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Energy-Conservation Strategies and Their Effects on Travel Demand

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ABSTRACT

The types of impacts on urban travel demand that might be expected from two broad, multifaceted energy-conservation strategies are described. Based on sketch-planning travel demand modeling conducted for three case study regions and generalized extrapolation of these results to national totals, illustrative travel impact results are presented. Five different types of impact are considered: (a) mode choice by trip purpose (work versus nonwork), (b) variations in transit travel by city type, (c) vehicle miles of automobile travel for work and nonwork purposes, (d) variations in trips per capita and per trip length by purpose, and (e) distributional differences in terms of household (central city, suburban, exurban). The in-place policy, marked by a sharp rise in automobile out-of-pocket costs, had no increase in per capita automobile travel by 2000, although aggregate energy consumption was lowered. The individual travel strategy, which lowered automobile operation cost relative to the in-place policy by improvements to automobile fuel economy, achieved noticeable energy savings with negligible impact on choice of travel mode. The group travel strategy, on the other hand, significantly altered mode choice and saved transportation energy in this way. Significant improvements in transit service and strong automobile travel disincentives yielded dramatic shifts to group travel modes for nonwork travel. Work travel mode choice was affected to a lesser extent, with increases of 30 to 40 percent in transit and shared-ride modal splits.

Meaningful analysis of the many different supply- and demand-oriented strategies for conserving urban transportation energy is a complex undertaking. Not only is the range of available conservation options a wide one, but the applicability of such options within urban areas varies greatly by urban area size and density (1-3). When the potential impact of technology-oriented options (e.g., alternate fuels, engine technology advances, and greater fuel efficiency from the vehicle mix) is considered, another layer of complexity is added (see papers by Hudson and Putnam, and by Saricks, Vyas, and Bunch elsewhere in this Record). Even more complications arise when the analysis tools available for the examination of travel demand impacts are considered, together with the necessary behavioral assumptions that are associated with them (see paper by Kaplan, Gur, and Vyas elsewhere in this Record).

Consequently, because of these complications the analysis results presented in this paper are illustrative only. In order to permit a systematic yet wide-ranging analysis to move forward, a host of reasonable (but still limiting) assumptions has been made. For example, only two scenarios regarding the future socioeconomic characteristics of urban regions [household size, income, energy price, gross national product (GNP)] were considered. Among the many different combinations of energy-conserving actions that could be devised, only two--one emphasizing group travel options (transit and shared ride) and another emphasizing greater efficiency in individual vehicle travel--were investigated (together with in-place policies as a baseline).

The four combinations of scenarios and strategies are intended to represent end-of-range impacts, with the understanding that many other intermediate levels of policy action and impact are possible.

The types of impact on urban travel demand that might be expected from two broad, multifaceted energy-conservation strategies are described. Based on sketch-planning travel demand modeling conducted for three case study regions and generalized extrapolation of these results to national totals, illustrative travel impact results are presented. The method for projecting city-specific responses to the strategies sequentially (1990 and 2000) applied a modified, logit model of travel demand (4, and paper by Kaplan et al. in this Record). Recalibration was performed for each case study city. The model was used directly for each forecast, with revised demographic as well as policy variables. Because of this structure, comparison of results for each year, strategy, and city was consistently achieved.

Five different types of impact are considered: (a) mode choice by trip purpose (work versus nonwork), (b) variations in transit travel by city type, (c) vehicle miles of automobile travel for work and nonwork purposes, (d) variations in trips per capita and per trip length by purpose, and (e) distributional differences in terms of household income levels and location within urban areas (central city, suburban, exurban).

Again, the results presented are not regarded as definitive (and certainly not prescriptive) but as illustrative of the kinds of traveler response that could be expected for organized urban transportation energy-conservation strategies. The modeling tools measured synergistic effects of the strategies and demonstrated differences between cities.

ALTERNATIVE CONSERVATION STRATEGIES

Economic Growth Scenarios

To help bound the analysis of urban transportation energy-conservation potentials, two economic growth scenarios were set forth. These scenarios provide two different economic and social aggregation futures as a backdrop for the analysis of the impacts of conservation policies. The scenarios are distinguished from each other primarily by assumed GNP growth rate, rate of fuel price increase, amount of technology development success, and social organization. Scenario I is generally greater on all these dimensions than scenario III (scenario II was dropped from the analysis). The percentage of the national population living in metropolitan areas is higher in scenario I than in scenario III. Household sizes are slightly smaller and household incomes are significantly higher under scenario I.

Scenario I can consequently be regarded as stronger and more vigorous in economic and technology development terms, whereas scenario III can be regarded as a slower growth, economically conservative, and lower-income economy. Key constrasts between scenarios I and III include (in order) the following items:

1. GNP growth rate--3.6 versus 2.2 percent;
2. Level of social aggregation--strong competition versus disassociation;
3. Research and development activities--high investment versus low investment;
4. Average household size, year 2000--2.37 versus 2.41;
5. Low-income households (less than $13,000 in 1975 constant dollars), year 2000--34 versus 51 percent;
6. High-income households (more than $23,000 in 1975 constant dollars), year 2000--33 versus 23 percent;
7. Total energy consumption, year 2000 (in quads)--114 versus 94; and
8. Oil price per barrel (1975 dollars), year 2000--$46 versus $62.

Case Study Regions for Travel Demand Analysis

Conservation policies were tested in three typical cities, and impacts were analyzed and then expanded to national urban totals. As the testing was done for each city, some variation in policy specification occurred in each according to its features. The typical cities were selected in light of major differences in their transportation-related characteristics; a factor analysis technique was used for grouping cities (see paper by Peterson elsewhere in this Record). The first typical city, Sprawlburg, represents relatively new, spread out, western metropolitan areas. The second city, Megatown, has certain characteristics of the big, densely settled city with satisfactory transit in place. The third typical city, Slowtown, might be best described as a midwestern, industrial, middle-sized metropolitan area.

Cities in the nation are viewed as combinations of the characteristics of these typical cities. The typical cities were selected as extreme or atypical cities along three primary dimensions. Intensive studies of these three cities were used to infer the response of all cities in the country. Because all cities, to some extent, assume the roles of service city, manufacturing center, government center, transport hub, and so forth, the data describing 237 standard metropolitan statistical areas (SMSAs), including 52 socioeconomic and transportation variables from various years (1970 through 1977), were used to define the primary dimensions and the relationships of all cities to those dimensions.

Sprawlburg examples include Phoenix, Nashville, Dallas, Anaheim, and Jacksonville. Megatown examples include Chicago, Philadelphia, Cleveland, Minneapolis, Boston, and San Francisco. Slowtown examples include Flint, Grand Rapids, Lima, Paterson, Norwalk, and York.

Range of Conservation Options

As a baseline for all impact analyses, an in-place policy was established as the extension of all programs and plans in place in 1980 that affect urban transportation. For the three case study cities, these were defined in terms of existing state, regional, and local plans. The two energy-conservation policy packages, so named to reflect the fact that a number of more specific options are contained within each, represent two different approaches to saving energy in urban transportation.

The group travel strategy promotes mass transit and ridesharing with no improvements to automobile technology relative to the in-place policy, whereas the individual travel strategy focuses on automobile technology improvements as the means to decrease transportation energy use while maintaining mobility. In general, the group travel strategy involves large-scale changes in level of service for transit, as measured by service frequency, line-haul travel time, and system coverage in each case study region.

The individual policy actions or measures that were analyzed are given in Table 1. Some 17 different actions are included, falling into four broad groups: land use controls, fuels and vehicles research and development (R&D), economic and regulatory disincentives (automobile travel), and group travel incentives (transit, ridesharing).

Policies varied by the scenario in which they were expected to have the greatest effect; in general, scenario I, with higher GNP and public and private dollars available for research and development, was assumed to be capable of supporting rail transit service expansion. Scenario III, on the other hand, emphasized reduced transit fares and express bus service, including busway construction. Levels of policy change for both 1990 and 2000 are indicated in Table 1, reflecting the years for which demand analyses were conducted.

the group travel strategy consequently did not change extent of service as much as the quality of the service provided.

Group Travel Strategy in Scenario I

The policy test of the group travel strategy in scenario I included no changes under land use controls or fuels and vehicles R&D, but there were extensive changes to transit service, including significant development of light rail service and

TABLE 1 TAPCUT Conservation Strategies as Tested in Travel Mode Changes from In-Place Policy by Forecast Year

		Group Travel Strategy		Individual Travel Strategy	
Policy Action (measure)	Year	Scenario I	Scenario III	Scenario I	Scenario III
Land use controls (%)					
Live close to work (work trip length)	1990		-6		
	2000		-14		
High density zoning (growth in households relocated near or away from centers)	1990		4.9[a]		4.9[b]
	2000		11.4		5.1
Decentralized work or shop locations (employment growth relocated near or away from centers)	1990		25.8[a]		16.9[b]
	2000		29.3		17.5
Further CBD growth (CBD share of employment)	1990		9.1		-6.8
	2000		18.0		-14.4
Fuels and vehicle R&D (%)					
Vehicle weight R&D (avg fleet car weight)	1990			-3.3	6.7
	2000			-4.3	8.2
Engine, vehicle, and fuels R&D (new car miles per gallon)	1990	2.2	1.8	28.4	-1.4
	2000	2.8	-1.8	23.4	3.6
Economic disincentives for automobiles					
Increase CBD parking cost (daily charge) (%)	1990	200	200		
	2000	200	200		
Impose cost on free parking (in 1975 dollars) ($)	1990	2.00	1.00		
	2000	2.00	1.00		
Increase automobile fuel tax (retail fuel price) (%)	1990	37.2	38.6		
	2000	97.2	42.0		
Group travel incentives (%)					
Carpool promotion (parking costs, walk time to work)	1990	-50	-50		
	2000	-50	-50		
New rail service (track miles built)	1990	235	1		
	2000	215	33		
New rail service[c] (in-vehicle time)					
Express busways built (busway lane miles)	1990	-[d]	164		
	2000	100	111		
Express bus service[e] (in-vehicle time)					
Conventional bus service (routes with improved frequency)	1990	50			
	2000	100			
Conventional bus service (wait time)	1990	-15			
	2000	-15			
Reduce transit fares	1990		-25		
	2000		-25		
Automobile travel behavior, trip linking[f]					

[a] Near.
[b] Away.
[c] Range of 40 to 60 percent for scenarios I and III for group travel strategy.
[d] Same.
[e] On busways and bus lines for scenarios I and III for group travel strategy.
[f] Parametric only; discuss impacts for scenarios I and III for group travel strategy.

Figure 1 also summarizes, in a conceptual way, the relative emphasis on selected conservation policies or action areas associated with each strategy. In addition, for the group travel strategy, scenario I relied on capital-intensive light rail systems and some busways, whereas scenario III used more extensive motor bus service in mixed traffic and in exclusive lanes--a low-capital, high operating cost choice.

The level of detail at which transit service changes were specified makes it difficult to simply summarize the changes in Table 1. The measures provided indicate that travel time changes were the same general magnitude in each scenario, but varied by transit mode (bus or rail) and travel corridor. Extent of service was increased substantially over the 20-year period according to the in-place policy;

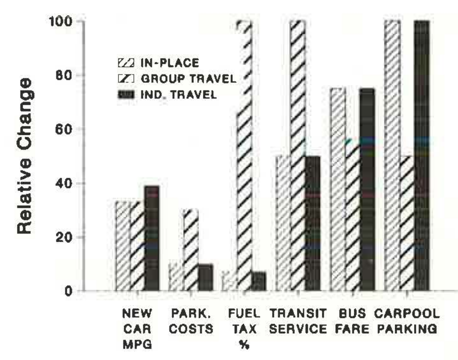

FIGURE 1 Summary of TAPCUT conservation policies in contrast to in-place policies in 2000.

bus frequency improvements, coupled with stringent automobile disincentives in the form of parking costs and fuel taxes. Busways were used in smaller cities, whereas new light rail was built in medium-sized cities. The fuel taxes increased to 50 percent of the retail price in 1990, and to 100 percent by 2000.

Parking costs tripled in central business districts (CBDs), whereas $2 (in 1975 dollars) charges were imposed on free parking under the in-place policy. There were 50 percent reductions in carpool parking costs and in walk times at the work place for both forecast years. Fuel economy changes in new car purchases are reflective of fuel price impacts on automobile purchases and of a minor vehicle design change in the medium-Otto vehicle.

Group Travel Strategy in Scenario III

Significant transit improvements with stiff increases in automobile costs marked the policy test of the group travel strategy in scenario III. Transit improvements focused on increases in express bus service, extensive use of busways in small and medium-sized cities, reduction of fares to 75 percent of in-place policy levels, and a 50 percent reduction in carpool parking costs and walk times was also included. The fuel taxes reached 50 percent of the retail price in 1990 and stayed there to 2000.

Parking taxes ($1 in 1975 dollars) were imposed throughout each metropolitan region, including those suburban lots that were free under the in-place policy. Some land use controls were imposed, which resulted in a net reduction in work trip length, increased residential density, and a damping of the trend under the in-place policy to decrease the CBD share of metropolitan employment. There were essentially no changes in the automobile characteristics defined under the in-place policy for this scenario.

Individual Travel Strategy in Scenario I

In the policy test of the individual travel strategy in scenario I, significant increases in automobile fuel economy were postulated. All other variables were unchanged from the in-place policy. New cars were 23.4 percent more fuel efficient in the year 2000 than their in-place policy counterparts. The stock held by households was nearly 23 percent more efficient than the in-place policy, and 125 percent better than that of 1980.

Fuel-economy gains in newly purchased automobiles are achieved without major weight changes. Engine design improvements in 1990 allow both performance and fuel economy to improve without much reduction in vehicle weight. In 2000 the need for weight change is somewhat greater, whereas the fuel-economy increase over the in-place policy vehicles is not quite as great as for 1990.

Individual Travel Strategy in Scenario III

A modest improvement in automobile fuel economy and an increase in decentralized development are the changes proposed for the policy test of the individual travel strategy in scenario III. The prices of fuel and transit, along with that of parking, are unchanged from the in-place policy. Growth in employment and households tended to locate away from established centers. About 17 percent of employment growth and 5 percent of households growth made these shifts, as compared with the in-place policy. Further, the share of employment in the CBD decreased more rapidly than under in-place policies; it was 14 percent less in 2000.

Automobile fuel economy dips below the in-place policy value in 1990 because of a shift in consumer preference to medium and large cars. With higher performance, technological improvements surpass the effect of the market shift by 2000, however. Market preferences also result in heavier average new car weight in spite of reductions of 3 to 4 percent in small and large cars over the in-place policy.

IMPACTS ON URBAN TRAVEL DEMAND

Both energy savings strategies had significant effects on household travel demand, differing by type of city, intraurban location of households, and household income. In general, the direction of the effects of each policy was the same for each scenario, but results in scenario I were always of a greater magnitude than the same change in scenario III. This is partly attributable to the higher household incomes assumed under scenario I relative to scenario III. Because travel impacts are largest for scenario I, most of the results presented here are drawn from scenario I analyses, except where scenario III results differed from scenario I.

Work Travel Mode Choice

Figures 2 and 3 show the change in year-2000 modal split for work travel under the in-place policy and the group travel strategy. The same number of work trips were assumed under each. Further, origin and destination pairs are also identical because work trips are considered as nondiscretionary trips in the chosen modeling approach. Thus destinations are fixed and only the mode can be chosen. The work trip transit modal share increased for all three city types and at the national average under the group travel strategy. Ridesharing increased significantly in each city, but drive-alone continued as the predominant mode for work travel. The transit share was almost negligible in both Sprawlburg and Slowtown.

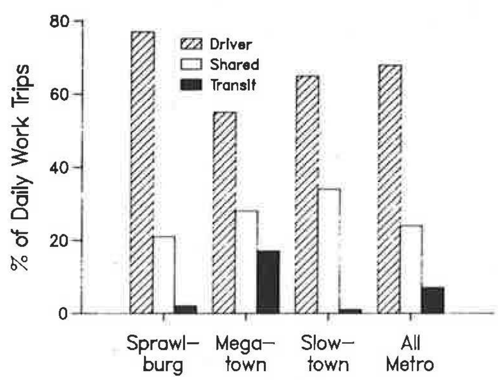

FIGURE 2 Work trip modal shares in scenario I under in-place policy, 2000.

The group travel strategy had its strongest effect on ridesharing rather than transit for work trips (5). Nearly all of the diverted drive-alone trips turned to ridesharing in each city. Even though the percentage of work trips is small for transit, the absolute impact on transit systems would nevertheless be large. In Sprawlburg, for example, a change from 1 to 2 percent of all work trips implies that a doubling of ridership occurs during peak hours. Substantial improvement in peak-hour transit service was correspondingly pro-

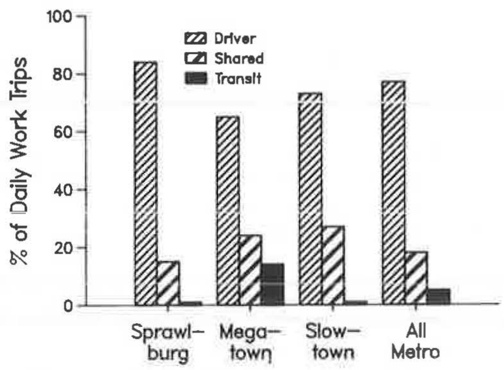

FIGURE 3 Work trip modal shares in scenario I under group travel strategy, 2000.

vided under this policy. Across all metropolitan areas the ridesharing increase of 33 percent [relatively (from 18 to 24 percent of all work trips)] and the transit increase of 40 percent (from 5 to 7 percent) represent significant modal shifts.

Nonwork Travel Mode Choice

To understand analysis results for nonwork travel, it is helpful to examine the average automobile operating costs associated with the policy options. In Figure 4 the rise in operating cost per mile, including fuel costs, is sharpest between 1975 and 1980, slightly moderated between 1980 and 1990, and actually decreases slightly between 1990 and 2000. Costs in 2000 are still higher, however, than costs in 1980.

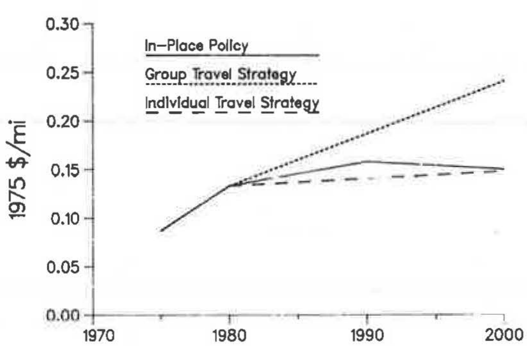

FIGURE 4 Out-of-pocket automobile operating costs in scenario I.

Several factors enter into this representation of automobile operating cost per mile. The retail cost of fuel, average maintenance and repair costs, and the actual fuel efficiency experienced in travel are all included in the analysis. This cost represents out-of-pocket costs associated with vehicle operation and is not equivalent to life-cycle costs. Further, automobile operating costs do not include parking costs, which are assessed per trip. Cost rose most sharply under the group travel strategy. This increase over the in-place policy is due solely to the high fuel tax imposed as part of the group travel strategy. Under the individual travel strategy costs per mile decreased only slightly. This difference was due only to the change in the technologies that were assumed available to households under this policy, because the price of fuel remained the same as under the in-place policy. Although households could have chosen vehicles that lowered operating costs relative to the in-place policy, they instead chose slightly larger automobiles.

In scenario III, not shown in the figure, the difference in per-mile operating costs were less between the in-place policy and the group travel strategy than under scenario I. Oddly, the individual travel strategy results in a slight increase over in-place policy costs. That anomaly was due primarily to the choice of relatively high-performance vehicles by households under that policy set. Operating costs generally were higher under scenario III than under scenario I; further, households are somewhat poorer in scenario III than in scenario I.

Nonwork automobile travel, measured as vehicle miles of travel (VMT) per person, decreased in both scenarios under the in-place policy, whereas nonwork trips per person (by both modes) remained relatively constant. The rise in automobile operating cost and parking costs help explain this phenomenon.

In Figure 5 the nonwork trip modal split for each city and the national metropolitan total is displayed for the year-2000 in-place policy in scenario I. In general, all nonwork travel took place by automobile. The highest transit share was in Megatown at only 4.2 percent of all trips. Figure 6 shows the dramatic impact of the group travel strategy on nonwork travel. The transit modal share over all metropolitan areas increased to 17 percent under this policy. Of greatest interest is the change in Megatown: 40 percent of nonwork trips were taken by transit.

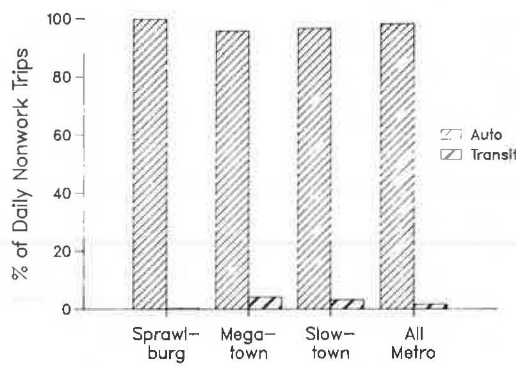

FIGURE 5 Nonwork trip modal split in scenario I under in-place policy, 2000.

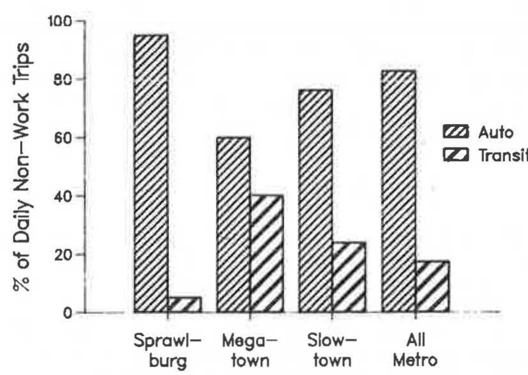

FIGURE 6 Nonwork trip modal split in scenario I under group travel strategy, 2000.

Nonwork travel is modeled as discretionary travel based on cost, household income, and number of attractive destinations. The number of trips per person is a variable result; it is lower under the group travel strategy than under the in-place policy because of the significant increase in automobile operating and parking costs. Nevertheless, the sharp increase in nonwork transit travel, particularly in Megatown, is not simply explained. Many variables were changed under this policy test, and nearly all of them must be examined to search for explanations. Certainly, the logit demand model has been pushed to its limit regarding the standard assumption of constant coefficient values, given the large changes in policy variables that were tested.

The primary explanation of higher transit modal shares for nonwork travel appears to lie with the travel cost and travel time differences of the automobile and transit modes. Discretionary nonwork travel appears highly sensitive to increases in automobile operating costs (including parking costs); as long as a transit option is available that provides significant travel time improvements (especially for out-of-vehicle time) at relatively low fares, a significant proportion of nonwork travel will shift to transit (6,7). Some nonwork trips, as previously noted, will not be made.

Figure 7 tends to support this interpretation. It also depicts the nonwork modal split under the group travel strategy, but for scenario III. Here transit service improvements were the same, except for cross-town corridors, as those hypothesized in scenario I for each city type. Increases in automobile operating costs (by fuel taxes) were less than in scenario I in the year 2000. Automobile operating costs were increased, however, so that nonwork transit ridership increased. (The same increases in group travel parking costs were assumed for CBDs under both scenarios, but scenario I had higher taxes in new areas.) The transit ridership increases were generally only one-third to one-half of those estimated for scenario I, however.

One question to pose is whether the method of calibrating the logit demand model to a new city is actually responsible for most of the difference among the three cities in their response to the group travel strategy, rather than service or population characteristics. The transit service provided in Sprawlburg was at least as satisfactory as that provided in Megatown; the large proportional increase in nonwork transit travel in Sprawlburg represents a huge change for that city, but is far less than the absolute magnitude of change in Megatown.

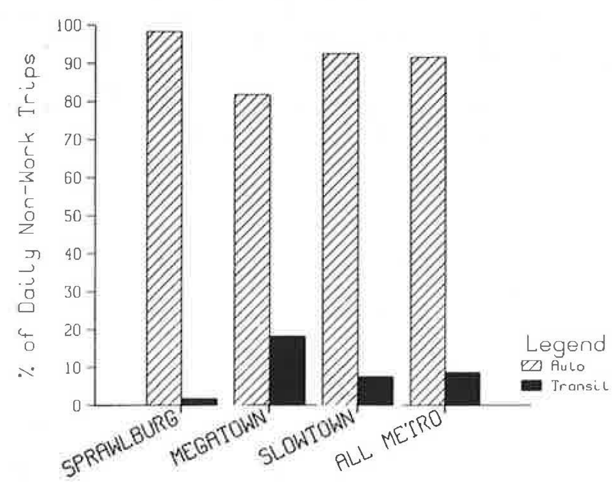

FIGURE 7 Nonwork trip modal split in scenario III under group travel strategy, 2000.

The change in service is apparently at a steep portion of the logit curve for Megatown, but at a flatter part of the curve for Sprawlburg. Slowtown was intermediate between the two in its amount of change; it no longer looks as much like Sprawlburg as it did under the in-place policy. As the calibration process does not change the shape of the choice curve, but rather its horizontal axis, the small absolute change in Sprawlburg may actually be an understated response to large increases in transit service. Because there are no observed data on responses to simultaneous service and cost changes of the magnitude tested here, it is difficult to judge whether the policy variable changes are too large for the model to handle.

Transit Travel by City Type

Primarily because of these increases in nonwork transit travel, all three cities saw parallel increases in overall transit ridership. Figure 8 shows the impact caused by the group travel strategy in each city in scenario I. The increase is expressed as a percentage of the transit trips recorded under the in-place policy in the same year. For example, under the group travel strategy in the year 2000, Sprawlburg had more than 900 percent as many transit trips as it did under the in-place policy. Although the total number of transit trips in Megatown is much larger than the number of transit trips made in Sprawlburg, the amount of increase is far greater in Sprawlburg than in Megatown. Note that there are no 1990 values for Megatown and Slowtown; only the year-2000 values were computed.

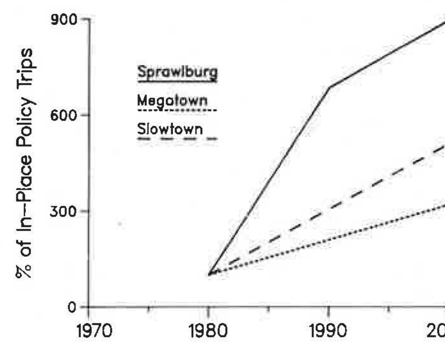

FIGURE 8 Change in transit trips caused by group travel strategy in scenario I by city.

The increase in transit travel in Sprawlburg is displayed under all three policies in Figure 9. These values are expressed as a percentage of the 1980 level of transit trips in that region. Even under the individual travel strategy there was a slight increase in transit ridership. However, the large service increase proposed from 1980 to 2000 under the in-place policy did not increase the absolute number of trips taken on transit. Only the really significant transit service improvements of the group travel strategy, which included an extensive light rail network for Sprawlburg, yielded a significant increase in ridership.

The change in transit travel for Megatown is shown in Figure 10. Again, under the in-place policy, transit trips decrease slightly from 1980 and follow exactly the same trend under the individual travel strategy. It is interesting to note that the improvements in the automobile mode under that policy did not steal from transit travel, but rather added new automobile travel. The group travel

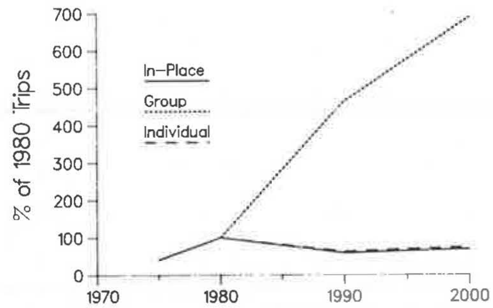

FIGURE 9 Transit trips in Sprawlburg in scenario I by policy.

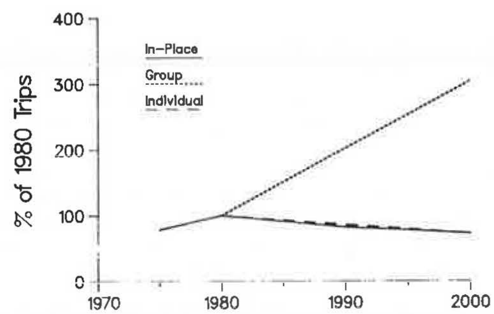

FIGURE 10 Transit trips in Megatown in scenario I by policy.

strategy again had a strong effect on overall transit trips. The increase of more than 300 percent was primarily caused by the increase in nonwork transit trips shown earlier.

The change in transit travel for Slowtown is shown in Figure 11. The in-place policy and the individual travel strategy are exactly the same, such that the line for the individual travel strategy cannot be seen on the graph. The group travel strategy increased transit ridership even more, relatively, than in Sprawlburg. Again, the majority of the increase is caused by the 24 percent transit share for nonwork travel.

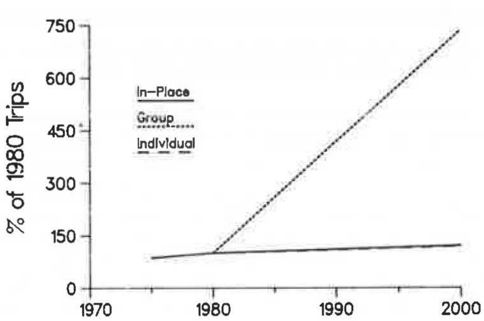

FIGURE 11 Transit trips in Slowtown in scenario I by policy.

Total Person Miles of Travel

In Figure 12 total person miles of travel (PMT) under the in-place policy are displayed, both for households and for individuals across all metropolitan areas. Several observations can be made from these plots. The first is that decreasing household size greatly affects the recording of any results by

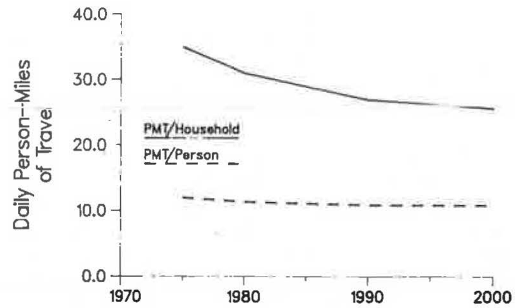

FIGURE 12 Person travel in scenario I under in-place policy.

household. PMT under the in-place policy remains virtually constant on a per capita basis, ranging between 11.98 miles per person in 1975 and 10.88 miles per person in the year 2000. The value for households, however, declined from 35 to 25.7 miles per day per person.

Actual travel per person is virtually unchanged, perhaps an unexpected result given the steady decrease in household size. From an examination of the 1977 Nationwide Personal Transportation Study (NPTS) results, it was expected that there would be a slight increase in per capita PMT; smaller households in that survey exhibited higher per capita, although lower per household daily PMT (8, p. 50). The values shown in Figure 12 represent daily home-based travel on all modes. Linked trips and walk trips are excluded from these values. The increase in automobile operating and parking costs probably explains the damping of growth in PMT per person because of the inability of the travel demand model to capture linked vehicle trips or walk trips.

Work and Nonwork Automobile Travel

Travel by automobile changed differently than total travel. In Figure 13 automobile travel for work trips, expressed as daily VMT per person, is displayed for each city under the in-place policy. The drive-alone and shared-ride modes increased in absolute terms under the in-place policy in each city. The number of work trips per person remained essentially constant, although work trips per household declined in all three cities. The varying patterns of VMT per person reflect the change in residential density in each city over time, as well as the increase in the total amount of work travel being done by automobile. (Only travel by automobile, and not all person travel, is reflected in Figure 13.)

In Sprawlburg and Slowtown VMT per person increases between 1980 and 2000, although it peaks in 1990 for Slowtown. This is primarily because of the

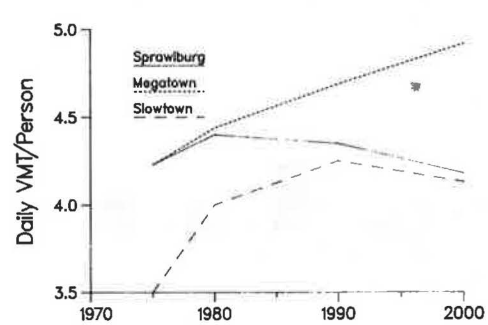

FIGURE 13 Work automobile travel under in-place policy by city in scenario I.

increase in use of the automobile for work trips, rather than the lengthening of average work trips. The anomalous result for Sprawlburg--a decrease in VMT per person after 1980--is primarily because of the infill development that characterized that city's growth in scenario I. Similar results were obtained under the group travel and individual travel strategies, which indicate that the pattern of urban development has more influence on average automobile work trip length than energy conservation policies.

In Figure 14 automobile travel for nonwork purposes is shown for each city for the in-place policy. In all cities automobile travel for nonwork purposes declined from 1980 to 1990 and then increased slightly. The parallel increase and then decrease in operating cost for automobile travel discussed earlier is the major explanation for this pattern.

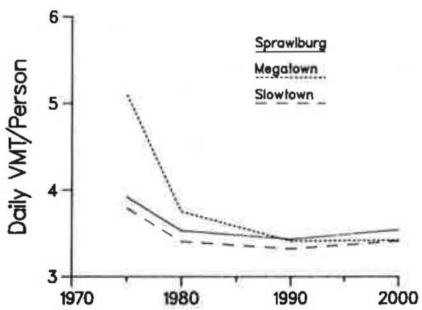

FIGURE 14 Nonwork automobile travel under in-place policy by city in scenario I.

Impacts due to policy actions for nonwork automobile travel are shown in Figure 15. (Again this includes only travel by automobile; not all person travel is reflected.) The group travel strategy sharply decreased per capita mileage for nonwork trips by automobile. The number of nonwork trips declined, which explains some of this decline; however, the length of trips taken also decreased. The individual travel strategy had no effect on nonwork travel, neither increasing nor decreasing automobile travel per person.

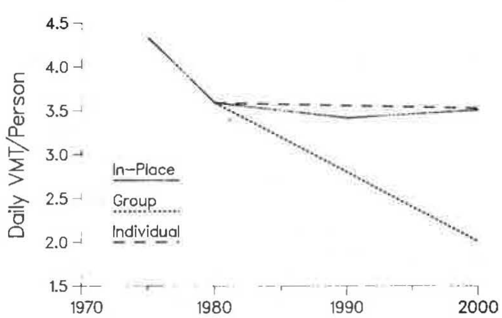

FIGURE 15 Nonwork automobile travel by policy in scenario I.

Trips per Person and Trip Length

Both the number of work trips per person and the average length of each trip are shown in Figure 16 under the in-place policy across all metropolitan areas. These rates do not vary by policy (with one exception--work trip length is reduced in scenario III under the group travel strategy). The number of trips per person is relatively constant, even though it appears to decrease slightly in the graph. It only ranges between 0.66 and 0.63 trips per person per day. Trip length, however, grows somewhat, from just under 8 miles one way to 8.4 miles one way.

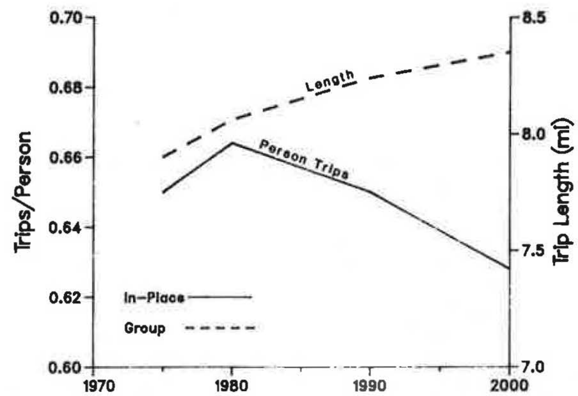

FIGURE 16 Daily work trip and trip length under in-place policy in scenario I.

Figure 17 shows the same information for nonwork trips, including the results of both the in-place policy and the group travel strategy. (Individual travel showed exactly the same pattern of trips per person and trip length as the in-place policy, and it is not marked on the figure.) Under the in-place policy, as the number of nonwork trips per person increased, average trip length correspondingly declined under scenario I. The reverse is shown under the group travel strategy, however. That is, as the number of trips per person declined, the average length of those trips over all modes increased. These results reflect the differing influence of household income gains, which tend to increase nonwork trip rates, and increased automobile operating costs, which tend to reduce them.

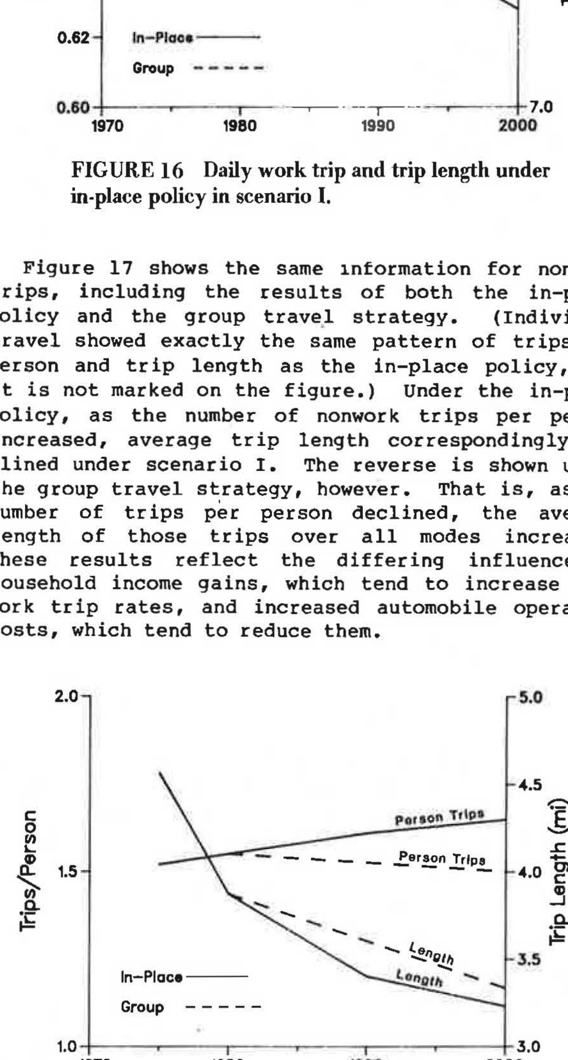

FIGURE 17 Daily nonwork trips and trip length in scenario I.

Work trips per person and trip length by policy in scenario III are shown in Figure 18. As in scenario I, work travel was unchanged across policies in terms of the number of trips per person. However, the length of work trips was shortened under the group travel strategy on input. The average decrease across the nation was about 15 percent by the year

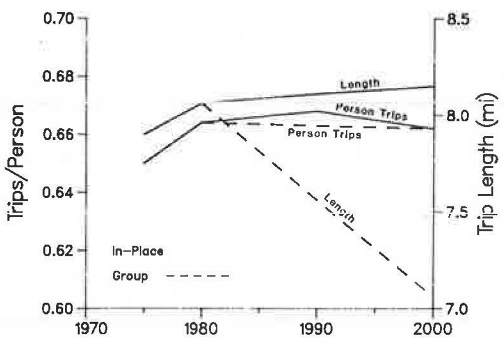

FIGURE 18 Daily work trips and trip lengths in scenario III.

2000, in contrast to the average trip length for the in-place policy. This percentage decrease varied slightly among the cities.

Under the group travel strategy nonwork trips in scenario III decreased further in frequency, while increasing only slightly in length (Figure 19) compared with the in-place policy. This is in the same direction as scenario I impacts, but the magnitude of change is far less.

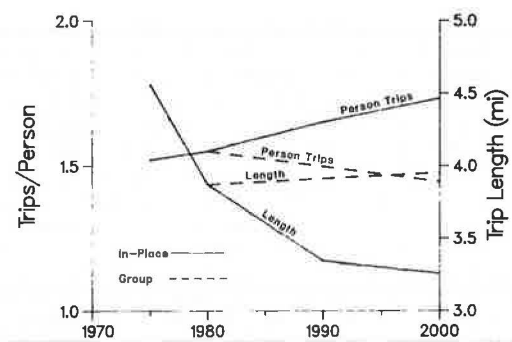

FIGURE 19 Daily nonwork trips and trip length in scenario III.

Differences by Income Group and Household Location

Figures 20 and 21 display further information on nonwork travel in Megatown under the group travel strategy. One reason for the large increase in the number of transit trips for nonwork purposes lies in the increase in the total number of trips that went to the CBD for nonwork purposes (Figure 20). For each income group there is a substantial increase in the share of trips going to the CBD, as opposed to any other destination in the region; further, practically all trips to the CBD were by transit under the group travel policy. This is a big switch from the in-place policy, where one-third to one-half of the trips to the CBD were by automobile. Even with the decrease in the total number of nonwork trips, the increase in the share to the CBD represents a substantial increase in the total number of transit trips--about 60 percent. It is interesting to note that high-income households made the most trips to the CBD, even though high-income households were disproportionately located in the suburban ring.

In Figure 21 all nonwork trips by transit are shown according to the location of the household making the trip. A sharp pattern emerges, in that the greatest proportion of transit trips was taken by urban households, although households in all

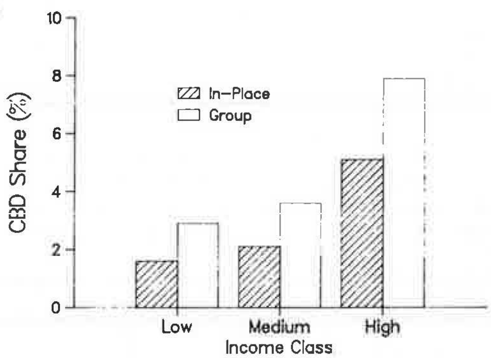

FIGURE 20 Nonwork trips to the CBD in Megatown in scenario I.

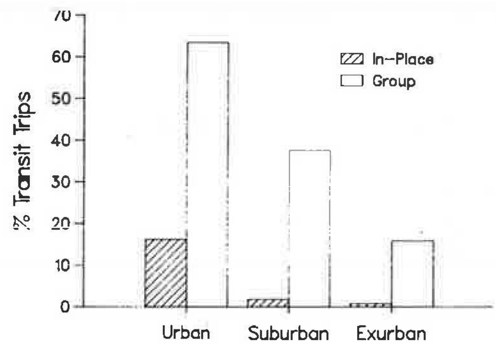

FIGURE 21 Nonwork trips on transit by household location in Megatown in scenario I.

three rings of Megatown experience radical increases in the modal split for transit. In absolute terms the greatest total number of trips is made by suburban households, so that there smaller fraction of trips by transit still represents more than two-thirds of the transit trips made by urban households. Detailed subarea examination of these transit trips indicates that suburban nonwork trips are primarily those taken on a cross-town rail network that was instituted in Megatown under the group travel strategy in scenario I.

CONCLUSIONS

Based on the analyses presented, several broad conclusions can be drawn regarding the potential for well-defined, multiple-action energy-conservation strategies to achieve significant impact on urban travel demand.

In general, it should be remembered that both of the contrasting conservation strategies analyzed in the overall study--group travel and individual travel--have the potential to save noticeable energy over in-place policies (4). The individual travel strategy achieved energy savings through the more efficient use of a significantly changed mix of private automobiles. There consequently was negligible impact on choice of travel mode, as compared to in-place policies. The group travel strategy, on the other hand, promises to significantly alter mode choice for both work and nonwork travel and to achieve transportation energy savings in this way. Group travel impacts on travel demand are consequently more noteworthy; they have been highlighted in this paper.

In-Place Policy

The potential impacts of the group travel strategy in achieving transportation energy conservation must be understood against the trends evidenced by in-place policies.

1. With increasing household incomes and decreasing household size, there is a trend toward more total travel per capita. Although work trips per person are projected to decline slightly, nonwork trips per person are expected to increase significantly.
2. PMT per capita and VMT per capita (for those who travel by automobile) are projected to remain close to constant. This reflects, in part, significant decreases in average trip length for nonwork trips and slight increases in work trip lengths. With steadily increasing automobile fuel economies, a healthy decrease in total (direct and indirect) transportation energy consumption can be expected and is in progress.
3. Even with projected increases in automobile travel cost, essentially constant transit costs, and significantly expanded transit service levels, only modest or no transit ridership increases were projected.

Group Travel Strategy

The various energy-conservation actions included under the group travel strategy, both to promote transit and ridesharing travel and to discourage individual automobile travel, can significantly increase the amount of both work and nonwork travel that is carried by the more energy-efficient group travel modes (9-11).

1. A modest impact on work travel mode choice, ranging between 30 and 40 percent for both transit and ridesharing modes, was estimated across all metropolitan areas. These percentages are applied against the in-place policy transit ridership levels of 5 percent and ridesharing levels of 18 percent.
2. The most dramatic impact of group travel policies potentially lies with nonwork travel. Automobile operating and parking costs were found to have a significant effect on nonwork trip generation, distribution, and mode choice. For this discretionary type of travel, nonwork trip modal splits to transit could increase from a base (across all metropolitan areas) of about 2 percent to as much as 17 percent.
3. Economic disincentives for automobile travel, especially drive-alone automobile travel, must be large to have a significant impact. Automobile fuel taxes of 50 to 100 percent of retail price and CBD parking taxes of 100 to 200 percent of the daily fee were both necessary to achieve the impacts previously discussed. Such disincentives would be particularly difficult to implement, given local political perspectives.
4. Although current transit peak-hour (work travel) ridership levels are modest, in low-ridership regions these group travel impacts could amount to a doubling of required service levels. Such large absolute changes in transit supply will present major challenges to the urban transit industry (12). The significant projected increases in off-peak nonwork transit travel could dramatically alter off-peak service levels, although peak-hour fleet requirements should be adequate for off-peak purposes.
5. Major shifts in nonwork travel patterns could potentially take place. In addition to increases in transit ridership for nonwork purposes, daily VMT per person for automobile travelers who make nonwork trips were projected to decline dramatically. Total nonwork trips per person could decline slightly, but with increases in trip length reflecting the decreasing cost per mile of flat-fare transit dominating the three typical cities' fare structures. Such impacts are especially important because discretionary nonwork travel represents a major arena for voluntary behavioral change, which could profoundly affect transportation energy-consumption patterns.

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Sketch-Planning Model for Urban Transportation Policy Analysis

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ABSTRACT

In this paper the urban transportation policy analysis process (UTPAP) is described. UTPAP was developed as a sketch-planning analysis tool for the study Technology Assessment of Production Conservation in Urban Transportation (TAPCUT). TAPCUT was a comprehensive study of the potential environmental, health, and public safety impacts of various alternative productive urban transportation energy-conservation strategies. Productive conservation strategies encourage energy conservation without disrupting the economy or life-styles. The strategies that were analyzed reflected alternative national investment in infrastructure and technology and regulatory policies. The UTPAP is a sketch-planning model package that incorporates state-of-the-art, household-based, disaggregate travel demand models for mode and destination choice, with detailed specification of automobile technologies. It is useful in analyzing both the short- and long-term implications of city-specific transportation planning policies, and it provides summaries of transportation, fuel-consumption, air quality, public health, and safety impacts. Stratified by both type of household and geographic area of occurrence, these impact measures are valuable in assessing the social equity of transportation policy impacts. Preliminary sensitivity analysis indicated that nonwork travel was more responsive to price and level-of-service (LOS) change than work travel. Transit ridership was most affected by transit LOS improvements, whereas automobile vehicle miles of travel were most affected by fuel price increases. There was also a significant synergistic effect that increased nonwork transit ridership by combining transit LOS improvements with automobile fuel price increases.

In this paper the urban transportation policy analysis process (UTPAP) is described. UTPAP was developed as a sketch-planning analysis tool for the study Technology Assessment of Productive Conservation in Urban Transportation (TAPCUT). TAPCUT was a comprehensive study of the potential environmental, health, and public safety impacts of various alternative productive urban transportation energy-conservation strategies. Productive conservation strategies encourage energy conservation without disrupting the economy or life-styles. The strategies that were analyzed reflected alternative national investment in infrastructure and technology and regulatory policies.

An in-place policy package and two alternative policy packages were defined. Both alternatives were composed of mutually reenforcing conservation strategies. Because there is a high degree of uncertainty about future conditions (exogenous variables), a scenario approach was used to analyze the range of future conditions analyzed through the year 2000. The two scenarios were distinguished by their demographics, macroeconomics, transportation fuels availability and price, and degree of social aggregation. Further details on the study structure are provided by LaBelle et al. (1).

Travel demand, fuel-consumption, and emissions estimates were determined for three prototypical cities. The cities were selected in light of major differences in their transportation-related characteristics by using a factor analysis technique for grouping cities. The first typical city, Sprawlburg, represents a relatively new, spread out, western metropolitan area. The second city, Megatown, has certain characteristics of the big, densely settled city with satisfactory transit in place. The third typical city, Slowtown, might be best described as a midwestern, industrial, middle-sized metropolitan area. Sprawlburg examples include Phoenix, Houston, Dallas, Anaheim, and Tacoma. Megatown examples include Chicago, Cleveland, Philadelphia, Boston, and Baltimore. Slowtown examples include Flint, Grand Rapids, Lima, Paterson, Norwalk, and York. The methods used to select the prototypical cities and expand city estimates to national totals are