Potential Use of Carpooling During Periods of Energy Shortages

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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.

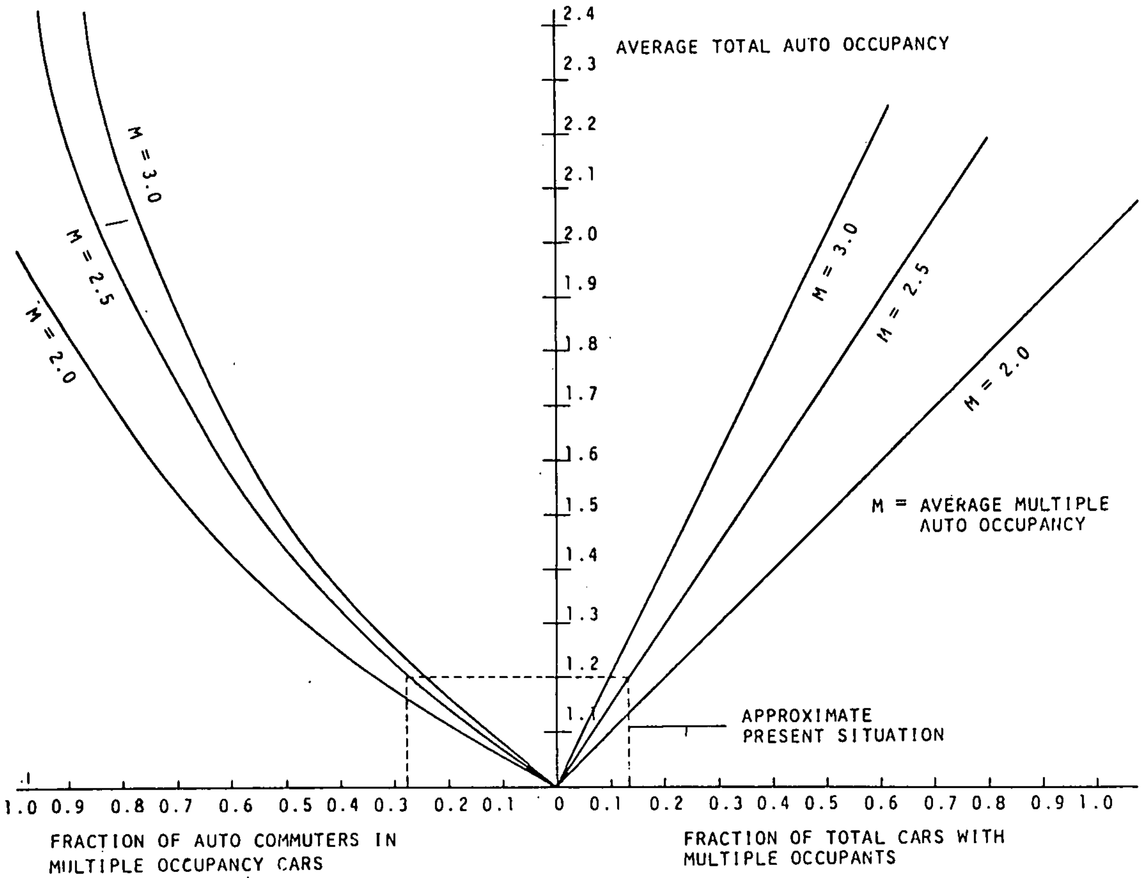
CARPOOL FORMATION DURING PREVIOUS SHORTAGES

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 mile^2), maximum delivery area (0.25 or 1 mile^2), 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.

		Modal Share (%)			
No. of Workers	No. of Vehicles	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.

		Modal Share (%)			
No. of Workers	No. of Vehicles	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.

		Modal Choice of Household Head (%)			
Other Household Members	No. of Vehicles	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.

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Capacity of Urban Transit Systems to Respond to Energy Constraints

Gary F. Taylor

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