sider all of the potential north-south bus routes that serve the area.

The multimodal process also assumes that every rail, bus, and air corridor provides equal service, and hence are equally attractive to the traveler. Obviously, this is a faulty assumption, but it should create no real problem if the transportation planner remembers that the process is designed to help locate the most feasible corridors for alternative modes and to measure the probable impact of the alternative modes on highway needs.

CONCLUSION

This paper describes a newly developed multimodal process designed to help measure the interrelated regional or statewide impacts of energy availability, population changes, and an increased emphasis on mass transit. It should help in location of potential mass transit corridors for rail, bus, and air and also evaluate the effect that such corridors could have on highway needs. Highway corridors that show grave deficiencies in all probable futures can be located by studying the travel assignments for each of the futures. Such corridors may then be assigned a high priority, and deficiencies that show in only a few of the probable futures may be assigned lower priorities.

The objective of this paper was to describe a process that enables a state or region to explore the potential diversion of different automobile trip purposes for various futures and the impact the diversion would have on transportation needs and deficiencies. The variables most often discussed by administrators, transportation planners, and citizens have been defined simply and are easily explained. This enables one to quickly and easily change desired variables and evaluate transportation needs to accurately reflect current issues. The application of the process in the northwest shows that the impacts are extremely complex. Changes in population or energy availability, for example, do not always cause uniform changes in all travel corridors. Transportation deficiencies and demands vary considerably, depending on the travel characteristics of any route.

The application of this process in the northwest region is described in detail to help show that the process is sensitive to all of the desired variables. These variables include not only the assumptions about modal selection in energy-short futures, but also population changes and general road use characteristics. Furthermore, the multimodal process uses tools previously developed for Michigan's statewide modeling system and so is completely compatible with that system. This compatibility ensures that all pertinent additions and improvements to that system will be immediately available for use in the multimodal process.

ACKNOWLEDGMENT

This paper is based on research sponsored by the Federal Highway Administration. Larry Brown of the Michigan Department of Transportation was the team leader for the Northwest Regional Transportation Study and John Ouderkirk of the North Region Planning Section, Michigan Department of Transportation, was the project manager.

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Publication of this paper sponsored by Committee on Statewide Multimodal Transportation Planning.

Transportation Energy Overview: Emphasis on New York State

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This paper summarizes recent work by the New York State Department of Transportation on transportation energy analysis, consumption, and conservation. Current uses and sources of American transportation energy are reviewed. Particular emphasis is on New York. Transportation energy (gasoline, diesel, and jet fuel) comes primarily from domestic sources, Africa, and the Middle East, and is used primarily for automobiles, commercial vehicles, and air travel. New York uses a relatively higher share of transportation energy in transit and air travel than does the rest of the United States. The paper also shows gasoline use by trip purpose and location in upstate New York, describes baseline transportation energy forecasts and the importance of increased automobile fuel efficiency on conservation, and reviews public attitudes toward conservation and changes in travel behavior during the energy crisis of 1973-1974. Possible conservation actions and their potential are also summarized.

The energy crisis of 1973-1974 increased the awareness of government, industry, and the general public to the problems of energy consumption and supply. Such awareness may have been short lived [four months at most (1)]; however, for a short period of time national attention was focused on that one issue. The Arab oil embargo, which precipitated that crisis, affected the availability and price of gasoline. Although other energy sectors were also affected, in retrospect, the transportation sector appears to have been particularly vulnerable. This is not surprising: In the United States transportation consumes over half of petroleum products and automobiles account for well over half of transportation energy. Clearly, because of the particular vulnerability of the transportation sector to petroleum sources and the large capital costs already made in transportation and transit facilities as well as in vehicles, transportation planners must understand and prepare for the impacts of such embargoes and other energy-related futures. The purpose of this paper is to provide relevant information for transportation planners and decision makers and to describe the kinds of practical actions that might be taken to plan for these uncertain futures. The objective of this paper is to provide an overview of the energy situation in the transportation sector and to look at the following key issues:

1. The sources and uses of transportation energy,
2. The forecasts of transportation energy,
3. The public's view of transportation energy conservation, and
4. The conservation actions or policies that make the most sense for the short and long term.

ENERGY SUPPLY AND DEMAND

Numerous reviews describe the supply and demand of energy by sector and source in the United States (2-5). They generally show the overview described below for 1976 (note: 1 J = 0.001 Btu) (3, 6).

	Supply (%)	
Source	New York	United States
Hydroelectric	7.5	4.1
Nuclear	4.0	2.7
Petroleum		
Residual	24.3	
Distillate	16.4	
Gasoline	19.0	
Jet fuel	4.2	
Kerosene and liquefied propane gas	1.5	
Subtotal	65.4	47.3
Coal	8.2	18.6
Natural gas	14.9	27.3
	100.0	100.0
Total (EJ)	4.31	78.07

	Demand (%)		
Sector	New York		United States
Residential	22.6		19.9 (Residential and Commercial)
Commercial	12.4		
Industrial	9.7		24.9
Transportation	26.1		26.2
Electric		2.4	
Petroleum		97.6	
Electric utility	29.2		29.0
Total	100.0		100.0

For the United States in general, and even more so for New York, petroleum products and natural gas are the main sources of energy. New York is generally more dependent on petroleum than is the nation and less dependent on natural gas and coal. The three largest demand sectors (residential and commercial, electric utility, and transportation) account for almost 80 percent of U.S. energy consumption; transportation is about 26 percent of both New York and national consumption. New York's energy consumption differs from the nation's in the industrial and in the residential sectors because it is primarily a cold-weather state and has relatively less industrial activity than other states.

Certain fuels are used primarily in certain sectors. Figure 1 shows the flow from source to demand sector for New York in 1976; similar charts are available for the United States. Jet fuel and gasoline are two commodities used exclusively in the transportation sector. A small amount of distillate (diesel fuel), residual, and electricity are also used in this sector. Clearly, the transportation sector is extremely dependent on two specific energy sources: gasoline and jet fuel.

Transportation energy resources come primarily from Africa and the Middle East, mainly from Nigeria and Saudi Arabia (7). Figure 2 shows the distribution of true dependence (i.e., both refined and crude oil sources) of New York and the United States on different foreign and domestic sources for four major petroleum products. Both the United States and New York are highly dependent on foreign sources for residual oil, which is used primarily for space heat and for the generation of electricity (Figure 1). The United States and New York depend primarily on Middle Eastern and African nations for lighter products. New York's dependence is significantly higher than that of the United States and averages 72 percent overall.

The largest share of transportation energy goes into the automobile (Table 1). Commercial vehicles, particularly trucks, use significantly less energy, but nevertheless they use a greater share than that used by any of the other modes of travel (8). Although specific numbers are not available for New York, the national data show that less than 1 percent of transportation energy is used for buses (New York's number would be higher). The implications are that significant energy conservation measures must be oriented to the use and efficiency of automobiles and trucks. Some savings are possible in other modes through diversions; however, it is apparent that their current shares of energy consumption are so low that significant savings relative to those achievable by the automobile will generally not be possible.

New York, by comparison, uses somewhat more automotive gasoline than does the nation and somewhat less energy for trucking. This is because of New York's relatively smaller industrial sector, in comparison to other states. On the other hand, New York uses more transportation energy for air traffic (primarily because of the heavy air traffic in the New York City area) and somewhat more vessel energy. Not all states have waterways or extensive harbor facilities. Both these functions are, of course, regional in character.

The distribution of New York's gasoline use is shown in Figure 3 (9). The data represent annual 1975 gasoline consumption for upstate New York, which totals about 11.4 billion L (3 billion gal) of gasoline annually. Certain shares are obvious (such as home and work travel, which constitutes the major portion of weekday energy consumption), and a significant share of energy is used in personal business, shopping, and social recreation travel.

FORECASTS

Oak Ridge National Laboratory (3) recently summarized numerous forecasts of transportation energy conservation made by the U.S. Department of Energy (DOE) and others. Tables 2 and 3 summarize 1985 and 2000 forecasts for the baseline, assuming an increase in new automobile fuel economy to 11.7 km/L (27.5 miles/gal),

Figure 1. New York energy flows in 1976.

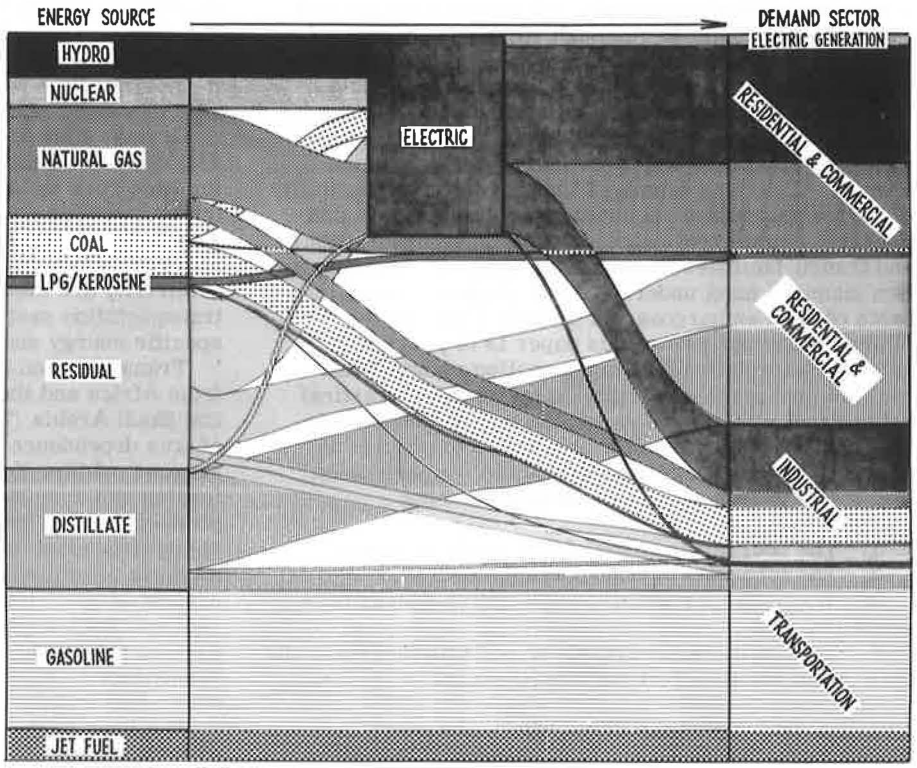


Figure 2. Sources of petroleum products.

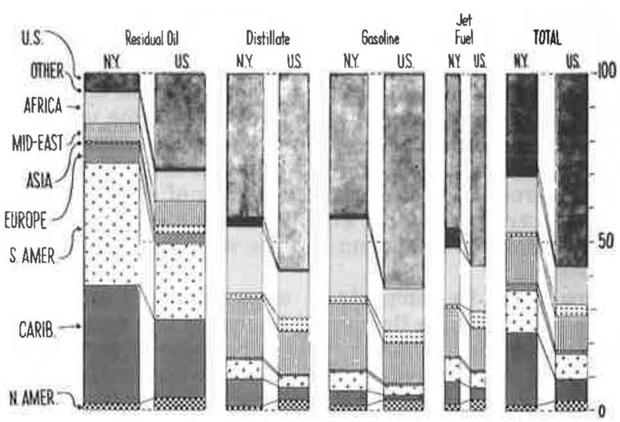
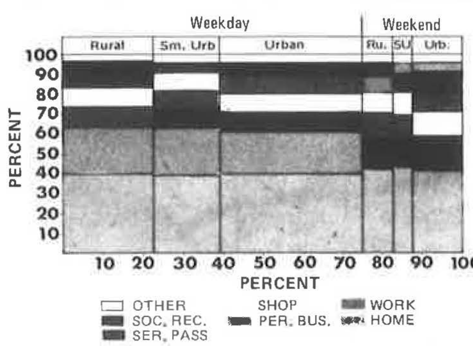


Table 1. Transportation energy use.

Mode	New York-1976 (%)	United States-1974 (%)
Automobiles	64.1	57.5
Trucks—commercial	10.7	25.2
Railroad—intercity	1.6	3.7
Transit buses, subway, and commuter rail	1.9	0.5
Vessel	5.9	5.0
Air—commercial	15.8	8.1
Total	100.0	100.0
Transportation sector, total direct transportation energy (1 EJ)	1.144	16.892

Note: 1 J = 0.001 Btu.

Figure 3. Upstate New York gasoline energy in 1975.



but no other conservation actions (3). The forecasts show that projected improvements in the efficiency of new automobiles are more than sufficient to support both significant increases in automobile vehicle kilometers of travel and increases in population and real per capita income. The tables show that, for the period 1975-1985, approximately a 37 percent increase in automobile travel could be sustained, with a 16 percent reduction in automotive fuel consumption. Beyond that time frame, certain fuel substitutes and blends may change automobile fuel requirements significantly. The analysis further suggests that savings in automotive fuel permit other subelements of the transportation sector (such as truck travel and air) to increase in both use and energy consumption. The total growth in transportation energy use over the 10-year period 1975-1985 is only about 7 percent. Thus, for achieving transportation energy conservation, the importance of improvements in automobile fuel economy and their acceptance by consumers is difficult to overstate.

The New York State Department of Transportation has conducted similar analyses. Econometric models were constructed that relate gasoline price and availability to gasoline demand (8). The models were built for each of the nine metropolitan areas of New York and the remainder of the state and have the following general form:

$$VKT_F = VKT_{75}(POP_F/POP_{75})[1 + e(\Delta x/x75) + \ldots] \quad (1)$$

where

VKT = vehicle kilometers of travel,
POP = population,
x = gasoline price availability, and
e = elasticity.

Therefore,

$$GASOLINE_F = VKT_F/EFF_F \quad (2)$$

where EFF = average automobile efficiency (km/L). The models assume that increases in travel will be a function of (a) increases in population and (b) changes in various background factors, including gasoline prices and availability. The model is operated in an iterative fashion: Gasoline consumption is its output and gasoline supply its input (gasoline availability is defined to be an estimate of gasoline used times average automobile efficiency). The model may, therefore, be operated in feedback fashion to solve for equilibrium prices, automotive fuel efficiency, or other variables that balance supply and demand against various assumptions about vehicle kilometers of travel and other factors. The model has been constructed as an iterative tool, intended to shed light on the general question of gasoline consumption in New York.

Calibration of the demand equations is achieved through least-squares regression of 48 monthly data points for the period 1972-1975. This period encompassed the energy crisis and was characterized by rapid rises in gasoline price and radical shifts in gasoline availability. Therefore, the data contain enough variation to be extracted by calibration. Calibration consisted of regression of the monthly data against trends in regional traffic counts, and then computation of elasticities at the mean values (9). The elasticities that result for each area are shown in Table 4.

Forecasts made by use of the tool are summarized in a number of reports (8-11), and in Table 5 and Figure 4. Test A, which summarizes the baseline forecasts, consists of an assumed turnover of the vehicle fleet along the guidelines of federal standards toward 11.7 km/L (27.5 miles/gal), projected moderate increases in gasoline price, and trend increases in vehicle kilometers of travel. The analysis shows, similar to the studies previously described at the national level, that considerable growth in vehicle kilometers of travel and reasonably stable gasoline prices can be achieved with about 18 percent less gasoline consumption than in 1975, assuming that the average efficiency of automobiles increases as mandated under federal law. This is, of course, a very attractive world, and it underscores the importance of vehicle fleet turnover in achieving gasoline consumption.

Tests B and C assume, for comparison, that such turnover would not occur as rapidly but would rise only to 9.4 km/L (22 miles/gal) instead of to 11.7 km/L. Test B assumes that the same amount of gasoline (18 percent) would be conserved (i.e., the conservation ethic would be maintained). The trade-off required to achieve such conservation under a less rapidly increasing efficiency is a significantly lower rate of increase in travel (13 percent over the 15-year period) and a very rapid rise in the nominal price of gasoline. Alternatively (test C), if one wishes to discard the conservation

Table 2. Baseline transportation energy travel forecast before conservation.

Mode	Demand in 1975 (000 000s)	Percentage Change 1985	2000
Vehicle kilometers of automobile travel	1641	37	90
Vehicle kilometers of personal truck travel	151	66	156
Total and weighted average of personal travel	1792	39	95
Vehicle kilometers of other truck travel	965	44	151
Passenger kilometers of bus travel	82	62	186
Passenger kilometers of air travel	256	94	146
Megagram-kilometers of rail travel	1386	34	100
Megagram-kilometers of marine travel	897	83	150
Megagram-kilometers of pipe travel	1114	5	31

Note: 1 km = 0.62 mile; 1 Mg = 1.10 ton.

Table 3. Baseline transportation energy forecast before conservation.

Mode	Energy in 1975 (PJ)	Percentage Change 1985	2000
Automobile	9 959	-16	-7
Personal truck	1 097	20	52
Total and weighted average of personal travel	11 056	-13	-1
Other truck	3 133	28	103
Bus	95	44	144
Air	1 498	33	98
Rail	528	34	160
Marine	675	80	134
Pipeline (other)	1 329	2	19
Miscellaneous	1 361	12	26
Total and weighted average	19 675	7	42
Population	213 500 000	9.6	23
Real per capita income	$5 062	31	96

Note: 1 J = 0.001 Btu.

Table 4. Elasticities of travel with respect to background factors.

Place	R^2	Overall F	Elasticity: Real Gasoline Price	Gasoline Supply	Retail Sales	Labor Force	Unemployment
New York City	0.78	30.2	-0.21	0.34	-	1.47	-
Buffalo	0.72	22.4	-0.13	0.08	0.36	-	-
Rochester	0.71	26.7	-0.09	0.39	-	-	-
Albany	0.84	57.0	-0.11	0.38	-	-	-
Syracuse	0.79	38.3	-0.10[a]	0.58	-	-	-
Utica-Rome	0.84	46.1	-0.10[a]	0.83	-	-	-
Binghamton	0.81	30.7	-0.10[a]	0.31	-	-	-0.29
Poughkeepsie	0.84	44.4	-0.10[a]	0.54	-	-	-
Elmira	0.80	34.3	-0.10[a]	0.37	-	-	-
Rest of state	0.89	59.6	-0.10[a]	0.28	-	-	-0.15

Notes: Models also include season indices.
Real gasoline price = nominal price/consumer price index; gasoline supply = gasoline available x average automobile efficiency.
[a] Assumed.

Table 5. New York forecasts for automobile gasoline demand.

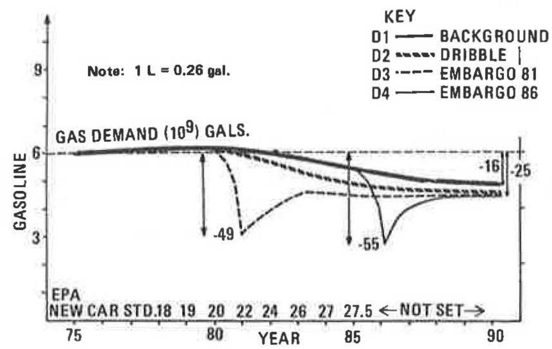
Test	Change 1975-1990[a] Gasoline Demand (%)	Change 1975-1990[a] Vehicle Kilometers of Travel (%)	1990 Nominal Price ($/L)
A—Full fleet turnover (11.7 km/L)	-18	36	0.26
B—Partial fleet turnover (9.35 km/L) with conservation	-18	13	0.46
C—Partial fleet turnover (9.35 km/L) without conservation	6	36	0.26
D-1—Best guess background[b] (11.7 km/L)	-16	45	0.24
D-2—Dribble away of supply (11.7 km/L)	-25	30	0.23
D-3—50 percent embargo 1981-1982 (11.7 km/L)			
1981	-49	-40	0.57
1990	-25	31	0.32
D-4—50 percent embargo 1986-1987 (11.7 km/L)			
1986	-55	-33	0.69
1990	-25	29	0.33

Note: 1 km/L = 2.35 miles/gal; 1 L = 0.26 gal; 1 km = 0.62 mile.

[a] 1975 levels: gasoline demand = 22.7 billion L, vehicle kilometers of travel = 10.39 x 10^{10}, and price of gasoline = $0.13/L.

[b] Increasing price elasticity, higher vehicle kilometers of travel.

Figure 4. Forecasts of gasoline demand.



ethic, growth in travel may be maintained at reasonably low real prices, but the cost will be approximately 24 percent more gasoline use (18 + 6 percent) than could have been saved through conservation.

A number of additional tests were constructed to represent declining supply scenarios. Test D-1 is a revised background projection and is similar to test A except that it assumes increases in price elasticity (such as a price threshold) and a slightly higher growth rate of vehicle kilometers of travel; it shows a 16 percent drop in gasoline demand over 1975-1990. Test D-2 (dribble) assumes a slow decline of supplies by 5 percent annually for five years, beginning in 1980. This results in approximately 25 percent reduction in gasoline demand over the five-year period but could probably be achieved at reasonably stable prices. Tests D-3 and D-4 are intended to simulate the shock effects of significant embargoes in the 1981-1982 period or alternatively in the 1986-1987 period. In both cases, significant rises in gasoline price occur immediately but retreat somewhat to prices in the range of $0.40/L ($1.50/gal) by 1990.

PUBLIC VIEWS AND RESPONSE

Since the implementation of conservation policies would require positive action by consumers and government, planners must understand and recognize the kinds of policies that are generally acceptable to the public. Our knowledge of consumer response to transportation energy constraints or price increases is limited. Most summaries of aggregate behavior come from the period of the energy crisis during the winter of 1974. The period resulted in a 15-20 percent shortfall in gasoline and a 60 percent increase in price. At that time a number of studies conducted by transportation analysts and others concentrated on changes in travel behavior and attitudes toward various conservation actions. In an extensive review of this literature (1), Neveu found only a handful of studies that reported actual behavior during the crisis; most were retrospective views reported up to three months after the crisis ended. Neveu summarized comparisons of both aggregate and disaggregate data as follows:

1. The availability of gasoline generally controlled use; increases in price per se had little effect on curtailing demand. Thus, gasoline price increases (particularly small periodic increases) used as a lever to reduce demand are unlikely to be particularly successful.
2. Changes in travel behavior were minimal. Most people reduced discretionary travel, combined trips, and drove slower. Carpooling increased only slightly (5 percent), as did transit use. No discernable shifts occurred in automobile ownership, residential location, or other major actions.
3. Low-income travelers, who make few discretionary trips to begin with, were more inclined to shift modes, particularly on work trips. Even here, however, the relative impact was small.
4. Sales of both large and small automobiles plummeted as consumers adopted a wait-and-see attitude.
5. Patterns of travel returned to normal shortly after the crisis.
6. Many people were inclined to view the crisis as an event contrived to increase gasoline price.

Thus, reaction to the crisis consisted of minimal actions, usually individual or family based, to ride out the storm. The data further suggest that consumer responses to future crises will be slow, measured, and, in general, sluggish.

To update this information, a poll was conducted during the fall of 1977 (12). A total of 500 households were selected in multistage fashion from New York; the probability of selection was proportional to population. The households were telephoned and administered a short opinion poll on the general subject of energy conservation in the transportation sector.

The results of this poll are somewhat surprising when viewed against similar findings of other studies. As the responses below show, New Yorkers are aware of the existence of a significant energy problem in the United States.

Does the United States have an energy problem?

Response	Percent
Yes	84
In the next 15 years	7
No	9

These numbers are significantly higher than those discovered from other studies and reflect the sensitivity of New Yorkers to gasoline price and availability, as well as New York's greater reliance on foreign energy imports.

Where should energy in New York State be saved?

Area	Response (%)	Current Share (%)
Home	18	22
Industry	22	10
Business	13	12
Transportation	17	26
Other	30	30

The answers to this question were divided, but respondents generally felt that industry should bear a significantly larger portion of the effort than its present share of energy consumption.

New Yorkers said that the energy problem in the United States has been caused by a combination of external and internal factors.

What are the causes of the energy problem?

Response	Percent
Consumer and industry waste	82
Slow development of new sources	79
World is using up energy sources	78
United States is using more than we have	71
Other countries control our oil	71
Prices not high enough	17

New Yorkers are inclined to point to increased consumption of energy resources worldwide and significant control of petroleum in the hands of other countries as primary factors that influence the energy situation. But they also blame both consumers and government for significant waste, and chide the country for slow development of new sources of energy. They strongly disagree, however, that low prices have been the primary cause of such waste.

When asked specifically where transportation energy can be conserved, the attitudes of New Yorkers begin to harden.

How can transportation energy be saved?

Response	Percent
Encourage intracity transit	60
Encourage intercity bus and train	22
Encourage reduction in gasoline use	15
Other	3

Only 15 percent of New Yorkers seem to recognize (or are willing to admit) that the primary user of transportation energy is the automobile and, therefore, only through concentration on this particular use can significant savings be achieved.

When asked for specific support for actions to reduce gasoline consumption, New Yorkers show strong support for incentive and low-key actions, such as enforcement of the 88-km/h (55-mph) speed limit, encouragement of people to carpool and to plan trips better, and improvement of the flow of traffic on city streets. Considerably less support was solicited for various rebate or taxing plans on automobiles, and weak support was shown for gasoline rationing or taxes.

Support	Action
Strong—80-90%	Enforce 88-km/h speed limit
	Carpool incentives
	Trip-planning incentives
	Improve city street traffic flow
Medium—40-50%	Rebates
	Taxes on large automobiles
Weak—20-30%	Rationing
	Gasoline taxes
	Build more superhighways

The general picture is one of a public concerned but recalcitrant when confronted with specifics. It is perhaps reasonable to suppose that the public naturally shies away from actions that will have significant impact on transportation energy conservation (e.g., actions intended to reduce gasoline consumption through rationing). The study again seems to underline the importance of taking unobtrusive actions, such as improvements in the vehicle fleet efficiency, combined with significant incentives, as the most effective mechanisms for reducing transportation energy use.

CONSERVATION MEASURES

The above analysis suggests that incentives are better than disincentives from the public's viewpoint and that certain actions (particularly those aimed at improving the efficiency of automobiles) would result in significant transportation energy conservation. But what of other actions oriented toward modal shifts or increased vehicle load factors?

Because of the way in which transportation energy is distributed by modes (Table 1), even very large improvements in the use of certain modes (through diversion from the automobile) would not have a significant impact, relative to that for improvement in automobile efficiency. A number of recent studies have summarized, in comparative form, the effectiveness of numerous actions to conserve transportation energy. The most comprehensive of these studies have been the reviews by Hiatt and Rubin (13), Alan M. Voorhees

Table 6. Conservation measures.

Strategy	Percentage Savings from 1973	
	1980	1990
Passenger vehicle efficiency		
Modest improvement	8	15
Advanced technology	9	24
Maximum off-shelf	10	22
Advanced technology and small automobiles	13	32
Radial tires	0.5	0
Other retrofits	0.5	0
Work carpool		
47 percent participation	1.9	1.5
70 percent participation	4.9	3.8
Other efficiency measures		
88-km/h speed limit	1.2	0.9
Bus vehicle efficiency	0.1	0.1
Air passenger efficiency	2.3	3.7
Truck vehicle efficiency	3.3	8.7
Mode shifts		
Urban automobile to bus	0.7	0.8
Urban automobile to bicycle	0.5	0.7
Intercity automobile to bus	0.2	0.2
Intercity automobile to rail	-	-
Air to automobile	0.2	0.4
Air to bus	0.2	0.4
Air to rail	0.2	0.3

Note: 1 km/h = 0.62 mph.

Table 7. Upstate New York projected energy savings.

Policy	Changes in Parameters	1980 Change Over 1975 Base[a] (%)
1975 baseline		0
1980 baseline		-3.3
Encourage carpooling	10 percent increase in automobile occupancy for work and school	-5.0
	25 percent increase in automobile occupancy for work and school	-7.0
	10 percent increase in automobile occupancy for shopping	-4.1
	25 percent increase in automobile occupancy for shopping	-5.2
Chauffeur service in urban areas	25 percent increase in automobile occupancy for serve passenger, change mode, and ride trips, small urban areas only	-3.7
	25 percent increase in automobile occupancy for serve passenger, change mode, and ride trips, urban areas only	-4.2
Combine trips—trip chaining	Weekend shopping—25 percent decrease in trip length for shopping, eating meals, personal business	-4.8
	Weekday stop off—50 percent decrease in trip length and trip rate for shopping and personal business	-13.2
	Shopping center—10 percent increase in automobile occupancy for shopping, eating meals, personal business, serve passenger, social and recreational, and 2 percent increase for home; 30 percent and 15 percent decrease in trip rate; 25 percent and 5 percent increase in trip length	-16.0

Note: 1 L = 0.26 gal.
[a]1975 baseline = 4.8 billion L.

Associates (14), the National Cooperative Highway Research Program (15), and Interplan Associates (16). All of these studies have reached essentially the same conclusion: Improvements in the internal operating efficiency of automobiles are by far the most cost-effective and significant actions that can be taken to save transportation energy.

The results of the Rubin study are summarized in Table 6 (13). The action "maximum off-shelf improvements in passenger vehicle efficiency", for instance, would appear to yield, over a 1973 baseline, about 10 percent savings in 1980 energy and about 22 percent savings in 1990. Results are about the same as those achieved and described earlier by New York State Department of Transportation and by DOE. Actions to improve carpool participation, although somewhat effective, would require significant participation levels in order to bring about a significant improvement in transportation energy savings. This is because, as described earlier, a significant part of automotive fuel use is expended on nonwork travel. By comparison, the enforcement of the 88-km/h (55-mph) speed limit would save about 1 percent of transportation energy, but improvements in bus efficiency would have a very small effect. Improvements in the efficiency of planes and trucks would be somewhat more effective, and their effectiveness would be more important in later years as a greater percentage of transportation energy shifts to those modes.

Mode shifts of passenger travel would appear to not be a particularly important means of transportation energy conservation, primarily because current use of bus, bicycle, and rail modes is very small. Therefore, even a significant increase, say a doubling of use, would have very little (perhaps even negative) (17) impact on total energy consumption and might not even be achievable within the 15-year time frame, given the present capacity of vehicle manufacturers to produce rail cars and buses. Diversion of air traffic to more efficient modes would also appear to have minor effectiveness.

Actions such as community-based chauffeur services or trip chaining would appear to be effective in certain environments, as demonstrated in Table 7 (9). In particular, a significant decrease in average trip length and trip rate for shopping and personal business trips might be achievable by combining them with other weekday travel, e.g., trips to work. If a 50 percent decrease could be effected (a very large percentage), the impact on transportation energy savings would be substantial. The numbers in Table 7 refer to percentages of gasoline consumption and not to all transportation energy. This review, of course, does not consider various combinations of actions that might be taken in the form of packages, and taken together might save upwards of 20 percent of transportation energy. Such packages can be constructed for a variety of purposes, such as transportation system management and the Clean Air Act Amendments of 1977, as well as on the basis of good common-sense transportation planning actions. The Voorhees report (14) describes such packages in some detail.

SUMMARY

The energy situation in New York can be characterized as follows:

1. New York's energy supply is concentrated in petroleum; less reliance is on coal and natural gas.
2. New York's foreign-oil dependence is great (72 percent overall); major gasoline and jet fuel suppliers are Africa and the Middle East.
3. Demand is spread evenly through all sectors; transportation, which is entirely petroleum dependent, constitutes 26 percent of demand.
4. Transportation use is concentrated in automobiles, 65 percent; air, 16 percent; and trucking, 10 percent.
5. The greatest share of automobile fuel goes to work travel.
6. Automobile energy use is projected to decline if average automobile efficiency increases by federal standards. Without such increases, trade-offs between energy conservation and growth in mobility are required.
7. The public favors voluntary and incentive actions to conserve transportation energy.
8. Conservation actions that focus on the private automobile are likely to be the most effective.

The New York State Department of Transportation is currently heavily involved in the analysis of transportation energy and is likely to remain so beyond the immediate future. Numerous other studies and reviews could be undertaken at this time; however, the effort to date represents a significant investment of time and effort on the part of the department in this very important subject area. The department intends to use this information for distribution to the various actors engaged in transportation planning and development in New York and elsewhere. The eventual result will be that actions to conserve transportation energy are taken by all responsible parties at all appropriate levels of government. Only through such actions can the general picture of increasing energy consumption in the transportation sector be reversed, and then New York and the nation can move toward energy independence and flexibility.

ACKNOWLEDGMENT

I particularly wish to thank Wilma C. Marhafer and Diane E. Davis for the preparation of this manuscript.

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Publication of this paper sponsored by Committee on New Transportation Systems and Technology.