the scenario forecasts combined with the TAPCUT policies, where more variables were changed between successive model runs. As the project was particularly concerned with synergistic effects from demographic, land use, and vehicle changes in addition to the transportation energy-conservation policy actions, this sensitivity analysis was essential in understanding the more complex and comprehensive analysis reported in a paper by Stuart, LaBelle, Kaplan, and Johnson elsewhere in this Record.

In summary, 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 measures are valuable in assessing the social equity of transportation policy impacts.

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Technology Assessment of Productive Conservation in Urban Transportation: An Overview

DAVID O. MOSES, SARAH J. LaBELLE, and MARTIN J. BERNARD

ABSTRACT

Travel within urban areas accounted for about one-third of all the person miles of travel and about 5 quads of energy in 1975. Two energy-saving strategies were designed for this sector that were aimed at minimal disruption to life-styles and the economy while achieving the reductions in aggregate energy, especially petroleum, consumption. These productive conservation strategies

were tested in three typical cities; results were expanded to national urban totals and compared with results under a reference forecast of in-place policies. One strategy stressed group travel, whereas the other promoted individual travel. A scenario approach was used for projection of economic and social variables. Both strategies saved energy. Trips per person declined under the group travel strategy, which suggests that its greater energy savings were at the expense of some decrease in mobility. The impacts of environmental degradation and traffic fatalities were significantly different under the group travel strategy and were better than impacts under either the individual travel strategy or the in-place policy.

The transportation sector directly consumes one-quarter of the energy used in this country, with automobile passenger travel accounting for half of the energy supply for the transportation sector. Because of rising fuel prices and intermittent supply shortages, federal, state, and local governments have begun to introduce various strategies (combinations of policies and technologies) designed to conserve urban transportation energy while maintaining a productive economy.

The environmental consequences of many of the conservation strategies have not been adequately assessed. As a result, a technology assessment project sponsored by the U.S. Department of Energy (DOE) was initiated in late 1979. The goals of the project were to provide a description of several alternative strategies that promote energy conservation in the urban passenger transportation sector, a better understanding of the environmental impacts of such strategies, and an identification of the constraints to the implementation of such strategies.

The study is the Technology Assessment of Productive Conservation in Urban Transportation (TAPCUT). The background, structure, and preliminary results of TAPCUT are presented in this paper.

BACKGROUND

The transportation sector is almost entirely dependent on petroleum (1-3). For the past 30 years transportation has accounted for more than one-half of the petroleum used or one-fourth of total energy consumed in the United States. Passenger cars alone account for half of the energy in the transportation sector.

Intraurban travel (i.e., travel that occurs within an urban area) corresponds to about one-third of all person miles of travel (PMT). In the absence of transportation controls [which to date have been strategies of reducing vehicle miles of travel (VMT) that were developed for air quality control plans], urban travel was expected to increase in proportion to changes in population.

Most forecasts assume that the automobile will continue to be the dominant urban travel mode, because average income is projected to rise faster than the costs of owning and operating a car. Transit ridership, which has steadily declined since World War II, has leveled off and has even shown slight increases since the oil embargo of 1973. Nevertheless, under current policies transit patronage, which accounts for about 2 percent of urban travel in most regions, is expected to achieve little if any growth.

To date the single most effective force in improving urban travel efficiency has been the corporate average fuel economy (CAFE) legislation in 1975. By 1985 total automobile fuel consumption should be less than that in 1975 because of improved vehicle efficiency. However, the continued increases in travel will eventually overcome this advantage, so that by the year 2000 energy consumption is predicted to surpass 1975 levels.

Figure 1 illustrates both the range of projected increases in travel as well as selected forecasts of automobile energy use. This figure shows the consistency of the view that vehicle fuel-efficiency improvements would have only a temporary effect on energy, and especially gasoline, consumption.

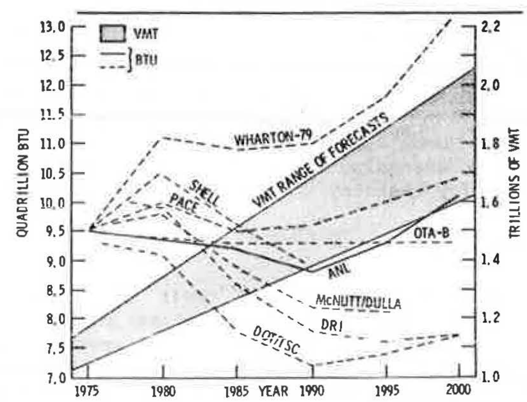

FIGURE 1 Selected projections of automobile energy.

With the real cost of gasoline declining since the 1950s, except for 1973 and 1980 in which it rose slightly in real terms, there have not been any clear signals to the American motorist that conservation was either a desirable or necessary behavior. Intermittent interruptions in gasoline supplies and price increases have served as sharp reminders to the public of the vulnerability of the current transportation system. The response has been a rapid increased demand for fuel-efficient vehicles and at least a short-term reduction in travel.

As indicated by changes in automobile purchase behavior and transit ridership, individuals are looking for solutions to the problem of remaining mobile while not greatly changing the amount of time and money devoted to travel. Declining domestic petroleum production coupled with the current expectation of no major market penetrations of alternative fuels and vehicles before the year 2000 (even the cumulative effect of electric vehicles, which may be introduced by 1985, are not expected to be major before 2000) leads directly to the heart of the problem: What can be done in the interim and what would be the effects of those actions?

Within DOE one responsibility is the conduct of technology assessments that identify the environmental consequences of various energy policies. Technology assessment is a form of policy study that systematically defines, explores, and evaluates both the direct and indirect economic, social, environmental, and institutional consequences of the introduction or expansion of new technologies or policies in society. The need for a technology assessment in the transportation sector was apparent in mid-1979, and a literature analysis was initiated to identify what was known about the problem.

PROBLEM REFINEMENT

An extensive literature analysis of transportation studies produced in recent years yielded data sources and identified issues where either the analysis was incomplete, of questionable quality, or the study had little effect on policy (4). The information gained from the literature analysis, when synthesized with current major issues in the transportation sector, provided an initial list of candidate technology assessment studies. To narrow this list three major bounding decisions, as illustrated in Figure 2, were applied:

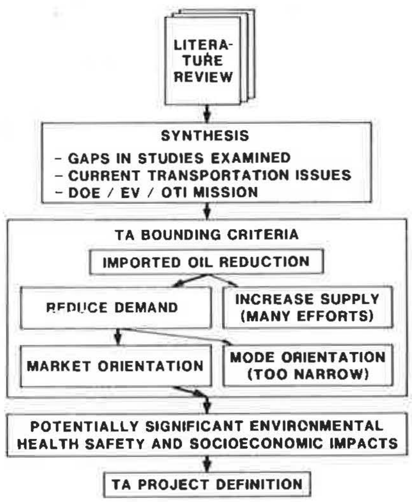

FIGURE 2 Problem refinement process.

1. The study had to be within DOE's purview of reducing dependency on foreign petroleum,
2. The study would emphasize demand-reducing rather than supply-increasing strategies, and
3. The study would take the more comprehensive market or transportation demand approach (as opposed to a single mode orientation); this approach groups travel modes according to use, which requires consideration of modal shifts and relative modal advantages.

The candidate studies were then examined to determine if significant environmental impacts were anticipated to warrant the technology assessment.

At the conclusion of the problem refinement process, a technology assessment project was defined that would

1. Cover the urban passenger transportation market,
2. Emphasize conservation (reduction of foreign petroleum demand) strategies,
3. Span the present-to-2000 time period within two bounding futures,
4. Consider both policy and technology alternatives, and
5. Focus on environmental (broadly defined) impacts.

From this definition the specific objectives of the technology assessment project were developed.

PROJECT OBJECTIVES

The technology assessment described in this paper was designed to investigate the potential environmental, health, and safety impacts of two alternative productive conservation strategies. Productive conservation strategies are defined as being neither disruptive of the economy nor of the American lifestyle but instead encourage conservation in various sectors, including transportation (5).

Because by this definition productive conservation promotes energy savings in a manner that is neither economically nor socially disruptive, special attention was paid to the unanticipated diffuse impacts of the strategies, a task well suited to the technology assessment format.

This technology assessment was designed to meet several broad objectives:

1. An identification of internally consistent (mutually reinforcing policy or technology elements following a specific theme) productive conservation strategies that will aid in the reduction of the United States' dependence on petroleum in urban transportation,
2. A comparative analysis of the energy savings and environmental impacts of the various productive conservation strategies, and
3. An analysis of the issues and the barriers that may constrain these productive conservation strategies from becoming effective.

A broader discussion of each objective follows.

Identification of Potential for Energy Conservation

The concept of productive conservation as applied to urban passenger travel can be partly defined as reducing energy consumption, especially consumption of petroleum-based fuels, while maintaining social interaction. The potential for this is substantial simply because energy has never been an important factor in financing and operating urban transportation systems.

These urban automobile-oriented systems are energy intensive as currently operated. The single-occupant vehicles operated within these systems were most often designed for comfort and speed in an era of cheap energy. That many proposals to reduce this energy intensity have been developed argues that reduction is possible even within the constraints of productive conservation. The matching of alternative strategies comprised of policy and technology elements to the distinct types of in-place systems (which can physically change only gradually during the time frame of the study) in three city classes promises to increase the potential for finding significant energy savings.

Comparison of Environmental, Health, and Safety Impacts

The transportation energy-conservation policies that were studied were for the most part similar to those measures necessary to improve environmental quality. That is, there were trade-offs between impacts on different environmental subsystems and, in some cases where energy-conservation strategies had negative environmental impacts, the design of mitigation strategies or redesign of the initial conservation strategy is required.

TAPCUT included a broad environmental impact analysis for each strategy and is now using the results of impact analyses to indicate where further mitigation of impacts might be required.

Analysis of Barriers to Implementation

A study of the impacts of any proposed new policy or technology element must include some consideration of its feasibility. This study was concerned with the feasibility of implementation, but it did not undertake any assessment of commercialization or a detailed barrier analysis. Instead these issues and concerns were incorporated in two places: development of the strategies and the environmental impact analysis. Cost and management or administrative barriers were considered in choosing policy elements for the productive conservation strategies.

The study's definition of environmental impact assessment covers many of the issues often included in barrier analysis: resource use and institutional, social, and economic impacts. Questions of equity in tax-based policies, of the impacts of labor unions, of safety on roads with smaller automobiles and large trucks, and of fuel economy and engine emissions trade-offs were considered.

The state-of-society assumptions associated with the socioeconomic impact analysis also provided a framework for evaluating the societal change that accompanied the implementation of the technological developments. These assumptions characterized the future society's economic and social systems, demographic make-up, institutional structure, as well as attitudes and values.

PROJECT STRUCTURE

The overall flow of the project is shown in Figure 3. Travel demand analysis was performed for each of three typical cities under policies now in place and forecast to continue. Environmental impact analysis of the forecast travel was also city specific. The two productive conservation strategies--group travel and individual travel--were defined, and the travel and environmental impacts were then estimated. The final step is the overall comparison of policy-driven results in contrast to the results under in-place policies.

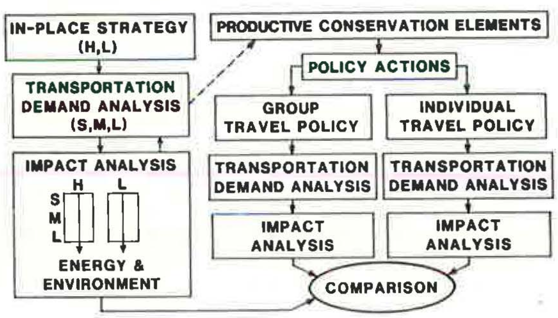

FIGURE 3 TAPCUT project flow.

The task structure designed to meet the project goals is shown in Figure 4. The other papers presented in this Record on TAPCUT relate to this structure. Hudson and Putnam discuss the design of the technologies; Saricks, Vyas, and Bunch present the forecasts of the supply of transportation; the city selection and expansion to national totals are covered by Peterson; Kaplan, Gur, and Vyas address the method for household travel demand forecasting; and Stuart, LaBelle, Kaplan, and Johnson highlight the changes in travel demand that result from the policies. The scenarios used as background in the analysis and the energy-conservation policies are briefly presented in this paper, as well as the method and preliminary results for the environmental impact analysis. Further detail is presented in the project final report (6).

Scenarios

Selected features of the two scenarios defined for this project are shown in Figure 5. These variables were considered scenario variables because they are out of the realm of direct control of the decision

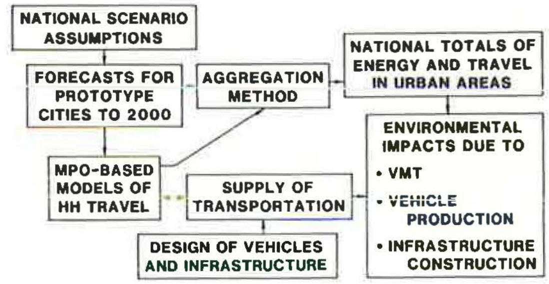

FIGURE 4 TAPCUT project structure.

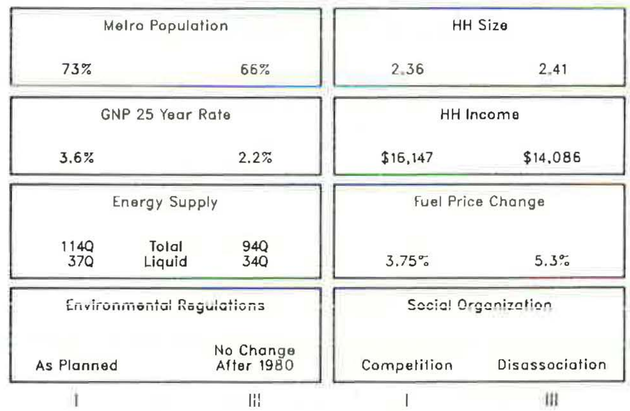

FIGURE 5 Scenario summary.

makers of interest in this project. Clearly, some of these variables will be affected indirectly by decisions made regarding energy conservation in transportation; however, these interactions are not of the first order and are not modeled directly in this project. The two scenarios can be briefly distinguished as scenario I (wealthy scenario with high technology success) and scenario III (relatively poor scenario with low technology success). The major differences between the scenarios that affect travel demand were in the forecast retail fuel price and the average income (in 1975 dollars). The range of difference in other variables was not sufficiently large to account for significant differences in the travel forecasts.

The rate of change in fuel price as shown is an average annual value from 1990 to 2000. The rate of change from 1980 to 1990 was higher than the 20-year rate in both scenarios. The rate of change in gross national product (GNP) is given as an average for the years 1975 to 2000. A 5-year cycle was built in to the annual GNP level.

Metropolitan population represented the percentage of national population residing in standard metropolitan statistical areas (SMSAs) in 2000 in each scenario, against the same national total. The Census Series II forecast of 260.378 million persons in 2000 was the national base.

Energy supply was forecast but was not directly used for the demand analysis. The demand for energy in urban local travel can be compared against demand by consuming sectors and against various supply forecasts. The scenario assumption on environmental regulation, by contrast, influenced which set of automotive emission standards was used in the air quality impact analysis; for scenario III the changes scheduled to take effect in 1983 and beyond were cancelled. The social aggregation assumptions influenced land use forms primarily, which led to higher employment densities in scenario I than in scenario III.

City Forecasts

Starting from a data base for 237 metropolitan areas, three typical metropolitan areas were identified for study in this project. A method was developed to select the cities based on characteristics relevant to transportation energy consumption, such as average daily travel, household income, and population density. Three cities were selected that constituted extreme examples along the three dimensions defined from city characteristics that influenced transportation energy use. One dimension identified large cities with satisfactory transit systems; this was called Megatown. The second dimension, called Sprawlburg, involved new, fast-growing sprawl cities. The third dimension identified midwestern, industrial towns that were smaller in population than the other two; it was termed Slowtown. All metropolitan areas in the nation were related to these three dimensions. A linear expansion method was also developed, which allowed national urban forecasts to be made by using the detailed forecast of the three typical cities.

The TAPCUT forecasting effort focused on the details of the three cities by using actual travel and land use data files from the cities as the base and by using the cities' forecast as a reference for all scenario-specific forecasts. Forecasts of employment activity by type and residential location were made for each city under the conditions of each scenario, with some modification for policy impacts. The forecast independent variables for TAPCUT for typical cities (by scenario and year) are as follows:

1. Residential location--total households, household size, earners per household, average income, and household location: central business district (CBD), center city, suburban, or exurban; and
2. Employment activity--total employment, location of employment, development density, and type of employment: manufacturing, retail, service, or other.

Travel Demand Forecasts

The city-specific forecasts previously described were organized for input to the travel demand modeling package. Household characteristics from the base year in each city's travel survey [supplied by the metropolitan planning organization (MPO)] formed the basis of the travel demand forecasting approach. The forecast citywide distributions were translated into model inputs to determine their effects on household travel behavior by using an iterative proportional fitting method.

Modified household records combined with the transportation level-of-service (LOS) forecasts for the horizon year drove the travel demand model. Transportation LOS parameters included detailed specification of transit service and of automobile characteristics, including speed, operating costs, and emission rates. Both work and nonwork travel were separately forecast and reported for households in three income classes and three locations within the urban area (center city, suburban, and exurban).

The urban transportation policy analysis package (UTPAP) was used for case study city travel demand forecasts (Figure 6). It included an extended version, called XRGP, of the short range generalized transportation planning (SRGP) model at its core. That model used a logit formulation, both for work trip mode and for destination and mode choice for nonwork trips. The changes in VMT for each class of household (the major output of UTPAP) provided the starting point for much of the environmental impact analysis.

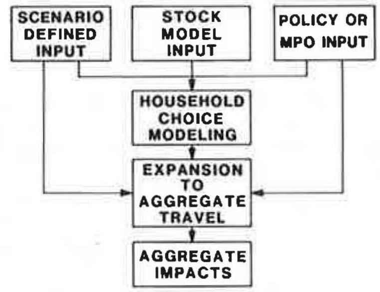

FIGURE 6 TAPCUT travel demand modeling (macro view).

Technology Characteristics

The characteristics of vehicles used by household were specified in great detail. Three different sets of new vehicles were designed for the policy tests. Initial price, operating cost, power/weight ratio, passenger capacity, fuel economy, and pollutant emissions were specified for each vehicle. Many of the characteristics were used to determine the cost of travel for the modal-choice models. Other characteristics, such as power/weight ratio, were used only in the vehicle stock model. That model determines which kind of automobile will be purchased by urban households and the distribution of vehicles held by household in forecast years.

The design of the automobiles reflected both policy and scenario considerations. In the in-place policy both scenarios were supplied with the same initial set of vehicles; there were slight differences in the vehicle mix chosen by households in each scenario. Under the individual travel strategy new car fuel economy was increased as a policy action. The increase was modest in scenario III (4 percent over the in-place policy) and fairly large in scenario I (23 percent). In scenario I the average new car fuel economy reached 40 miles per gallon in 2000. Specific vehicles, of course, reached higher fuel economies; this fuel-economy value includes the effects of consumer choice among the vehicles offered for sale.

New car weight declined in all size classes in each technology set, averaging about a 25 percent decrease from 1980 new cars. The individual travel strategy technology sets had a decrease in average new car weight of 10 percent from the in-place policy in scenario I and only 3 percent in scenario III. In scenario III consumers chose some automobiles in 2000 that had actually increased their weight. In general, weight decreases were constrained by the standards for reasonable performance (power/weight ratio) in all TAPCUT vehicles.

Environmental Impacts

The major focus of this study was to determine the environmental impacts associated with energy-conservation strategies. Consequently, environmental impact analysis was quite detailed. Air quality and water quality impacts from vehicle production and VMT were addressed, as well as the associated health effects. Traffic safety and workers safety were both estimated. Impacts on all resources, both energy and minerals, have been estimated. Further, socioeconomic effects from the changes in travel, in production of vehicles, and in the transportation infrastructure were also addressed, focusing on the transportation industries, subpopulations in urban areas, and interest groups.

Transportation Energy-Conservation Strategies

The first task of the study was to prepare reference forecasts, that is, to build a baseline against which to compare the energy-conservation strategies. The in-place policies were defined as those current policies directly bearing on transportation and energy consumed in transportation by urban households. Key aspects of in-place policies are summarized in Figure 7. Generally, policies were interpreted as what was on the books in 1980 plus any scheduled changes beyond that time. For example, the CAFE requirement for 27.5 miles per gallon in new cars by 1985 was now scheduled, but no increases beyond that are scheduled. Other important policies include the constant dollar value of gasoline taxes; this implies an increase in inflated dollars, but not in real dollars.

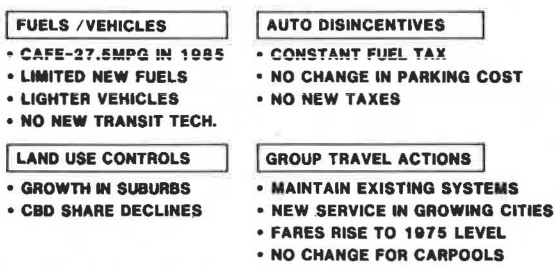

FIGURE 7 In-place policy in transportation energy.

Although automobile technology is expected to improve considerably over the 20-year horizon simply from forces now in place, transit technology is not expected to change much at all by 2000. No exotic transit technologies were selected for use in any of the typical cities in their own plans, that is, the in-place policy for this project. Only slight improvements to current technologies, such as light rail, diesel bus, and rapid rail, were tested. The policies regarding elderly and handicapped users of transportation were presumed to moderate from their 1980 versions in such a way as to allow transit systems to continue operating, although certain resources would be devoted to the provision of special services for those groups. (The expected changes in those policies have since occurred.)

The in-place policy was translated into variables that could be changed in the modeling package selected for the project. These variables are referred to as policy levers. It was essential to define any policy of interest in terms of these levers. As shown in Figure 7 the five major classes of policy levers are fuels and vehicles, economic disincentives for automobile travel, group travel actions, and land use controls. Other categories of policy levers were examined and then excluded from the analysis when either no reasonable policy could be defined in terms of these levers or there was no sufficient theoretical work done to define the relationship between a policy action and a response to the action. An example of the first case is extensive land use controls that would result in major changes in the length of the work trip. An example of the second is the relation between telecommunications and transportation.

Two strategies were developed, and both were aimed at reducing energy consumption in urban travel. The group travel strategy focused on reduction in energy use through increased use of efficient group travel modes. The individual travel strategy was aimed at that same goal, but achieved it through significant improvements in automobile technology. As shown in Figure 8, many more levers were adjusted for the group travel strategy than for the individual travel strategy. The arrows indicate the direction, not the magnitude, of the change.

The group travel strategy changed the tax on automotive fuels and the tax on parking, in one instance lowered transit fares, extensively improved transit systems, and induced land use changes supportive of transit system use. No changes were made in automotive technology with respect to the in-place policy.

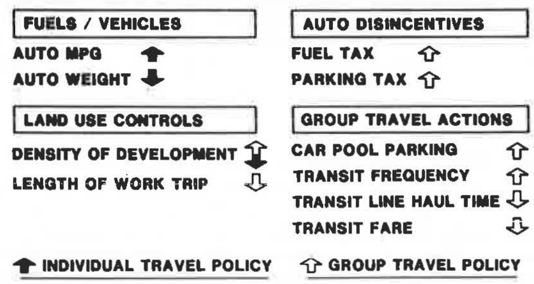

FIGURE 8 TAPCUT policy levers.

The individual travel strategy required only an improvement in automobile fuel economy achieved through new design for automobiles. In scenario III small land use changes that were supportive of automobile use were instituted.

TAPCUT Fuel Price

The fuel price in TAPCUT was the result of both scenario assumptions and policy changes. The base price without taxes was a scenario-specified variable. Taxes on that price were a policy variable, however. In Figure 9 the net resulting price to the consumer is plotted in 1975 dollars for each scenario and policy from 1975 until 2000. The price in scenario III ($2.55 in 2000) was considerably higher than the price in scenario I ($1.89). However, the tax on fuel under the group travel strategy for scenario I was double the rate of the tax for scenario III under that policy. As a result the price in the year 2000 was nearly the same in each scenario under the group travel strategy.

For scenario III, the higher rate of price increase was tied to the limited success in finding new domestic sources of oil and the unsatisfactory international position of the United States in purchasing imports. The technological success in scenario I was the main reason behind the lower price of the primarily domestically produced fuels.

As all liquid fuels were competing for the same market, it was presumed that there would be relatively small variation among fuel prices, just as now. Thus even if a fuel costs more to produce than the average liquid fuel, it would be priced close to the predominant fuel in the market. This is reasonable, given the assumption that a few large suppliers would provide all the different kinds of fuels, such that the cost of one could be balanced out by the profits from another cheaper-to-produce fuel.

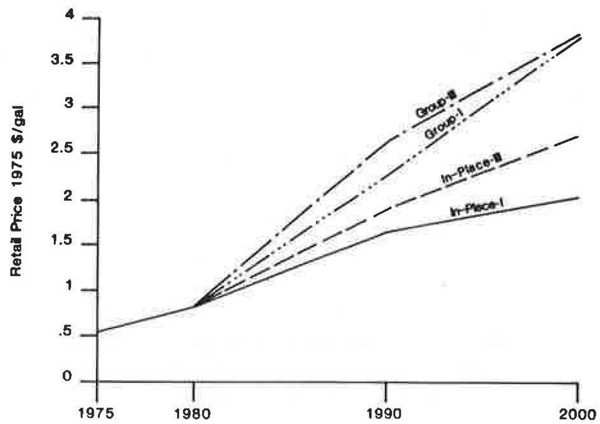

FIGURE 9 TAPCUT fuel prices.

SELECTED ANALYSIS RESULTS

Aggregate Measures of Travel

VMT and PMT from urban households in scenario III are plotted in Figure 10. These are annual figures and include an estimate of non-home-based travel. Under the in-place policy PMT in the aggregate did not change much, although VMT increased slightly. The forecast metropolitan population change was only 6 percent from 1980 to 2000 in scenario III, so that large growth in travel would not be expected. Nevertheless, these plots are nearly flat (0.1 percent change in PMT, 3.5 percent change in VMT), primarily as a result of increase in the price of travel.

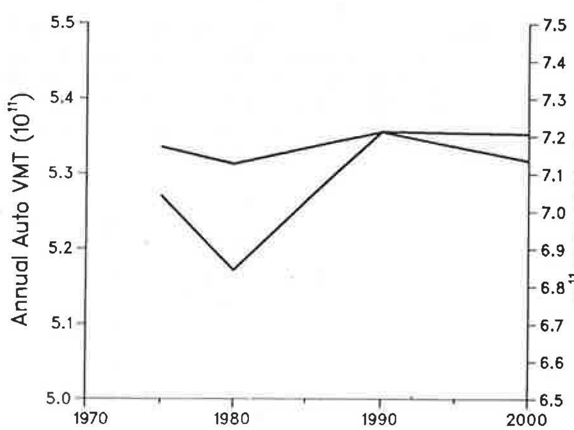

FIGURE 10 Aggregate travel demand result in scenario III under in-place policy.

In scenario I, where metropolitan population grows 17 percent and households are wealthier, person travel increases 7.6 percent over 20 years and vehicle travel increases 17 percent.

The strategies affected aggregate travel measures differently. The group travel strategy resulted in a 23 percent decrease in VMT with respect to the in-place policy in both scenarios; but PMT increased in scenario I by 0.6 percent, yet decreased nearly 10 percent in scenario III. This difference in the scenario results under the same strategy suggests that the households located in the denser land patterns of scenario I can satisfy travel needs more easily on satisfactory transit. Some of this difference is explained by the policy action in scenario III that only resulted in a 14 percent decrease in average work trip length. In scenario I, however, changes in PMT occurred only in nonwork (discretionary) travel, as work trip length and frequency were unchanged by the policy action.

The individual travel strategy had virtually no effect on the aggregate travel measures of VMT and PMT. The fuel-economy increases, although notable, did not affect out-of-pocket expenses sufficiently to increase travel demand. Households chose slightly larger automobiles that had satisfactory fuel economy, but not the best fuel economy available; the net effect was no change in out-of-pocket expenses relative to those under the in-place policies.

Examination of costs of the strategies and the tax and fare revenues generated indicated that costs were 80 percent, whereas revenues fell 40 percent, under the in-place policies. This situation was worse under the individual travel strategy but reversed under the group travel strategy. In the latter strategy transit fares covered operating costs and gasoline tax revenues covered projected capital expenditures (6).

Energy Consumption

Figures 11 and 12 show the total direct energy consumption under all three policies in each scenario. Even under the in-place policy energy use for urban transportation declined significantly--about 40 percent from 1980 to 2000. Further, under each policy energy consumption declined still more. The lowered energy use per trip, which resulted from fuel-efficient vehicles, explains much of this reduction in total use. The increase in the price of automobile travel without large increases in transit service also figures in the decline in energy use under the in-place policy (7).

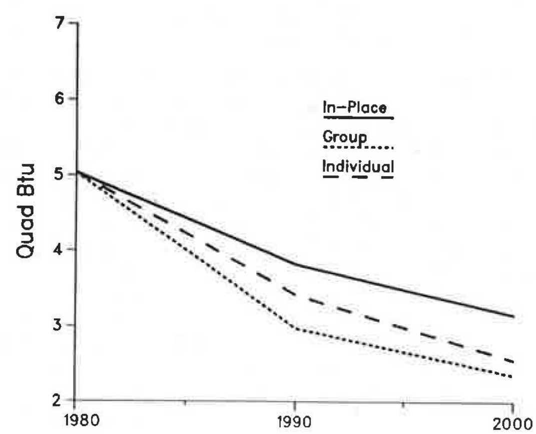

FIGURE 11 Direct energy consumption by urban households for local travel in scenario I.

Under the group travel strategy direct energy consumption was reduced 25 percent compared to the in-place policy in 2000 in scenario I. The decrease was 18 percent in scenario III (see Table 1). Direct energy savings were less under the individual travel strategy, but still significant--19 percent in scenario I and 7 percent in scenario III. However, when direct and indirect energy consumption are both included, the energy savings from the individual travel strategy diminishes considerably--9 percent in scenario I and only 1 percent in scenario III. The group travel strategy decreases remain the same.

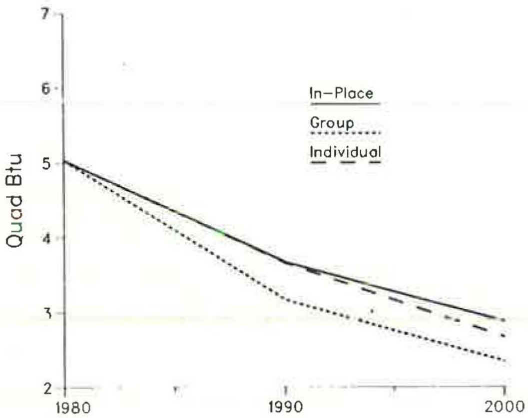

FIGURE 12 Direct energy consumption by urban households for local travel in scenario III.

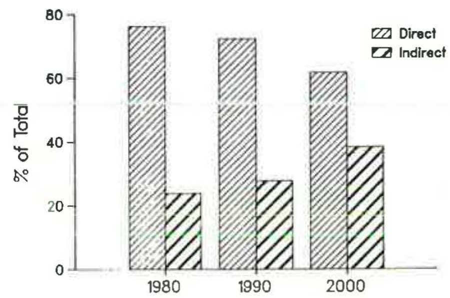

FIGURE 13 Comparison between direct and indirect energy use for urban travel in scenario III under individual travel policy.

TABLE 1 Selected TAPCUT Results: Changes in Aggregate Travel and Energy for National Metropolitan Travel

		Percentage Change in				
Policies and Years Compared	Scenario	VMT	PMT	Direct Energy	Indirect Energy	Total Energy
In-place policy 1980 to in-place policy 2000	I	+17	+8	-37	+53	-16
	III	+4	+0.1	-43	-4	-34
In-place policy 2000 to group travel policy 2000	I	-23	+0.6	-25	-22	-25
	III	-23	-9.7	-18	-17	-18
In-place policy 2000 to individual travel policy 2000	I	+0.1	+0.2	-19	+4	-9
	III	-1	-0.6	-7	+10	-1

Note: The total metropolitan population differs in each scenario.

On a passenger mile basis (rather than lane mile) automobiles and highways are more energy intensive to produce than buses and light rail systems, the dominant TAPCUT transit modes.

The relationship between direct energy consumption (i.e., for vehicle operation) and indirect energy consumption (i.e., for manufacture of vehicles, fuels, and roadways) changed over time (Figure 13). Indirect energy accounted for nearly 40 percent of the total energy expended for urban transportation under the individual travel strategy. Under scenario I use of synthetic fuel increased the indirect energy total. Further, the more fuel-efficient vehicles were more energy intensive to produce. Increased use of transit under the group travel strategy did not change the relationship between indirect and direct energy as significantly. Even the more energy-intensive forms of transit are less energy intensive than automobile manufacture. Petroleum savings are greatest under the group travel strategy in scenario I. Energy savings are greatest, however, in scenario III. Petroleum savings achieved through fuel substitution (as in scenario I) exact a price in the form of higher consumption of other fuels (8). These last three figures taken together indicate that energy savings can be achieved in many different ways, but the costs of achieving the savings vary significantly.

The relationship between energy use and total trips per person is shown in Figure 14 for scenario I. There it can be seen that trips increased under the individual travel strategy, even though energy use was decreasing significantly. This is a contrast to the group travel strategy, where both trips and energy use declined, the latter even more dramatically than under the individual travel strategy. Trips per person can be interpreted as a measure of mobility, although not a complete measure, which indicates that the greater energy savings of the group travel strategy was at the expense of slight decreases in mobility. Only transit and automobile trips by household members (and not pedestrian travel) are included in this figure.

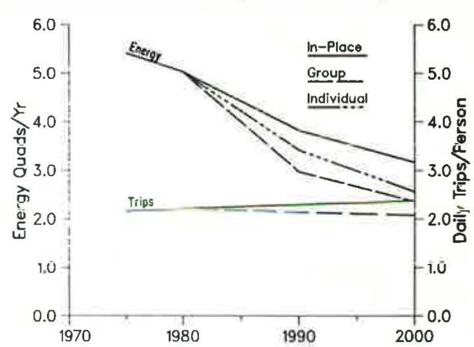

FIGURE 14 Change in trips and direct energy for travel in scenario I.

Health Effects: Air Quality

The health effects from vehicle operation have been estimated on a city-specific basis. The health effects were related to pollutant emissions from the vehicles, including carbon monoxide, ozone, nitrogen oxides, particulates, and hydrocarbons. Health effects were measured in terms of excess deaths, hours of discomfort, and morbidity. These changes were estimated for various groups in the population, including groups more sensitive to each of the pollutants. Health effects caused by carbon monoxide were given considerable attention; both ambient exposure for the region and specific periods of exposure from travel in each portion of an urban region were included (9).

The bulk of the CO emission reductions from automobiles went into effect in the 1980 model year, with the 7.0 g/mile standard for automobiles. That reduction has the largest single beneficial impact on health effects of all variables considered. If that reduction is maintained, differences in strategy effects are fairly small at the national level. However, if either the vehicle emissions return to pre-1980 levels or significant VMT increases beyond the TAPCUT forecast occur (e.g., because of lower fuel prices), the forecast reductions in deleterious health effects are unlikely to occur. City differences were evident here; Sprawlburg CO emissions begin to rise in 2000 in scenario III. In that scenario population growth was highest for Sprawlburg, and CO emission standards were not made more stringent after 1980. Discomfort from CO emissions was projected to rise from 1990 to 2000, thus approaching 1980 levels. Megatown and Slowtown had no such increases in any forecast.

Traffic Safety

Figure 15 shows the effect of the changing automobile fleet on traffic safety. Specifically, fatalities per million population caused by vehicles in urban areas are plotted alongside the amount of VMT in small vehicles for the in-place policy. These values are for one of the typical cities that is most similar to national trends. The graph demonstrates the strong relationship between small car VMT and the fatality rate. Unless there is a decrease in the rate per million vehicle miles of fatalities in small cars with respect to the other size vehicles, then the forecast switch to small-sized vehicles will bring with it an increase in overall fatality rates. Speculation about changes in severity and frequency of accidents when there are more small cars in the fleet suggests that the rates may go down; however, there is currently no empirical basis for making these conclusions (10).

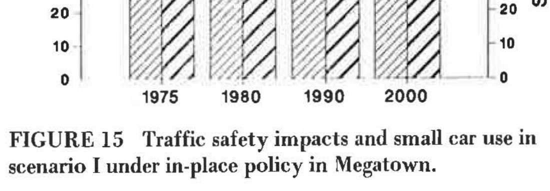

FIGURE 15 Traffic safety impacts and small car use in scenario I under in-place policy in Megatown.

Economic Impacts

The economic analysis addressed the question of whether the conservation policies were really productive. The result was that they were productive at the scale of national economic activity. No impacts on industries outside transportation were projected. Within transportation industries, such as highway construction and bus manufacture, growth was expected to correspond to the strategy. Changes to the balance of trade were estimated and were found to be small relative to the other factors that influence the balance of trade.

One caution is that only changes from metropolitan area travel and vehicle production were forecast. Metropolitan households hold three-quarters of the automobile stock, so automobile production impacts are probably dominated by the market studied. However, nonmetropolitan household automobile travel, all intercity travel, and all goods movement are excluded from consideration in TAPCUT. Impacts from decreases in vacation travel, for example, that might occur with TAPCUT's high fuel prices, are excluded from the analysis, thereby limiting the conclusion about the productivity of the strategies. Because of interactions among the four travel markets, of which one was studied, it is difficult to draw conclusions about the net effects on all travel. Goods movement might increase as delivery trucks are substituted for personal cars in shopping, whereas intercity automobile travel might decrease.

Physical Environment Impacts

Overall, the group travel strategy is significantly less harmful to the environment than either the in-place policy or the individual travel strategy. Analysis of the impacts of air quality, water quality, and toxic pollutants at a city level support this conclusion. The reduction in VMT is the strongest explanation for the dominance of the group travel strategy, coupled with the absence of any new pollution problems under that strategy. The forecasts of impact are sensitive to the VMT forecast; in Sprawlburg cities, where VMT and population are growing rapidly, air quality begins to deteriorate after 1990.

CONCLUSIONS

The TAPCUT project began with three goals: a description of several alternative strategies that promote energy conservation in the urban passenger transportation sector, a better understanding of the environmental impacts of such strategies, and an identification of the constraints to the implementation of such strategies. The conclusions are stated in terms of these goals.

1. Two distinct approaches to saving energy in urban passenger transportation have been defined in realistic terms. Both approaches resulted in energy savings beyond policies currently in effect. In terms of national economic activity, both are productive conservation policies. However, the total vehicular trips by households was decreased under the strategy (group travel) that saved the most energy. The reduction in trips could be construed as nonproductive because of life-style changes imposed on some households. A further productivity consideration is that the group travel strategy raised enough revenues to pay for the capital and operating costs incurred for roads and transit, whereas the individual travel strategy worsened the deficits projected under the in-place policies.

2. The policy that focused on group travel was more benign than the others tested on environmental grounds. That is, however, the same strategy that lowered trips per person with respect to the in-place policy. It is clear that the assumed motor vehicle emission standards played an important part

in this conclusion, however. Improvements in fuel economy were decoupled from emissions rates in TAPCUT technologies within the selected performance specifications for personal automobiles. Failure to meet the currently mandated emission standards could significantly worsen the environmental impacts of the individual travel strategy, where fuel economy was raised to its highest value.

3. Some barriers to implementation of energy-saving policies have been identified. The individual travel strategy requires a healthy automobile industry that is able to systematically improve new cars over a 20-year period and anticipate some shifts in consumer preference for vehicle size and propulsion system. The strong, government-supported research and development element tested under this strategy increased industry vitality. The current abrupt shifts in government policy toward industry may add to the many barriers internal to the industry, especially in the area of long-term research and development. The group travel strategy requires cooperation by various levels of government, as the service improvements were financed from fuel tax revenues. The organizational structure of service providers may have to change to a more competitive system to be sufficiently flexible to serve new markets.

The land use controls hypothesized, although modest in their net effect, constitute a significant directed change in growth patterns. Tools to implement the changes proposed under both policies have been suggested, but further examination of them is warranted, given the importance of activity patterns in using the group travel modes effectively.

Imposition of the gasoline and parking taxes listed under group travel, although they were effective in the simulation, would be unpopular with several groups. These taxes did demonstrate the magnitude of change in the transportation taxing structure necessary to produce significant changes in travel behavior. Previous limited experience with economic disincentives (taxes) for automobile travel as transportation control measures has elicited a strong reluctance on the part of local governments to implement them.

ACKNOWLEDGMENT

In this paper selected results of research carried out by a large team of environmental analysts and transportation planners for a project funded by the Office of Environmental Analyses, DOE, are summarized. Their work is separately documented in the technical memoranda indicated in the references. Summaries of the physical environmental impacts were taken from analyses by John Croom, Management of Resources and the Environment. Several staff members of the Futures Group firm assisted in the scenario definition and economic impact analysis. Additional support was provided by Larry Hill, Lewis University, on economic and resource impacts, and by Alan Schnaiberg, Northwestern University, on demographic forecasts.

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Errors in this paper are solely the responsibility of the authors.