sources and associated procedural restrictions and requirements. In general, administrative and procedural difficulties also seem to increase geometrically as the number of agencies involved in a particular action area is increased.

The six different energy conservation measures aimed at ridesharing, listed both in Tables 6 and 7, provide a good example of these kinds of interagency coordination problems. A variety of state, regional, and local public agencies, as well as major employers and private carriers, can all be involved in these measures—carpooling, vanpooling, preferential parking for multiple-occupancy vehicles (MOVs), preferential lane treatment for MOVs, and park-and-ride facilities. In Illinois, for example, the Institute of Natural Resources has been involved in the statewide promotion of and assistance to employer-sponsored vanpools. The Regional Transit Authority in Chicago is currently undertaking a major program in the promotion and encouragement of carpooling activities and is emphasizing employer sponsorship. Regional and local planning agencies have also been involved in recent ridesharing planning activities. The responsibilities of the private sector, in terms of major employers who participate (administratively or financially) in the inauguration of ridesharing activities, as well as private carriers who may undertake related vanpool or demand-responsive paratransit services, can also be significant.

REFERENCES

1. Cambridge Systematics, Inc. Guidelines for Travel Demand Analyses of Program Measures to Promote Carpools, Vanpools, and Public Transportation. Federal Energy Administration, Nov. 1976.
2. Barton-Aschman Associates, Inc. Petroleum Shortage Response Program for the State of Illinois. Illinois Institute of Natural Resources, Springfield, Vols. 1 and 2, July 1979.
3. Transportation Energy Contingency Planning: Local Experiences. Federal Highway Administration, U.S. Department of Transportation, June 1979.
4. J.M. Gross and others. Energy Impacts of TSM Actions in NYS, 1978-1980. Planning Research Unit, New York State Department of Transportation, Albany, Prelim. Res. Rept. 151, May 1979.
5. A Metropolitan Transportation Plan for National Energy Contingencies. North Central Texas Council of Governments, Arlington, Aug. 1977.
6. R.L. Creighton. A Systematic Search for a Realistic Policy for Energy Conservation in Urban Transportation Planning. Presented at the Seminar/Workshop to Discuss Energy Considerations in the Urban Transportation Planning Process, U.S. Departments of Energy and Transportation, Oct. 1979.
7. D.T. Hartgen. Energy Considerations in Transportation Planning: The New York State Approach. Presented at the Seminar/Workshop to Discuss Energy Considerations in the Urban Transportation Planning Process, U.S. Departments of Energy and Transportation, Oct. 1979.
8. D.T. Hartgen and others. Guidelines for Transportation Energy Contingency Planning. Planning Research Unit, New York State Department of Transportation, Albany, Prelim. Res. Rept. 157, May 1979.
9. R.K. Mufti and M.J. Munson. Approach to Assessing the Impact of Energy Conservation Policies on Transportation Demand. TRB, Transportation Research Record 726, 1979, pp. 1-7.
10. TSM Sensitivity Report: An Analysis of the Potential for Transportation System Management Strategies in the Denver Area. Denver Regional Council of Governments, March 1979.
11. J.H. Suhrbier. Increasing the Energy Conservation Effectiveness of Transportation Decisions. Presented at the Seminar/Workshop to Discuss Energy Considerations in the Urban Transportation Planning Process. U.S. Departments of Energy and Transportation, Oct. 1979.
12. J.F. DiRenzo. Travel and Emissions Impacts of Transportation Control Measures. TRB, Transportation Research Record 714, 1979, pp. 17-24.
13. Interplan Corp. Joint Strategies for Urban Transportation, Air Quality, and Energy Conservation. U.S. Environmental Protection Agency; Federal Energy Administration; Urban Mass Transportation Administration, 1975.
14. B.I. Keyani and others. Transportation System Management: State of the Art. Urban Mass Transportation Administration, Sept. 1976.
15. R.L. Peskin, J.L. Schofer, and P.R. Stopher. The Immediate Impact of Gasoline Shortages on Urban Travel Behavior. Federal Highway Administration, U.S. Department of Transportation, DOT-FH-11-8500, April 1975.
16. Energy, the Economy, and Mass Transit. Office of Technology Assessment, U.S. Congress, Dec. 1975.
17. Peat, Marwick, Mitchell and Co. Air Quality Impacts of Transit Improvements, Preferential Lane, and Carpool/Vanpool Programs. U.S. Environmental Protection Agency, March 1978.
18. R.H. Pratt Associates, Inc. Immediate Action Policies to Induce Urban Mode Shifts. Federal Energy Administration, 1975.
19. R.H. Pratt Associates, Inc. Traveler Response to Transportation System Changes: A Handbook for Transportation Planners. U.S. Department of Transportation, Feb. 1977.
20. Strategies for Reducing Gasoline Consumption Through Improved Motor Vehicle Efficiency. TRB, Special Rept. 169, 1975.
21. Energy Primer: Selected Transportation Topics. Transportation Systems Center; Office of Technology Sharing, U.S. Department of Transportation, 1978.
22. Guidelines to Reduce Energy Consumption Through Transportation Actions. Urban Mass Transportation Administration, U.S. Department of Transportation, May 1974.
23. F.A. Wagner and K. Gilbert. Transportation System Management: An Assessment of Impacts. U.S. Department of Transportation, Nov. 1978.
24. G.S. Cohen. TSM Actions: A Study of the Energy Costs. Planning Research Unit, New York State Department of Transportation, Albany, Prelim. Res. Rept. 155, July 1979.
25. J.M. Gross. Forecasting Energy Impacts of TSM Actions: An Overview. Planning Research Unit, New York State Department of Transportation, Albany, Prelim. Res. Rept. 156, 1979.
26. D.T. Hartgen. Long-Range Transportation Planning Under Energy Constraints: A Critical Review of Current Capability. Planning Research Unit, New York State Department of Transportation, Albany, Prelim. Res. Rept. 87, July 1975.
27. J.M. Witkowski and W.C. Taylor. Urban Transportation Planning Under Energy Constraints. TRB, Transportation Research Record 707, 1979, pp. 1-5.
28. W.G. Barker. The Direction of Energy-Related Urban

Transportation Planning at the North Central Texas Council of Governments. Presented at the Seminar/Workshop to Discuss Energy Considerations in the Urban Transportation Planning Process, U.S. Departments of Energy and Transportation, Oct. 1979.
29. Cambridge Systematics, Inc. Urban Transportation Energy Conservation: Analytic Procedures for Estimating Changes in Travel Demand and Fuel Consumption. U.S. Department of Energy, Rept. DOE/PE/8628-1, Vol. 2, Oct. 1979.
30. Charles River Associates. Estimating the Effects of Urban Travel Policies. U.S. Department of Transportation, Final Rept., DOT-TSC-OST-76-10, April 1976.
31. A.B. Sosslau, A.B. Hassam, M.M. Carter, and G.V. Wickstrom. Quick Response Urban Travel Estimation Techniques and Transferable Parameters: User's Guide. NCHRP, Rept. 187, 1978.

The 1979 Energy Crisis: Who Conserved How Much?

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During the 1973-1974 oil embargo and again in 1979, U.S. foreign supplies of petroleum were greatly reduced. Transportation, almost totally dependent on petroleum (1), and New York State, whose dependence on foreign oil is much greater than that of the United States (2), were particularly hard hit. During both periods, prices rose about 35 percent and shortfalls of 11-13 percent were experienced (3). People encountered unpleasant experiences of Sunday station closings, long queues at stations, concern about availability, and odd-even and minimum-purchase restrictions. However, during these two shortfall periods, partial relaxation of supplies, coupled with certain government actions and strong positive consumer response, alleviated the crisis in three or four months. But the U.S. embassy takeover in Iran and the Russian invasion of Afghanistan have once again spurred price increases and raised the specter of shortages.

A large number of analyses have been prepared on energy impacts of transportation actions, but until recently most have focused on conservation actions (4-7). More recent attention has turned to the analysis of actions from a contingency viewpoint—that is, studies of transit system capacity (8-12) and ridesharing (10). County, city, and state-level analyses have only recently been prepared (13-16). These efforts are generally intended to address the issues raised by state or federal legislatures, satisfy DOT requests for energy contingency planning, or provide information and overview to planners (17-18). The Emergency Energy Conservation Act of 1979 provides further impetus for the preparation of such plans. Through the Standby Federal Emergency Energy Conservation Plan (proposed interim final rules, February 1980), the federal government, after setting targets for conservation, can impose plans on states whose own plans or efforts to conserve are not satisfactory. A number of states, notably California (19), have begun such work, and some draft guidelines have been prepared by the Massachusetts Institute of Technology (20).

We are particularly concerned, however, that few, if any, of these studies integrate the role of the consumer into the planning and energy contingency efforts. All the studies we have reviewed are prescriptive in nature, purporting to show what actions, if taken by government, can induce the requisite conservation response from the public. Yet numerous reviews of consumer response during the 1973-1974 and 1979 crises (21-23) show that, in spite of government efforts, consumers did the saving on their own by cutting discretionary travel where possible and by taking numerous personal actions to conserve. Although rationing at shortfalls of more than 20 percent (24) may force conservation, state and federal plans developed for less severe shortfalls (8-20 percent) must consider voluntary as well as coerced public response. The purpose of this paper is to determine in actual savings what the nature of public response has been so far and is likely to be in the future.

THE 1979 CRISIS

Both the 1973-1974 and the 1979 crises were precipitated by major international events. In 1979, the Iranian revolution of December 1978 subsequently led to the cutoff of Iranian oil production. When production did resume, it was at significantly lower levels. Government directives concerning the buildup of heating fuel supplies for the 1980 season exacerbated a precarious balance, resulting in a severe (7-10 percent) shortfall in California in May 1979. Pressure subsequently mounted in New York during that same month, resulting in the imposition of an odd-even gasoline purchase plan in New York City in June 1979 and the tapping of future set-asides. In the meantime, the crisis eased in California. These actions, coupled with significant conservation by the public, gradually loosened the squeeze; odd-even was removed in New York City in September 1979 with prices in the $0.97/gal range, an increase of $0.27 in 10 months. The takeover of the U.S. embassy in Iran on November 4, 1979, and the Russian invasion of Afghanistan have spurred prices again; the February 1980 U.S. average price of regular gasoline was $1.15/gal for unleaded, with premium at $0.05-$0.15 higher (prices in New York were about $0.05-$0.15 above the U.S. average). Many analysts predict that gasoline will cost $1.50/gal by the end of 1980.

As a result of these events, traffic and gasoline consumption in New York State since then declined. Traffic was down 4.5 percent in New York, while gasoline consumption dipped 5.3 percent. Total gasoline saving in New York was 280 million gal for the first three quarters, 328 million gal for the year.

CONSUMER SAVINGS

To determine precisely how these savings were achieved, the New York State Department of Transportation (NYSDOT) engaged in a two-part analysis of energy actions. The first part—determining what actions the public took—was obtained from responses to a public opinion poll conducted by Crossley Surveys on behalf of NYSDOT (22). The second part—quantifying the savings from each action—was accomplished by applying reported trip length, trip rate, and energy use data to the Crossley responses. Each of these efforts is discussed below in light of three scenarios: (a) actions between January and October 1979, (b) actions at $1.50/gal for gasoline, and (c) actions at a 20 percent shortfall.

Actions Taken by the Public

Consumer actions taken in 1979 were generally similar to those taken during the 1973-1974 crisis, but several important differences were noted. Table 1 indicates results of the Crossley poll, which was based on a representative sample of 1520 New York households and conducted in October 1979. The poll responses thus cover the period of January through mid-October 1979. Respondents were

Table 1. Results of Crossley poll of New York State residents showing percentages who took energy-saving actions during January-October 1979.

Action	Area: New York City	Area: Long Island	Area: Westchester and Rockland Counties	Area: Upstate	Age: 18-34	Age: 35-64	Age: >65	Sex: Male	Sex: Female	Cars per Household: 0	Cars per Household: 1	Cars per Household: >2	Household Size: 1-2	Household Size: 3-4	Household Size: >5	Household Income ($000s): <10	Household Income ($000s): 10-25	Household Income ($000s): >25
Combined shopping with other trips	30	55	43	62	50	48	31	40	53	13	51	57	42	49	54	36	49	52
Drove slower	36	47	45	46	43	43	31	46	38	12	48	49	39	43	48	33	41	49
Shopped closer to home	31	45	46	49	43	41	36	37	45	20	45	46	38	43	44	38	43	41
Tuned car	24	46	41	47	39	40	19	39	36	4	41	47	30	40	49	22	37	46
Shopped less often	24	43	27	45	36	37	26	30	40	11	38	42	29	38	44	30	35	40
Shopped on way home from work	21	24	22	30	32	25	4	24	26	11	25	31	20	29	31	14	27	33
Vacationed closer to home	11	12	16	25	21	16	9	19	15	7	17	22	13	20	21	14	18	19
Used train, bus, or plane for vacation	18	15	14	14	21	14	7	16	16	13	15	18	17	16	12	12	15	23
Canceled vacation trip	14	13	8	19	19	15	7	14	17	6	20	15	14	17	18	11	18	14
Bought a more fuel-efficient car	9	18	5	22	20	14	9	16	15	5	14	21	13	17	19	10	17	17
Used bus or subway for non-work travel	26	8	13	7	19	13	10	16	14	20	19	9	16	14	15	17	18	13
Carpooled to work	9	16	16	18	19	13	2	17	12	7	13	18	10	17	16	8	17	16
Took bus or subway to work	22	5	10	5	17	9	4	14	10	13	16	8	11	12	13	11	14	12
Eliminated recreational vehicle or boat	4	14	1	15	13	7	6	10	9	2	10	12	7	11	12	8	8	12
Sold a car	4	14	0	12	11	7	3	9	8	7	6	11	6	11	11	8	8	9
Walked or bicycled to work	6	9	3	11	13	6	1	8	9	10	8	8	7	9	11	9	9	8
Take job closer to home	3	6	5	7	9	3	1	5	6	4	5	7	3	6	7	6	6	4
Moved closer to work	2	1	0	4	4	2	0	2	3	1	3	3	2	3	2	2	3	3

asked to indicate what actions they had taken since January to cope with the crisis. The data show that consumers have emphasized small and frequent actions, such as driving slower, getting cars tuned, and combining and reducing discretionary and shopping travel. But certain major actions have also been taken by a significant share of most groups. These include vacation-related actions (since the crisis peaked during the summer months), fuel-efficient car purchasing, carpooling, and use of transit for work and nonwork trips. Few consumers mentioned taking drastic actions, such as changing jobs or residences and selling a car. Relatively few were willing to eliminate the use of a recreational vehicle or boat. Most important, responses vary significantly for different geographic and demographic groups.

To evaluate how response patterns would change in the future, the Crossley poll also included questions on intended response if gasoline prices were to rise to $1.50/gal. Table 2 shows how New Yorkers would react. While the overall profile of response is similar to that for actions taken already, certain major actions would increase in incidence, supplanting minor actions. In particular, the incidence of driving slower and car tune-up would decline sharply as purchases of fuel-efficient cars rapidly accelerate. Thus, in a seeming contradiction, it may be difficult to hold down speeds if gasoline prices continue to increase.

The Crossley poll also elicited response on a major shortage scenario. Table 3 shows how the Crossley respondents indicated they would respond to a somewhat more severe shortfall of 20 percent. Responses are generally similar, in rank order, to actions already taken in 1979. However, more emphasis would be placed on major actions such as vacationing closer to home and changing travel modes for vacation, purchasing fuel-efficient cars, using transit for nonwork travel, and selling a car. Certain other actions (driving slower, car tune-up, and shopping-related actions) would decline in incidence as their places were taken by major actions. Overall, these responses are similar to those under the $1.50/gal gasoline-purchase scenario. In addition, a 20 percent shortfall would also increase vacation trip cancellations, undoubtedly because of fears of not being able to get fuel while on the road. As with the previous scenarios, major differences in response are apparent by geographic and demographic groupings.

The limitations of the above data are readily apparent. While the data show the relative frequency of response to various actions, they do not show how much energy was actually saved by each action. Because some actions are expensive as well as effective (e.g., fuel-efficient car purchasing), they may only be taken infrequently. Nevertheless, they still have a major effect on consumers. In exchange, other actions may be taken very frequently (e.g., driving slower) but not save much energy on a per-time basis. We must thus adjust the above responses to account for the savings potential of each action. [Further detailed statistics applicable to this study of New York's energy saving and actions may be obtained from the authors.]

Energy Saving

In order to better understand the conservation potential inherent in the public's response to various energy-constrained futures, it is necessary to explicitly quantify an action's energy saving. In this analysis, the quantification of the savings of all 18 actions used in the Crossley poll was accomplished by using typical state trip lengths and trip rates by purpose and an assumed statewide car average fuel efficiency (CAFE) of 15 miles/gal. Different approaches were used for each action, but generally the methods are based on the following equations:

$$S_{ij} = (\phi)(L_B - L_A)(R_B - R_A)(CLH)(1/15) \quad (1)$$

$$S_i = \sum_{j=1}^{18} S_{ij} \quad (2)$$

where

S_{ij} = savings for action j for household i;
ϕ = 1 if action j were taken, 0 otherwise;
L = trip length, before and after change in behavior;
R = trip rate;

Table 2. Percentages who would take energy-saving actions if gasoline cost $1.50/gal.

Action	Area: New York City	Long Island	Westchester and Rockland Counties	Upstate	Age: 18-34	35-64	>65	Sex: Male	Female	Cars per Household: 0	1	>2	Household Size: 1-2	3-4	>5	Household Income ($000s): <10	10-25	>25
Combined shopping with other trips	28	50	43	62	50	45	29	43	47	12	49	55	41	49	49	32	49	48
Drove slower	20	31	25	31	31	26	13	26	27	10	30	30	23	26	35	22	26	30
Shopped closer to home	27	41	53	48	42	39	28	36	42	13	42	47	35	42	43	31	40	43
Tuned car	14	43	19	38	34	27	13	27	28	3	27	39	21	32	36	20	29	34
Shopped less often	25	48	39	48	40	39	25	33	42	11	40	49	33	39	49	29	38	42
Shopped on way home from work	16	25	46	28	31	23	4	24	24	10	24	29	20	26	30	11	27	28
Vacationed closer to home	13	20	33	30	26	22	11	22	22	8	20	29	18	24	27	16	24	24
Used train, bus, or plane for vacation	21	21	31	26	29	21	17	23	25	14	24	27	25	24	20	20	24	30
Canceled vacation trip	10	20	16	22	18	16	14	14	19	6	19	18	14	17	21	14	19	15
Bought a more fuel-efficient car	10	28	23	24	25	18	3	19	19	5	19	24	14	21	27	14	20	22
Used bus or subway for non-work travel	26	11	18	11	21	16	11	18	17	16	22	13	18	17	16	20	20	16
Carpooled to work	9	15	24	23	25	13	1	18	15	6	15	22	13	19	18	11	18	19
Took bus or subway to work	16	7	23	7	18	8	6	12	12	12	14	9	12	11	11	8	15	12
Eliminated recreational vehicle or boat	3	9	7	14	13	6	4	9	8	2	8	12	6	10	11	8	8	10
Sold a car	10	15	5	12	14	10	5	11	11	5	13	12	9	12	16	11	12	11
Walked or bicycled to work	5	7	11	14	14	7	2	9	10	6	10	9	8	9	14	10	10	9
Take job closer to home	3	6	8	6	8	3	2	4	5	3	4	6	4	5	6	6	5	4
Moved closer to work	1	2	2	4	4	2	0	2	3	2	2	3	1	2	4	3	2	3

Table 3. Percentages who would take energy-saving actions if a 20 percent gasoline shortfall occurred.

Action	Area: New York City	Long Island	Westchester and Rockland Counties	Upstate	Age: 18-34	35-64	>65	Sex: Male	Female	Cars per Household: 0	1	>2	Household Size: 1-2	3-4	>5	Household Income ($000s): <10	10-25	>25
Combined shopping with other trips	23	52	42	59	48	43	26	40	46	11	44	55	36	48	49	33	45	46
Drove slower	20	30	23	30	30	25	13	26	25	9	29	29	22	25	36	22	26	30
Shopped closer to home	23	29	48	47	40	36	24	34	38	11	39	44	33	38	41	30	37	38
Tuned car	13	34	19	34	31	23	11	24	26	3	24	35	19	29	30	19	27	28
Shopped less often	21	47	45	47	39	38	22	32	40	11	36	47	30	39	45	27	37	40
Shopped on way home from work	14	25	31	27	28	21	2	21	22	8	21	28	17	24	28	12	24	23
Vacationed closer to home	12	22	36	28	27	20	13	22	41	8	22	28	18	24	26	17	23	23
Used train, bus, or plane for vacation	22	21	37	26	30	22	17	24	25	13	25	29	25	26	21	22	23	32
Canceled vacation trip	13	25	41	22	23	20	14	19	22	6	23	24	18	20	25	16	23	20
Bought a more fuel-efficient car	10	26	28	22	22	19	5	18	18	5	19	24	13	21	27	15	19	21
Used bus or subway for nonwork travel	27	11	25	11	23	16	11	21	16	16	22	16	20	17	18	20	21	18
Carpooled to work	9	18	30	22	25	14	1	18	16	6	15	23	13	20	18	10	18	20
Took bus or subway to work	15	7	20	8	17	8	4	13	11	9	14	10	11	12	12	8	14	12
Eliminated recreational vehicle or boat	4	9	8	13	13	6	4	9	8	1	9	11	7	9	11	6	8	4
Sold a car	11	15	4	11	14	11	4	11	11	6	13	11	9	12	15	12	11	10
Walked or bicycled to work	5	7	7	13	14	5	2	8	9	6	9	9	8	8	12	11	10	7
Take job closer to home	2	4	6	6	7	3	1	3	5	3	4	5	3	5	5	6	5	3
Moved closer to work	1	2	0	4	4	2	0	2	3	2	2	3	2	3	3	4	3	2

CLH = factor for car left at home;
1/15 = miles per gallon for average car; and
S_i = household i's savings.

The following table shows the average amount of gasoline that a household would save per week by taking various actions:

Action	Average Household Saving per Week (gal)
Work related	
Bus, subway to work	4.18
Carpool to work	2.22
Walk, bicycle to work	0.93

Action	Average Household Saving per Week (gal)
Shopping	
Shop closer to home	0.43
Combine shopping with other trips	0.20
Shop less often	0.30
Bus, subway for nonwork trips	0.74
Shop on way home from work	0.58
Car	
Tune up	0.65
Drive slower	0.19
Buy a more fuel-efficient car	5.23
Sell a car but do not replace	8.02
Vacation	
Cancel trip	0.87
Change travel mode	1.91
Vacation closer to home	0.33
Eliminate recreational vehicle, boat	0.18
Move	
Live closer to work	1.54
Take job closer to home	2.04

(The average for New York State is 12.8 gal/week/car.) The actual derivations for different actions may be found in the Appendix.

By using these energy-savings values, the actual, or implied, number of gallons saved by each respondent who adopted these actions was computed and examined by various demographic breakdown for each of the three scenarios. Computation of total state savings for the 39-week period, Jan.-Sept. 1979, is obtained by expanding the data: total state savings = $\sum_{i=1}^{1520}$ (savings$_i$)(39 weeks)(0.30 incidence rate) (6.3 M households/1520).

Total Savings

Table 4 summarizes the total energy saved by New Yorkers based on various actions taken during the first 39 weeks of 1979. Overall, state residents conserved an estimated 289.5 million gal of gasoline. This represents a per-household saving of 46 gal. Of this saving, 44 percent was due to car-related actions, primarily the purchasing or selling of a car. Work and nonwork savings are approximately equal, with vacation-related savings close behind. Savings through the use of transit accounted for 16 percent and carpooling conserved 8 percent of the total.

When New Yorkers were queried about their future actions, the savings picture changes. If the price of gasoline increases to $1.50/gal, New Yorkers would increase their saving to 320.9 million gal of fuel. However, the breakdown of this saving shifts. Vehicle-purchasing action assumes greater importance as well as certain vacation-related actions (primarily modal changes). These upward trends come at the expense of work and nonwork actions, especially in the use of transit for the work trip, in driving slower, and in car tune-ups.

If a 20 percent reduction in the supply of gasoline were to occur, a similar pattern is forecast. Work and nonwork savings decline as vacation and car-purchasing savings increase.

Savings by Region

Significant differences were evident when the energy savings by region in New York were examined. During 1979, upstate residents accounted for 45 percent of the total savings; New York City residents, 35 percent; and Long Island residents, 16 percent. However, Long Island households had the highest average savings (56.4 gal), with upstate New York households a close second (51.3 gal). New York City households averaged the lowest saving (10.2 gal).

Downstate (New York City, Long Island, and Westchester and Rockland Counties) residents concentrated their savings in work-related actions, with transit accounting for 31 percent of New York City's savings. Upstate residents emphasized car-related actions for more than half of their total savings. Transit was responsible for only 4 percent of the gasoline saved in upstate New York. From these data, it can be concluded that transit is an effective energy saver if the service is already available. In areas such as New York City, with its extensive transit system, transit-related savings will be very high. However, in other areas with poorer service, transit will not be as effective, and policymakers should concentrate their efforts on other, more productive actions.

When looking at the two different futures (i.e., gasoline at $1.50/gal and a 20 percent shortfall), the savings picture is

Table 4. Overall transportation energy savings by New Yorkers during 1979 and under two scenarios.

Action	January-October 1979		At $1.50/gal		At 20 Percent Shortfall	
	Gallons (000 000s)	%	Gallons (000 000s)	%	Gallons (000 000s)	%
Work related						
Bus or subway to work	37.0	13	30.3	9	28.9	9
Carpool to work	22.9	8	24.5	8	26.4	8
Walk or bicycle to work	5.5	2	6.1	2	5.3	2
Shopping						
Shop closer to home	13.1	5	12.3	4	11.4	4
Combine shopping with other trips	6.9	2	6.7	2	6.3	2
Shop less often	7.7	3	8.4	3	8.0	3
Use bus or subway for nonwork trips	8.2	3	9.3	3	9.9	3
Shop on way home from work	10.6	4	10.0	3	9.0	3
Car						
Tune up	17.6	6	13.1	4	11.7	4
Drive slower	5.9	2	3.8	1	3.6	1
Buy a more fuel-efficient car	57.8	20	71.3	22	69.3	22
Sell a car (do not replace)	47.3	16	62.2	19	61.4	19
Vacation						
Cancel a vacation trip	10.3	4	11.0	3	13.4	4
Change mode for vacation	22.5	8	33.4	10	34.5	11
Vacation closer to home	4.1	1	5.3	2	5.2	2
Eliminate recreational vehicle or boat	1.2	–	1.1	–	1.1	–
Moves						
Move closer to work	3.4	1	3.1	1	3.6	1
Take job closer to home	7.5	3	9.0	3	6.6	2
Total saving	289.5	100[a]	320.9	100[a]	315.6	100[a]

[a]Percentage does not add to 100 due to rounding.

altered somewhat. Although the relative savings by region remain stable (even though New York City conserves less fuel), the emphasis within each region is changed. The importance of work-related actions in New York City declines primarily because of a reduction in the savings attributable to transit. Car-purchasing actions assume greater importance in all areas but upstate New York (where it is already high), and vacation-related savings increase everywhere. The relative importance of driving slower and tune-up declines.

Savings by Age

The elderly (over 65) population does not account for much of the total energy savings, either relatively or absolutely. This is not surprising because they travel less than the rest of the population. They place greater emphasis on shopping travel and less on work travel. However, all age groups give roughly equal emphasis to car purchasing, with a surprisingly high percentage of elderly (25 percent) taking these actions. On a per-household basis, young families conserved the most (57.1 gal).

Under a future of gasoline at $1.50/gal, all age groups increase their savings, but the proportion of savings in each age group remains constant. The middle-age group (35-64 years) puts increased focus on car- and vacation-related actions at the expense of work and shopping travel. The elderly population increases its savings from vacation actions (modal changes) and decreases its focus on shopping-related savings slightly. But 48 percent of the group shifted to car selling. Price squeezes would clearly affect car ownership patterns of the elderly more than any other group.

Potential fuel savings under a future of reduced energy supplies (20 percent less) are similar. The elderly would have a slightly lower energy savings (18.4 gal) than in 1979 (19.8 gal).

Savings by Sex

The energy savings in all areas are just about equal between men and women. In 1979, men concentrated their savings on work travel, and women placed more emphasis on shopping travel. Both sexes had their greatest savings in car-related actions—men, 43-45 percent, and women, 47-48 percent.

The pattern of savings is similar for each of the two futures. In each future, savings from car-related actions increase, males decrease their work-travel savings, and women decrease their shopping-travel savings. Both groups place more of their savings emphasis on vacation travel.

Savings by Car Ownership

As was expected, households with more than two cars were responsible for half of the gasoline conserved by New York State residents in 1979. Zero-car households accounted for less than 10 percent of the total savings. They placed more emphasis on transit actions (22 percent versus 9 percent for two-car households) and on vacation actions, especially modal change for the vacation trip. Car-related savings (accounting for more than 35 percent of the savings in all groups) was surprisingly similar across the groups.

Again, the two futures provide similar pictures. The importance of car-related action increased in households with zero or one car, and decreased in the two-car households. Vacation-related savings increase across the board at the expense of work and shopping-travel savings. The relative savings of each group remain constant, although zero-car households actually conserve less fuel (19 gal) under the two futures than they did in 1979 (24.1).

Savings by Household Size

Energy savings are spread across the various household sizes. Each group is responsible for a significant portion of the overall reduction in energy use, although one- or two-person households save less on a per-capita basis. Car-related savings are almost half of each group's total savings, with one- and two-person households saving a slightly smaller portion. Additionally, these households also have a larger portion of their savings in vacation-related actions. Overall, in 1979, the energy savings are about equally distributed among each household group.

In the two energy futures, car-related savings are still the greatest; vacation-related savings increase, and work and shopping-related savings decrease. Again, the savings are spread equitably across household groups.

Savings by Household Income

In the first nine months of 1979, the lower-income households accounted for only 11 percent of the total gasoline saved in New York State and saved relatively less per capita. Since this group is generally one with few travel options, this result is not surprising. Those that are more able to conserve, the middle- and upper-income groups, are the ones that bear the brunt of the savings, both relatively and absolutely. Car-related savings again are the largest—more than 40 percent of the total savings in each group. The lower-income group places more emphasis on car and shopping actions and less on work travel than the other two income levels.

The results under the two energy futures are again similar to each other. Work-related savings, especially for transit to work, decline in all groups. Vacation- and car-related savings increase across the board. The lower-income group again accounts for only 10-12 percent of the total conservation effort.

CONCLUSIONS AND IMPLICATIONS

Table 5 provides a summary of the energy savings in New York State during 1979 based on six demographic characteristics. Perhaps the primary observation from this analysis is the extensiveness and internal rationality of consumer actions to conserve transportation energy. New York residents did respond significantly to the 1979 energy crisis and saved more than 6 percent of the total gasoline used in the first three quarters of 1979 through a variety of actions that cut across all facets of travel.

Second, contrary to government pressure and exhortations, consumer saving is not accounted for primarily by carpooling, transit, slower driving, or by cuts in discretionary travel. While certain actions were mentioned with great frequency (e.g., rearranging shopping travel), they do not save much energy either cumulatively or individually. Most conservation occurred through car-related actions, particularly fuel-efficient car purchasing and car selling. In this way, many consumers are saving energy while maintaining mobility.

Third, the data suggest that consumers do not view conservation actions separately but as elements of sets that are selected for maximum benefit and minimum pain. Thus, actions taken early on to conserve marginal amounts of fuel (e.g., shopping travel actions, driving slower, and tuning cars) are likely to be replaced by major actions as prices rise or shortages deepen. As consumers switch to major actions—a trend clearly discernible in our data—government efforts to enforce or encourage unpopular or lower-level actions (such as ridesharing, use of transit, driving slower, and tuning cars) are likely to become more difficult. In fact, our data suggest that upward trends in transit use, driving slower, ridesharing, and, possibly, tune-ups have probably peaked and are likely to turn downward in the future without strong government pressure.

Fourth, we are struck by the observation that consumer actions were generally independent of government directives. In fact, viewed against the wide range of survey responses and their particular focus, government suggestions and efforts to encourage conservation have been narrow and ineffective. Clearly, there is a lot more going on out there than we are readily able to assess.

Table 5. Percentage of energy saved by New York State residents, January-October 1979, based on six demographic characteristics.

	Percentage of Total Saving																	
	Area				Age			Sex		Cars per Household			Household Size			Household Income (000s)		
Action	New York City	Long Island	Westchester and Rockland Counties	Upstate	18-34	35-64	>65	Male	Female	0	1	>2	1-2	3-4	>5	<10	10-25	>25
Work related																		
Bus or subway to work	25[a]	11	17[a]	3[b]	2[b]	13	11	16	9	15	19	8[b]	13	12	14	11	14	14
Carpool to work	6	9	16[a]	8	8	9	1[b]	10	5	6	7	9	8	9	7	4	9	10
Walk or bicycle to work	2	2		2	12[a]	2		2	2	2	1	2	2	1	3	2	1	2
	33	22	33	13	22	24	12	28	16	23	27	19	23	22	24	17	24	26
Shop related																		
Shop closer to home	4	4	9[a]	5	4	5	9[a]	4	6	4	5	4	5	4	4	6	4	4
Combine shopping with other trips	2	2	3	3	2	3	4	2	3	1	3	2	3	2	2	2	2	2
Shop less often	2	3	3	3	2	3	5	2	3	2	3	3	3	3	3	3	2	3
Bus or subway for nonwork trips	6	1	4	1	3	3	5	3	3	7	4	1	3	2	3	4	3	2
Shop on way home from work	4	3	5	4	4	4	1	3	4	3	4	4	3	4	4	3	4	4
	18	13	24	16	15	18	24	14	19	17	19	14	17	15	16	18	15	15
Car related																		
Tune up	5	6	11[a]	7	5	7	7	6	7	1[b]	7	7	6	6	7	5	6	6
Drive slower	2	2	3	2	2	2	3	2	2	1	2	2	2	2	2	2	2	2
Buy a more fuel-efficient car	14	20	10[b]	26	20	19	25	19	21	12	18	23	20	20	21	19	21	18
Sell a car (do not replace)	10[b]	22[a]	–[c]	21[a]	18	15	13	16	17	24[a]	12	18	13	18	18	23[a]	15	15
	31	50	24	56	45	43	48	43	47	38	39	50	41	46	48	49	44	41
Vacation related																		
Cancel a vacation trip	4	2	3	4	4	4	3	3	4	3	5	3	4	4	3	4	4	3
Change mode for vacation	10	6	11	6	8	7	7	7	9	12[a]	7	7	10	7	5	8	7	9
Vacation closer to home	1	1	3[a]	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1
Eliminate recreational vehicle or boat				1			1									1		
	15	9	17	13	13	12	12	11	14	16	13	11	15	12	9	15	12	13
Moves																		
Move closer to work	1	2		1	1	1		2	1	1	1	1	2	1		1	1	1
Take job closer to home	3	3		2	3	2	4	3	2	5[a]	2	3	3	3	1	1	3	2
	4	5		3	4	3	4	5	3	6	3	4	5	4	1	2	4	3

Note: Blank cells represent less than 1 percent.

[a]Higher than average. [b]Lower than average. [c]Less than 1 percent, but lower than average.

From this analysis, the following conclusions can be drawn.

1. Consumer behavior under energy constraints is not well understood. Clearly, though, behavioral response depends on (a) options available, (b) economic position, (c) prior investments and options, and (d) crisis severity. What is known is that numerous options are taken jointly by different groups. Therefore, the role of government at all levels should be to expand options and make them available to more people rather than to constrain and coerce behavior.
2. Narrow governmental focus solely on transit and ridesharing is unproductive because it encourages actions that in total save little energy and constrain mobility. A better strategy would be to develop and encourage packages of actions for different market segments, based on the savings behavior of different groups.
3. Because replacement behavior by consumers may have impacts on other dimensions (e.g., declines in driving slower affect safety), governments should be particularly aware of possible negative impacts and losses in energy savings. Programs to prevent such deterioration should be developed as part of energy conservation and contingency planning.
4. Relative savings effort (e.g., savings per household) should not be viewed too rigorously. Although such statistics may indicate a softness of response in certain markets and overachievement in others, a more reasonable conclusion is that the economic circumstances of respondents, combined with options available to them, slows or accelerates relative savings. Government should focus on the differences in action profiles rather than on the differences in relative savings.

In summary, our major finding is that consumers are responding to energy constraints and will continue to do so in the future. The nature of these responses varies by area and group. Generally, consumers will choose sets of actions

that are available, are in their own best interests, minimize mobility loss, build on prior actions, and are economically workable for them. If government operates to help consumers by expanding, publicizing, and economizing the use of options, conservation can occur with minimum mobility loss and without coercion.

APPENDIX—Derivation of Weekly Energy Savings

In order to develop estimates of the energy savings that resulted from the public's response to the gasoline shortages during the summer of 1979, some estimates of the weekly energy-saving potential of each of the 18 actions taken during this time period must be derived. In this project, these estimates were developed by using typical New York State trip lengths and trip rates (24) and an assumed average statewide CAFE of 15 miles/gal. To account for the car left home for some actions, the estimated savings are reduced by 40 percent (24). This section documents the formulations used to estimate the weekly energy saved by each action contained in the Crossley survey. Independent checks are provided where available.

1. Take Bus or Subway to Work

Savings = work-trip length x 2 x 1/CAFE x 5 days/week x car-left-home factor = work-trip length x 2 x 1/15 x 5 x 0.6 = work-trip length x 0.400 gal/week.

As an independent check, Erlbaum (26) shows that the increase in transit ridership on state transit systems during the first three quarters of 1979 accounts for about 25.9 million gal of gasoline saving, or about 9 percent of this total gasoline saving of 280 million gal. Adding the expanded estimates from Table 4 provides an estimate of 45.2 million gal from the Crossley poll. (Work-trip length for each household is taken from the Crossley study.)

2. Carpool to Work

Assume (a) a circuity factor of 10 percent and (b) drive 2 days/week.

Savings = [(work-trip length x 2 x 5 days/week)$_B$ - (work-trip length x 2 x circuity x 2 days/week)$_A$] x 1/CAFE x car-left-home factor = work-trip length x [(2 x 5) - (2 x 1.1 x 2)] x 1/15 x 0.6 = work-trip length x 0.224 gal/week.

An independent check can also be made. Brunso (27) showed that the effect of the 1979 energy crisis was to increase the percentage of people carpooling by 3.5 percentage points among state workers in Albany. Further, the average gasoline saving per carpooler was found to be 283 gal/year. If this saving holds for all workers, then a rough estimate of total savings is as follows: energy saved = (283 gal/year) (0.75 year) (0.035) (4.1 M workers upstate) = 30.4 million gal. This is reasonably close to the Crossley estimate of 22.9 million gal (Table 4).

3. Walk or Bicycle to Work

Assume either mode applicable for six months.

Savings = work-trip length x 2 x 5 days/week x 1/CAFE x 1/2 year x car-left-home factor = work-trip length x 2 x 5 x 1/15 x 1/2 x 0.6 = work-trip length x 0.200 gal/week.

4. Shop Closer to Home

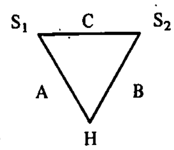
Assume (a) a potential saving of 30 percent and (b) opportunity to shop 5 days/week.

Savings = shopping-trip length x 2 x 5 days/week x shopping-trip rate/day x 1/CAFE x potential savings = 2.75 x 2 x 5 x 0.77 x 1/15 x 0.3 = 0.424 gal/week.

5. Combine Shopping with Other Trips

Assume the following:

(a) one opportunity/week
(b) before-trip pattern: H→S_1→H→S_2→H
(c) after-trip pattern: H→S_1→S_2→H



Savings = [(2A + 2B) - (A + B + C)] x 1/CAFE x times/week = [(2 x 2.75 + 2 x 2.75) - (2.75 + 2.75 + 2.45)] x 1/15 x 1 = 0.203 gal/week.

6. Shop Less Often

Assume a 20 percent lower shopping-trip rate.

Savings = shopping-trip rate x 0.2 x shopping-trip length x 2 x 1/CAFE x 5 days/week = 0.77 x 0.2 x 2.75 x 2 x 1/15 x 5 = 0.282 gal/week.

7. Use Bus or Subway for Nonwork Travel

Assume an opportunity for nonwork travel 2 times/week.

Savings = shopping-trip length x 2 x 1/CAFE x 2 times/week = 2.75 x 2 x 1/15 x 2 = 0.733 gal/week.

8. Shop on Way Home from Work

Assume the following:

(a) before-trip pattern: H→W→H→S→H
(b) after-trip pattern: H→W→S→H
(c) opportunity 2 times/week.

Savings = (before-trip length) - (after-trip length) x 1/CAFE x 2 times/week = [(5.1 + 5.1 + 2.75 + 2.75) - (5.1 + 3.70 + 2.65)] x 1/15 x 2 = 0.567 gal/week.

9. Tune Car

Assume (a) a saving of 5 percent and (b) an annual VMT/car of 10 000 miles.

Savings = 0.05 x VMT/week x 1/CAFE = 0.05 x 10 000/52 x 1/15 = 0.641 gal/week.

10. Drive Slower

Assume (a) a saving of 1.5 percent and (b) an annual VMT/car of 10 000 miles.

Savings = 0.015 x VMT/week x 1/CAFE = 0.015 x 10 000/52 x 1/15 = 0.192 gal/week.

11. Buy a More Fuel-Efficient Car

Assume (a) a saving of 40 percent and (b) an annual VMT/car of 10 000 miles.

Savings = 0.4 x VMT/week x 1/CAFE = 0.4 x 10 000/52 x 1/15 = 5.128 gal/week.

12. Sell a Car (Do Not Replace)

Assume (a) a saving of 60 percent and (b) an annual VMT/car of 10 000 miles.

Savings = 0.6 x VMT/week x 1/CAFE = 0.6 x 10 000/52 x 1/15 = 7.692 gal/week.

As a check, Erlbaum (28) estimated the 1979 saving due to fleet turnover as 140 million gal on an annual basis, or 105 million gal for 9 months. This is close to the Crossley estimate of 105.1 million gal for selling a car and buying a more fuel-efficient car (Table 4).

13. Cancel a Vacation Trip

Assume that the average vacation trip is 717 miles.

Savings = vacation-trip length x 1/CAFE x 1/52 weeks = 717 x 1/15 x 1/52 = 0.919 gal/week.

14. Change Mode for Vacation

Assume a 1500-mile trip.

Savings = vacation-trip length x 1/CAFE x 1/52 weeks = 1500 x 1/15 x 1/52 = 1.923 gal/week.

15. Vacation Closer to Home

Assume 250 miles saved.

Savings = vacation miles saved x 1/CAFE x 1/52 weeks = 250 x 1/15 x 1/52 = 0.321 gal/week.

16. Eliminate Recreational Vehicle or Boat

Assume that the average household uses 9.36 gal/year for recreational vehicle or boat.

Savings = 9.36 x 1/52 = 0.180 gal/week.

17. Move Closer to Work

Assume a work-trip cut of 50 percent.

Savings = work-trip length x 2 x savings x 1/CAFE x 5 days/week = work-trip length x 2 x 0.5 x 1/15 x 5 = work-trip length x 0.333 gal/week.

18. Move Job Closer to Home

Assume a work-trip cut of 50 percent.

Savings = work-trip length x 0.333 gal/week.

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REFERENCES

1. D.T. Hartgen. Transportation Energy Overview: Emphasis on New York State. TRB, Transportation Research Record 710, 1979, pp. 26-33.
2. R.M. Margiotta, L. Reilly, and D.T. Hartgen. Foreign Oil Dependence: State-Level Analysis. TRB, Transportation Research Record 726, 1979, pp. 14-18.
3. D.T. Hartgen. Transportation Energy Contingencies: A Status Report on Public Response and Government Roles. Journal of Advanced Transportation, Spring 1980.
4. E.D. Arnold. Opportunities for Energy Conservation in Transportation Planning and Systems Management. Virginia Highway and Transportation Research Council, Richmond, Nov. 1978.
5. J. Pollard and others. A Survey of Opportunities to Conserve Transportation Energy. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, 1975.
6. Energy Conservation Measures. ITE Journal, Aug. 1978.
7. R. Krzyczlsowski and others. Joint Strategies for Urban Transportation, Air Quality, and Energy Conservation. Interplan Corp., Santa Barbara, CA, Dec. 1974.
8. W.G. Barker and L.C. Cooper. One Approach to Local Transportation Planning for National Energy Contingencies. TRB, Transportation Research Record 689, 1978, pp. 31-37.
9. Interim Energy Contingency Plan for the Kansas City Metropolitan Region. Mid-America Regional Council, Kansas City, June 1979.
10. Contingency Plan in Support of a Transportation Energy Conservation Program. Central Mississippi Planning and Development District, Jackson, 1978.
11. Fuel Conservation/Fuel Emergency Contingency Plan. Capital District Transportation Committee, Albany, Tech. Memorandums 1-3, May 1979.
12. Transportation Energy Contingency Plans: Local Experiences. U.S. Department of Transportation, June 1979.
13. Emergency Energy Contingency Plan. Nassau County Planning Commission, Long Island, NY, Dec. 1979.
14. Barton-Aschman Associates. Petroleum Shortage Response Program for the State of Illinois. Illinois Institute of Natural Resources, Springfield, June 1979.
15. Systems Design Concepts, Inc. Transportation Energy Contingency Plans for New York State: Work Plan. New York State Department of Transportation, Albany, Nov. 1979.
16. Energy Emergency Handbook. Economic Regulatory Administration, U.S. Department of Transportation, Dec. 1979.
17. D.T. Hartgen and others. Guidelines for Transportation Energy Contingency Planning. New York State Department of Transportation, Albany, Prelim. Res. Rept. 157, Aug. 1979.
18. Fuel Supply Limitations and Passenger Travel: Scenarios Report. Charles River Associates, Cambridge, MA; NCHRP, Project 8-23, in preparation.
19. S. Goldstein and others. Toward a California Gasoline Shortage Energy Plan. California State Energy Commission, Sacramento, Dec. 1979.
20. Planning Guide for State-Level Emergency Motor Fuel Conservation Actions. Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge; U.S. Department of Energy, Nov. 1979.
21. A.J. Neveu. The 1973-1974 Energy Crisis: Impact on Travel. Planning Research Unit, New York State Department of Transportation, Albany, Prelim. Res. Rept. 131, 1977.
22. D.T. Hartgen and others. Changes in Travel During the 1979 Energy Crisis. New York State Department of Transportation, Albany, Prelim. Res. Rept. 170, 1979.
23. R.L. Peskin. Policy Implications of Urban Traveler Response to Recent Gasoline Shortages. Presented at the National Energy Users' Conference for Transportation, San Antonio, April 13-16, 1980.
24. G.S. Cohen and M.A. Kocis. Components of Change in Urban Travel. New York State Department of Transportation, Albany, Prelim, Res. Rept. 165, 1979.
25. J. M. Gross. The Car Left Home. New York State

Department of Transportation, Albany, Prelim. Res. Rept. 168, 1979.
26. N.S. Erlbaum. How Much Did Transit Really Help During the Energy Crisis? New York State Department of Transportation, Albany, Memo., Dec. 5, 1979.
27. J.M. Brunso. Carpool Coordinator Demonstration Study. New York State Department of Transportation, Albany, Prelim. Res. Rept. 171, Jan. 1980.
28. N.S. Erlbaum. NYS CAFE: Monitoring Changes in 1979. New York State Department of Transportation, Albany, Memo., June 18, 1979.

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