BART was that it had not created any new trips. Such an assumption defies logic. By making distant suburbs more easily and comfortably accessible, BART obviously encourages people to live farther from their jobs in the city. Such an assumption also defies the empirical evidence: The average BART trip is 40 percent longer than had been anticipated by its planners, and the largest growth of patronage has been at the most distant stations (20).

Assuming that BART has created no new trips also contradicts the results of on-board surveys done shortly after each BART route was opened, which show an overall trip-creation effect of 15.2 percent (Table 1). According to the on-board surveys, 15.2 percent of the passengers indicated that they had never made the trip before. In my paper I ignored these people. If they are to be counted in explicitly, the simplest way to do so is to make a 15.2 percent reduction in the BART load factor in Table 2, which increases energy intensity to 3.67 MJ/passenger·km (1.65 kW·h/passenger-mile). Making the conservative assumption that all of the 1.6 percent who formerly used other modes should be added to those who formerly used automobiles, I calculate that the diversion mode split would be 47.5 percent automobile/52.5 percent bus. Given the energy intensities in Table 2, it is easy to calculate that, on their former combination of modes, these people had an average energy use of 3.59 MJ/passenger·km (1.62 kW·h/passenger-mile). Thus, they use more energy now than they did before. It can be seen, therefore, that moving even this one assumption closer to reality would show that BART can never repay its invested energy. The same thing would happen if I were to use more realistic figures for gasoline consumption.

REFERENCES

33. Characteristics of Urban Transportation Systems: A Handbook for Transportation Planners. DeLeuw, Cather and Co. and Urban Mass Transportation Administration, May 1975; NTIS, Springfield, Va., PB 245 809.
34. C. A. Lave. A Behavioral Approach to Modal Split Forecasting. Transportation Research, Vol. 3, No. 3, Fall 1969, pp. 463-480.
35. A. Sherret. BART's Energy Consumption, Operating Costs, and Revenues. Paper presented at the 56th Annual Meeting, TRB, 1977.
36. Congressional Budget Office. Urban Transportation and Energy: The Potential Savings of Different Modes. Report prepared for Subcommittee on Transportation of the Senate Committee on Environment and Public Works, Sept. 1977.
37. C. Lave. Negative Energy Impact of Modern Rail Systems. Science, Vol. 195, Feb. 11, 1977, pp. 595-596.
38. C. W. Bullard and R. Herendeen. Energy Cost of Consumer Goods 1963-1967. Center for Advanced Computation, Univ. of Illinois, Urbana, No. 140, Nov. 1974.
39. Railroad Energy Study: Description of Rail Transportation in the United States. Stanford Research Institute and Energy Research and Development Administration, SRI Project TCU 5419, Jan. 1977.

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Energy-Crisis Travel Behavior and the Transportation Planning Process

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This study investigated the adjustment strategies adopted by individual households in response to situations of real and potential fuel shortages and higher prices. It also determined the attitudes of individual households toward regional policies to deal with existing or prospective transportation facilities and costs. The study used a mail questionnaire distributed in November 1975 to a random sampling of households in southeastern Wisconsin. The results suggest that the transportation planning process needs substantial revision only under conditions of excessive fuel-price increases or restricted fuel availability. Moderate and gradual increases in fuel prices are unlikely to bring about significant modifications in the travel patterns of households.

During the post-World War II era, American cities physically expanded as the total population increased, and individual households, encouraged by the relatively inexpensive price of automobiles and fuel, began to locate in single-family homes in suburban areas. The availability of the automobile for the typical American family also enabled families to locate at greater distances from employment locations (5, 6). At the same time, federal, state, county, and local governments made massive financial commitments to the construction and maintenance of highway facilities. The post-World War II era has witnessed the near completion of a 68 383-km (42 500-mile) Interstate highway system as well as thousands of miles of urban expressways and suburban roads. The much improved highway network allowed trucking firms to become major transporters of manufactured goods and large factories to locate on the urban periphery to take advantage of lower land costs and larger available tracts of land (1, 2, 4).

The net result of these interacting factors is what is commonly referred to as urban sprawl. In many American cities, location is not dependent on distance from major activities but on total commuting time from place to place by the family automobile. This increasing reliance on the automobile has meant a commensurate increase in gasoline consumption for urban travel. Present estimates indicate that urban automobile travel consumes about 40 percent of the total energy used in the transportation sector or 10 percent of the nation's energy consumption.

The 1973 Arab embargo on shipments of crude oil to the United States was the first in a series of events that

ended the cheap and abundant supply of gasoline to the American household. In 1973 the Organization of Petroleum Exporting Countries also substantially increased the price of crude oil. Although the embargo was subsequently lifted, the higher prices of gasoline remained. These events meant that many individual households had to develop strategies for coping with the situation. Such strategies may be designed to solve either specific transportation problems or a set of transportation problems. The aim of this study is to investigate three major aspects of such strategies devised by households during the period of the energy crisis: (a) the adjustment strategies adopted by individual households in response to situations of real and potential fuel shortages and higher fuel prices, (b) the attitudes of individual households toward regional policies that may be considered for dealing with existing or prospective transportation facilities and costs, and (c) the policy implications of the basic findings.

CONCEPT OF HOUSEHOLD ADJUSTMENT

Given the rigid budget constraint under which the average household operates and the fact that most of the entries in the monthly budget list are fixed, the period of the fuel crisis between 1973 and 1975 must have created situations of stress for many households. One such area of stress is the overcoming of the problem of distance to work, recreation, and shopping.

The literature on stress theory asserts that when stress results in a stress-strain conversion, a stress situation exists and the individual has to devise strategies either to remove the cause of stress or to reduce the situation to more manageable levels. Whatever their goals are, households select from a finite set of alternatives. This selection is largely influenced by the household's socioeconomic attributes and the nature and the intensity of the information available to that household. In this study, the types of alternatives available to households can be described as behavioral and distance-related strategies. These strategies can be categorized as follows (3):

Strategy	Type of Change	Activity	Change
a	Behavior	Journey to work	Change mode
			Purchase additional, smaller automobile
			Trade in larger for smaller automobile
			Sell automobile and do not replace it
			Postpone purchase of second automobile
			Purchase motorcycle
b	Behavior	Shopping	Combine shopping trips
			Combine shopping and other trips
c	Behavior	Recreation	Use public transportation for vacation and other recreation
			Car pool
d	Distance	Journey to work	Relocate residence
			Quit job
e	Distance	Shopping	Shop closer to home
			Move closer to shopping area
			Make fewer shopping trips
f	Distance	Recreation	Cancel long-distance vacation
			Take shorter distance vacation

In a set of households, individual households that experimented with combinations of these strategies could be identified. They ranged from households that adopted one strategy in either the distance or the behavior category to households that combined two or more strategies in one category or the other or both categories. The two remaining groups of sample households were those who selected all strategies and those who chose none.

One of the hypotheses proposed and tested in this paper is the null hypothesis (H_o) that there are no variations in the number and combination of strategies preferred by households for coping with the transportation effects of the energy crisis. The proposition that the types of strategies adopted are influenced by the socioeconomic attributes of households is also tested. The following appear to constitute a reasonable set of discriminating variables for the analysis: (a) income, (b) household size, (c) automobile ownership (size and number), (d) household employment characteristics, (e) distance to work, (f) household location, (g) age of household members, and (h) educational level of the household head. The particular strategy adopted by a household is a function of the complex interactions among these variables.

When a situation causes stress to a large part of the population, institutional attempts to reduce or remove the causes of stress become necessary. Such attempts are here called planning policies. In the formulation and selection of such policies, the attitudes of households to the policies must be known. That might lead to the selection of some policies, the rejection of some, and, in some cases, to the identification of a new set of potential policies. This paper attempts to determine household attitudes toward various planning policies for energy-crisis conditions.

STUDY QUESTIONNAIRE

Planners from the Southeastern Wisconsin Regional Planning Commission (SEWRPC) consulted and assisted in developing a questionnaire to determine how shortages and higher prices of gasoline have influenced the travel habits and patterns of households in the past and may influence them in the future. Some of the questions used in that survey are used to investigate the research questions posed here.

The questionnaire was mailed during November 1975 to a random sample of 9881 households in the southeastern Wisconsin region (which includes the counties of Washington, Ozaukee, Waukesha, Milwaukee, Walworth, Racine, and Kenosha), and 1461 usable returns (or 14.6 percent of the total) were received. The highest returns came from the predominately suburban counties of Ozaukee (20.7 percent) and Waukesha (20.9 percent), in which the majority of household heads were employed in professional occupations, were middle-aged, and owned two or more vehicles. These occupational, locational, and demographic biases in the survey are understandable because households with these attributes generally have extensive, diversified travel patterns that would be seriously affected by changes in gasoline price and availability.

PATTERNS AND DETERMINANTS OF HOUSEHOLD STRATEGIES

The questionnaire asked respondents to list the types of transportation strategies they used during the fuel crisis and what strategies they might use if there were a future fuel scarcity and if the price of gasoline were increased by $0.05/L ($0.20/gal). Table 1 gives the combinations of strategy selections that characterized the response groups in the sample.

Table 1. Response groups formulated by pattern of strategy selection.

Response Group[a]	Strategy Selection					
	a	b	c	d	e	f
1	No	No	No	No	No	No
2	No	Yes	No	No	No	No
3	Yes	No	No	No	No	No
4	Yes	Yes	No	No	No	No
5	No	No	Yes	No	No	No
6	No	Yes	Yes	No	No	No
7	Yes	No	Yes	No	No	No
8	Yes	Yes	Yes	No	No	No
9	No	No	No	No	Yes	No
10	No	Yes	No	No	Yes	No
11	Yes	No	No	No	Yes	No
12	Yes	Yes	No	No	Yes	No
13	No	No	Yes	No	Yes	No
14	No	Yes	Yes	No	Yes	No
15	Yes	No	Yes	No	Yes	No
16	Yes	Yes	Yes	No	Yes	No
17	Yes	Yes	No	Yes	Yes	No
18	No	Yes	No	No	No	Yes
19	Yes	Yes	No	No	No	Yes
20	Yes	Yes	Yes	No	No	Yes
21	No	No	No	No	No	Yes
22	No	No	No	No	Yes	Yes
23	Yes	No	No	No	No	Yes
24	No	Yes	No	No	Yes	Yes
25	Yes	No	No	No	Yes	Yes
26	Yes	Yes	No	No	Yes	Yes
27	No	Yes	Yes	No	Yes	Yes
28	Yes	No	Yes	No	Yes	Yes
29	Yes	Yes	Yes	No	Yes	Yes
30	Yes	Yes	No	Yes	Yes	Yes
31	Yes	Yes	Yes	Yes	Yes	Yes
32	Yes	Yes	Yes	Yes	Yes	No

[a] Response groups with less than 10 observations are not included in the table.

Table 2. Regional percentage distribution of response groups for actual and future energy-crisis conditions.

Response Group	Regional Percentage Distribution		
		Future Crisis Condition	
	1973 to 1975	Higher Fuel Prices	Restricted Fuel Availability
1	9.172	4.928	2.738
2	3.286	1.848	0.890
3	3.012	1.369	1.711
4	2.533	0.890	0.753
5	1.437	0.958	—
6	1.369	0.890	0.890
7	0.684	0.890	0.753
8	1.095	1.437	1.300
9	2.190	1.095	0.684
10	8.556	3.560	2.122
11	1.848	1.369	1.164
12	7.529	4.312	2.533
13	1.437	1.164	0.890
14	4.928	2.738	2.190
15	1.232	1.848	1.848
16	5.955	7.187	9.582
17	0.753	—	—
18	1.369	0.890	—
19	1.437	1.574	1.027
20	—	1.027	0.753
21	0.890	—	—
22	1.437	0.753	—
23	0.958	—	—
24	7.734	4.244	2.396
25	1.780	2.053	1.437
26	10.268	8.419	7.118
27	3.901	5.544	3.833
28	—	1.437	1.027
29	6.434	29.911	38.809
30	1.095	0.753	1.232
31	0.753	2.190	6.776
32	—	—	0.890
Groups with <10 observations	4.928	4.722	4.654
Total	100	100	100

1973-1975 Period

The basic pattern of behavior change during the energy-crisis period is summarized in the data given in Tables 2, 3, and 4. These data indicate certain basic tendencies.

1. Over 75 percent of the sampled households made multiple adjustments in travel behavior. The most common strategy involved some combination of distance-related and behavioral changes in travel. Some households combined changes in the journey to work with changes in recreation and shopping. Across all categories of households, however (Table 3), the most important method of coping with the crisis is always that involving both types of modifications.
2. Households preferred an adjustment strategy of careful retreat, making changes that caused the least disruption to their precrisis travel patterns and putting off hard decisions that would involve major changes. For example, approximately 70 percent made one or more of the following changes in shopping behavior: combined several shopping trips, combined shopping trips with other trips, made fewer shopping trips, and shopped at

Table 3. Regional percentage distribution of households by number and mix of strategies selected for actual and future energy-crisis conditions.

Number and Mix of Strategies Selected	Regional Percentage Distribution		
		Future Crisis Condition	
	1973 to 1975	Higher Fuel Prices	Restricted Fuel Availability
One			
a	3.012	1.369	1.711
b	3.286	1.848	0.890
c	1.437	0.958	—
d	—	—	—
e	2.190	1.095	0.684
f	0.890	—	—
Total	10.815	5.270	3.285
Two			
ab, ac, bc	4.586	2.670	2.396
de, df, ef	1.437	0.753	—
Both categories	14.168	6.983	4.176
Total	20.191	10.406	6.572
Three			
abc	1.095	1.437	1.300
def	—	—	—
Both categories	24.640	16.769	11.431
Total	25.735	18.206	12.731
Four	20.877	23.614	22.313
Five	7.529	30.664	40.931
All	0.753	2.190	6.776
None	9.172	4.928	2.738
Groups with <10 observations	4.928	4.772	4.654
Total sample	100	100	100

Table 4. Actual and intended behavior change of sample households by strategy category.

Strategy	Percentage Making at Least One Change		
		Future Crisis Condition	
	1973 to 1975	Higher Fuel Prices	Restricted Fuel Availability
a	49.56	68.65	80.29
b	71.87	79.81	85.01
c	32.58	60.03	72.01
d	5.40	5.41	10.75
e	71.04	81.04	86.72
f	41.34	62.22	67.76

Table 5. Actual and intended work-trip transportation mode of all wage earners in sample.

Transportation Mode	November 1975 (%)	Future Crisis Condition	
		Higher Fuel Prices (%)	Restricted Fuel Availability (%)
Automobile			
Driver	68.6	63.4	45.7
Passenger in family automobile	9.5	3.3	3.6
Automobile and bus	2.5	2.1	2.8
Car pool	7.2	13.2	17.7
Bus	5.0	6.1	10.1
Motorcycle	0.2	0.9	2.6
Bicycle	0.5	1.5	2.5
Walk	5.7	7.2	8.4
Other	0.7	2.2	6.7

stores closer to home. It should be noted that the first two strategies constitute behavior changes and the last two are distance changes.

3. Besides reducing the frequency of trips and changing the places visited, approximately 50 percent of the sample households made one or more of the following adjustments: purchased an additional automobile that was smaller than automobiles already owned, traded in a larger for a smaller automobile, sold one automobile and did not replace it, postponed purchase of a second automobile, purchased a motorcycle, and shifted mode for the journey to work. These adjustments are all behavioral journey-to-work changes. In approximately 20 percent of the households, at least one wage earner made a shift in the mode used for the journey to work.

4. Over 40 percent of the households made changes in recreation travel. Canceling plans for a long-distance vacation and taking vacations of shorter distances were more frequent adjustments than was using public transportation for vacations because such an adjustment involved a higher out-of-pocket cost, especially for households with children.

5. Residential relocation as a response to the fuel crisis was rare. Only 5 percent of the households moved closer to their place of employment.

6. Nine percent of the respondents are households who indicated no change in their travel behavior.

Future Crisis

Investigating what households did during the 1973-1975 period may give an indication of what they will do in future fuel-crisis situations, but it is not a sufficient basis for formulating policies for the future. Therefore, households were asked to suggest which strategies they might use in two future situations: (a) if the price of gasoline were increased by $0.05/L ($0.20/gal) but no limit were placed on its availability and (b) if gasoline per driver were restricted to 30 L/week (8 gal/week) but the price remained at current levels. These restrictions would last for at least 5 years. The basic findings for these future situations are also given in Tables 2, 3, and 4. In comparison with the 1973-1975 situation,

1. Households are more likely to adopt multiple adjustment strategies in the future. The economic and psychological effects suffered by many households during the energy crisis and the associated flood of information about fuel conservation may have contributed to the decision of many households to cope with such emergencies in the future by experimenting with several strategies.

2. In the two future conditions of higher prices and restricted fuel availability, more than three-fourths of the respondents would modify their shopping behavior by using both kinds of strategies.

3. Approximately 68 and 80 percent respectively said they would make one of the following adjustments under a situation of gasoline price increases or restricted fuel availability: purchase an additional, smaller automobile; trade in a larger for a smaller automobile; sell one automobile and not replace it; postpone purchase of a second automobile; purchase a motorcycle; and shift the mode for the journey to work.

4. According to the respondents, an increase in the price of gasoline of $0.05/L ($0.20/gal) would have a substantially less severe mode-shift impact on the journey to work than would gasoline rationing (Table 5). More households would tend to use car pools and public transportation for the journey to work under conditions of restricted fuel availability than under conditions of higher fuel prices.

5. Even in a future crisis, the sample households would be very reluctant to move closer to their jobs. Only 5.4 percent and 10.8 percent of households in the sample said they might relocate their residences in the two future crisis situations.

SOCIOECONOMIC AND LOCATIONAL FACTORS OF HOUSEHOLD ADJUSTMENT

1973-1975 Period

The following significant relations were found between household adjustment patterns and the attributes of households:

1. Households with younger heads were more likely than households with older heads to change their journey-to-work behavior, to make distance-related shopping changes, and to relocate closer to employment. In general, younger households are more flexible in their travel patterns and less likely to be tied to a particular residential location. They are usually renters and are more likely than homeowners to change residential location in response to higher fuel prices.

2. Behavioral shopping changes, distance-related recreation changes, car pooling, the purchase of a new small automobile, and the trade-in of a larger automobile for a smaller automobile were more common among middle-income households, possibly because of the less diverse travel patterns of low-income households. In contrast, higher income households (over $25 000/year) do not need to adjust because of higher gasoline prices.

3. Individuals with certain occupations had a tendency to respond in similar ways to the higher fuel prices that occurred between 1973 and 1975. Sales workers were more likely to make a change in their recreation behavior (involving the use of public transportation) than were craftsmen, foremen, and operatives. Behavioral recreation changes are generally less likely for a blue-collar homeowner with a large family than they are for a high-income sales worker who can afford the expense of a vacation on public transportation. Clerical workers were the group most likely to move closer to places of employment between 1973 and 1975. Many clerical household heads are nonhomeowners and thus better able to relocate in response to higher fuel prices than are professionals or managers, who are likely to be homeowners. Professionals, managers, and blue-collar workers who were most likely to work either in a central location or in establishments that have a large number of employees have the highest car-pooling rates. Sales persons were the group with the highest percentage of households purchasing a smaller automobile, which in-

dicates that sales persons tend to maintain precrisis travel patterns by purchasing a more fuel-efficient automobile.

4. Households with one or two children made more adjustments in shopping than childless households or households with more than two children, possibly because larger families may have made the necessary distance and behavior adjustments in shopping before the crisis occurred. Because many childless households often have two wage earners, the need for shopping adjustments may not be critical.

5. Geographic location influenced households' use of car pooling and other distance-related journey-to-work adjustments. Car pooling was highest among residents of Waukesha County and then among residents of the exurban counties of Walworth, Ozaukee, and Washington.

Future Crisis

The most important similarities and dissimilarities in the way in which household attributes may have affected adjustment patterns between 1973 and 1975 and the way they may affect them under future conditions of rising fuel cost and restricted quantity of fuel can be summarized as follows:

1. Younger households may again make more behavioral changes in recreation travel and more distance-related changes in the journey to work and in shopping than do older households.
2. In a future situation of restricted fuel availability, sales workers will be more likely to make behavioral recreation changes than will craftsmen and operatives. If the quantity of gasoline is restricted, clerical workers will be more likely to change their journey-to-work behavior than will professional and managerial groups.
3. In a future fuel crisis, families with one or two children are more likely to make changes in their shopping patterns than are childless families or those with more than two children. This was also true of the 1973-1975 period.

The basic patterns that emerged from an analysis of future household adjustments are similar to those that emerged from an analysis of behavioral change between 1973 and 1975. Although in certain cases the number of significant contributing variables was greater for the two future categories than it was for behavior between 1973 and 1975, in all cases actual behavioral changes contributed significantly to the explanation of intended behavioral changes in future crisis situations.

HOUSEHOLD ATTRIBUTES AND ATTITUDES TOWARD PUBLIC POLICY

The questionnaire also investigated the attitudes of the sample population toward certain potential public policies. The major policy areas examined were (a) gasoline price levels, (b) freeway construction, (c) bus transportation costs, (d) public subsidy for bus transportation, and (e) fuel conservation measures. An analysis of the responses to these five types of policies indicates that households prefer those policy alternatives that minimize costs or maximize benefits to themselves, that they seek to maintain current travel patterns at current prices, and that they are most willing to accept policy changes that will adversely affect groups other than themselves. Opposition is greatest to policy alternatives that increase costs or threaten to disrupt current travel patterns.

Gasoline Price Levels

Households were asked to determine a gasoline price threshold beyond which they would make significant changes in their travel patterns. Approximately 30 percent cited $0.21/L ($0.80/gal) or more. Only 9.9 percent of the households stated that a gasoline price level of $0.13 to $0.15/L ($0.50 to $0.59/gal)—the actual level of gasoline prices at the time of the survey—would bring about significant changes in travel patterns. The results suggest that high-income households or households with wage earners in certain occupation groups (sales workers, managers, officers, proprietors) have very high gasoline price thresholds. In contrast, low-income households or households in which wage earners are craftsmen, foremen, operatives, and workers and laborers employed in private homes have very low gasoline price thresholds.

Freeway Construction

Approximately 65 percent of the respondents felt either that the planned freeway system should be completed or that it should be completed and expanded. More than 27 percent believed that the construction of freeways should be stopped. Suburban households that rely heavily on the automobile and need to shorten lengthy work trips were more likely to support additional freeway construction than were low-income households or those in which heads of households were older.

Bus Transportation Costs

Approximately 70 percent of the respondents believed that public transportation costs should be shared between the rider and a combination of federal, state, and local support. About 25 percent believed that transportation costs should be assumed entirely by the rider. Households opposed to public financing of bus systems are more likely to be high-income, suburban households to whom bus service is not currently available. In spite of the fact that only a small percentage of households in the study region use the bus system on a day-to-day basis, substantial support exists for the maintenance of a bus system.

Local Sources of Public Subsidy for Bus Transportation

The questionnaire tested attitudes on the sources of local funds for a public transportation subsidy. The specific local sources considered were taxes on property, sales, income, and vehicles. Only 6.8 percent of the respondents believed that local subsidy funds should come from a local property tax. In contrast, 28.9 percent felt that a local sales tax should be used to collect the transportation subsidy and 18 percent preferred the local income tax. The highest percentage of households (31.3 percent) favored a local vehicle tax. Fifteen percent of the respondents did not favor any of the stated local sources. In fact, many households in this group were opposed to the use of any local funds for a public transportation subsidy.

A review of the attributes of particular household groups indicates that support for the use of a local income tax was highest among low-income groups (those least affected by increases) and lowest among high-income groups (those most affected by increases). Support for the use of a local vehicle tax was greatest among younger households and lowest among households in Waukesha County, the most automobile-dependent county in the region. In general, greater regional support was

found for either a local sales tax or a local vehicle tax than for a local property tax or a local income tax.

Measures to Increase Fuel Conservation

Respondents were asked to list their first, second, third, and fourth choices among a series of policy suggestions designed to increase the conservation of gasoline. The four specific policy choices were (a) place a higher tax on a liter of gasoline, (b) place a higher registration fee on large than on small automobiles, (c) ration gasoline, and (d) offer free or reduced-fare bus transportation.

Among the 1445 respondents identified by geographic location, the policy indicated by the most respondents (approximately 36 percent) as first choice was a higher registration fee for larger automobiles. Logically, this policy represents the least threat to existing travel patterns and costs. Once the higher fee is assessed, the action in no way restricts the amount of driving an individual may do. The next most popular policy action—the first choice of 27 percent of the households—was free or reduced-fare bus transportation. Again, this type of action represents no basic threat to the current travel patterns of individual households. The two policy alternatives that pose a threat to either the cost of travel or the amount of driving done by households were least preferred: Only 17 percent gave gasoline rationing as their first choice, and 14 percent gave higher gasoline taxes.

The pattern of household attitudes toward the four policy alternatives is clear: Households give greater support to the policy alternatives that have the least adverse impact on them. They will support policy alternatives that do not interfere with current travel patterns or do not adversely affect them economically. Thus, gasoline rationing, for example, would be extremely unpopular. Low-income households would, however, prefer gasoline rationing to substantial increases in gasoline prices that would restrict their travel patterns but would not affect the travel patterns of high-income households.

POLICY IMPLICATIONS OF THE RESULTS

In 1972, SEWRPC conducted a home interview survey to provide the data base for a reevaluation of transportation and land-use plans that were first developed on the basis of 1963 data. The results of the energy-use survey are discussed below in relation to the procedures used in the SEWRPC plan reevaluation report (7) in developing transportation models for the future: trip generation, trip distribution, modal split, and traffic assignment.

Trip Generation

SEWRPC estimated both trip production and trip attraction in the region. Trip-production rates were analyzed and forecast by using the disaggregate technique of cross-classification analysis. Trip-generation rates were explained on the basis of the two independent variables—household size and automobile availability—that were best able to account for variations in trip-production rates. Trip attractions were analyzed and forecast by means of multiple regression based on land uses in the various zones of the region. Trip-generation rates were developed and projected for the following types of trips: home-based work, home-based shopping, home-based other (including personal business, medical-dental, social-eating, and recreation), and non-home-based trips. Trip-generation rates were calculated for four subregional units: the urban areas of Milwaukee, Racine, and Kenosha and all other areas in the region. According to the SEWRPC report (7),

> Separate models for each trip purpose were developed for these four areas because analysis of regional household trip-making as surveyed in 1963 and 1972 indicated substantial differences in trip frequency between urban and rural areas within the Region and between urban areas of different sizes within the Region.

The urban areas of the region had higher trip-generation rates than did the rural areas.

The significant findings of the energy-use survey in relation to trip generation are as follows:

1. The basic pattern of higher trip-generation rates in urban areas remains essentially unchanged in the two future fuel-crisis situations. The study showed that adjustments, especially in shopping and the journey to work, were fewer in Milwaukee County than in the exurban counties of Walworth, Washington, and Ozaukee.
2. The figures for the proportion of people working at home varied slightly from SEWRPC data for the two future alternatives. In general, individuals would continue to go to work, though possibly by a different mode. Under conditions of restricted fuel availability, however, a small percentage of wage earners said they might quit their jobs rather than continue the long commuting journey. Thus, overall trip-generation data for the home-based work trip analyzed for the region by SEWRPC would be affected only slightly by the future restricted availability of fuel.
3. The energy-use survey suggests substantial changes in shopping behavior under the suggested future crisis conditions. One of the major findings is that trip-generation rates may be reduced. Distance-related variations in shopping changes may be evident in future crises. A lower percentage of households in Milwaukee County said that they would change shopping behavior than did households in Racine, Kenosha, Waukesha, and the exurban counties of Washington, Walworth, and Ozaukee. Furthermore, shopping changes would increase as the number of automobiles in the household increased. Such a change would also be higher among households with one or two children than among childless households. In short, trip-generation rates for shopping may decline significantly in either of the alternative future situations. As a result, the data used in the SEWRPC trip-generation tables may need to be reevaluated.

Trip Distribution

The results of the energy-use survey indicate that significant changes may be made in the distribution of work and shopping trips. The basic findings include the following:

1. The energy crisis did not cause a significant amount of residential relocation as a way to reduce the journey to work. Even under future conditions of higher prices and restricted fuel availability, sample households indicated they were very reluctant to move their places of residence closer to their jobs. Thus, regional lines that connect trip ends and their associated trip-length distribution for the journey to work should remain essentially unchanged.
2. In future crises, shopping trips and patterns would be modified. Many households indicated that they would shop at stores closer to home, which implies that smaller neighborhood shopping areas may increase their traffic and therefore their customers at the expense of regional shopping malls. Thus, the 1963-1972 pattern of increase in the mean distance for shopping

trips, attributed by SEWRPC to the increased construction of regional shopping malls, may change during future fuel crises.

Mode Choice and Automobile Occupancy

The results of the energy-use survey also suggest that in future fuel crises changes can be expected in choice of mode for the work trip. An additional $0.05/L ($0.20/gal) increase in the price of gasoline, for example, would effect some mode change in the journey to work. But this effect is substantially less than what might occur under gasoline rationing.

In November 1975, approximately 68 percent of wage earners were automobile drivers. If fuel prices increased, over 63 percent would continue to be automobile drivers. The most important effect of higher fuel prices would be a decrease in the percentage of wage earners who are passengers in family automobiles—from 9.5 to 3.3 percent—and an increase in the percentage of wage earners who are car poolers—from 7.2 to 13.2 percent. In November 1975, 16.7 percent of wage earners were either passengers in family automobiles or car poolers. Higher prices would change this only slightly, to 16.5 percent. Increased car pooling in response to higher fuel prices might bring about greater automobile occupancy if wage earners who ordinarily ride as passengers in family automobiles obtained additional riders for the journey to work. Increased automobile occupancy, of course, would affect vehicle trips in the region (person trips divided by automobile occupancy) and thus possibly influence the traffic-assignment models.

Changes in the journey to work would be far more substantial if fuel availability were restricted. According to the energy survey, the percentage of wage earners who are automobile drivers would decline from the current level of 68.6 to about 45.7 percent. Car pooling would increase from the current 7.2 to 17.7 percent and bus ridership from 5 to 10.1 percent.

Traffic Assignment

Traffic assignment is the assignment of trips to an existing or proposed transportation network. The travel changes predicted in the energy-use survey are bound to reduce the number of trips (especially automobile trips) that can be assigned to the transportation network. Nevertheless, the assignment process would remain unchanged; nothing in the study suggested that the basic rationale for choosing a route between an origin and a destination (i.e., a minimum time path) would be changed. In view of the findings of the survey, however, planners now have the basis for testing the sensitivity of their traffic-assignment models. If fewer trips are loaded onto the system, certain proposed freeway links may no longer be needed. Test runs could determine the amount of trip reduction required to reduce the need to construct specific freeway links. In short, the energy-use survey provides a basis for checking the sensitivity of traffic-assignment results to various future conditions.

SUMMARY

The results of this study suggest that the transportation planning process needs substantial revision only under conditions of excessive fuel price increases or restricted fuel availability. Moderate and gradual increases in fuel prices are unlikely to cause significant modifications in household travel patterns.

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REFERENCES

1. J. A. Connally and C. O. Meiburg. The Washington Capital Beltway and Its Impact on Industrial and Multi-Family Expansion in Virginia. HRB, Highway Research Record 217, 1968, pp. 9-27.
2. G. Gilbert. Energy, Urban Form and Transportation Policy. Transportation Research, Vol. 8, 1974, p. 269.
3. M. E. Harvey and W. M. Ross. The Spatial and Non-Spatial Implications of a Short and Long-Term Gasoline Shortage. Department of Geography, Kent State Univ., Ohio, 1976.
4. E. V. Kiley. Highways as a Factor in Industrial Location. HRB, Highway Research Record 75, 1964, pp. 48-52.
5. L. K. Loewenstein. The Location of Residences and Work Places in Urban Areas. Scarecrow Press, Inc., New York, 1965.
6. J. R. Meyer, J. F. Kain, and M. Wohl. The Urban Transportation Problem. Harvard Univ. Press, Cambridge, Mass., 1965.
7. A Land Use Transportation Plan for Southeastern Wisconsin—2000. Southeastern Wisconsin Regional Planning Commission, Waukesha, Planning Rept. 25, 1976.

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