Tax-base sharing is a potential means of pooling resources and sharing benefits of a regional approach to economic development.
- Unskilled labor and unemployed youth will be a major problem under any set of regional conditions.
- In the coming decade a joint effort by government and the private sector will be required to retrain a labor force.

Following this session, the staff prepared revised policy statements that were mailed to the panel for final review. The panel was also asked to indicate which of the policies could be recommended for the 1982 General Development Plan and which should be the subject of further study.

The final policy recommendations were presented to appropriate subcommittees of the Regional Planning Council for approval before they were included in the General Development Plan.

THE STUDY AND ONGOING PLANNING ACTIVITIES

As was the intent, the scenario exercise delved into concepts and substantive issues that are not usually covered by conventional planning. The most important of these is that the future is not necessarily an extension of the present and that existing programs and policies may not be appropriate for the future. Those concepts and the specific, substantive results of the study depart sharply from the current approach and substance of transportation planning.

Because the study concepts are innovative, they cannot be easily embraced by the conservative, well-established planning procedures and decision-making process. In practice such a change would require major changes in agency work programs that would allow a more flexible agency response to uncertain and constantly changing needs and in the attitude of decision makers to new and controversial policies.

The panel was largely comprised of individuals who will continue to be influential in policy and program development and can be expected to support the methodology and results of the futures project. Their support is essential to any substantial realignment of the planning process or change in transportation decision making. It remains to be seen whether the influence of this group will be sufficient to alter the firmly entrenched practices of the existing planning framework; therefore, the long-term benefits of scenario analysis in this context remain uncertain at this time.

Publication of this paper sponsored by Committee on Energy Conservation and Transportation Demand.

Incorporation of Energy Analysis in the Transportation Improvement Program Process

NATHAN S. ERLBAUM and WILLIAM C. HOLTHOFF

ABSTRACT

The New York State Department of Transportation in cooperation with the Genesee Transportation Council (the metropolitan planning organization of Rochester, New York) studied ways to incorporate energy conservation in urban transportation planning and project decision making. The study evaluated the energy impact of 92 proposed transportation projects, described these findings to local officials, and examined the impact of this information on project selection.

In 1980 the transportation sector used approximately 56 percent of the nation's petroleum, and more than 97 percent of the energy used in transportation was petroleum based. Clearly, reductions in the use of energy by the transportation sector would help reduce the nation's use of petroleum and its dependence on foreign oil.

At the state and local level, limited progress has been made to incorporate concerns about energy into the urban transportation planning and project decision-making process. To investigate ways to increase concerns about energy at this level, the New York State Department of Transportation (NYSDOT) and the Genesee Transportation Council (GTC) (the metropolitan planning organization of Rochester, New York) jointly assessed the energy implications of the proposed 1983-1988 Rochester Transportation Improvement Program (TIP). (TIP is a federally mandated compilation of all transportation projects and expenditures planned for a region.) The purpose of the study was to

1. Determine the energy savings and energy costs (of construction) for all projects to be included in the 1983-1988 TIP.
2. Use these results at various points in the local area's process for setting project priorities.
3. Assess the effectiveness of the procedures, both technical and administrative.

To accomplish these goals, the study group (a) developed analysis tools for those projects for which current methods are weak or are not available; (b) monitored key energy-use and travel indices for the Rochester area; and (e) sketched future energy use in the area, accounting for the long-range plan, changes in car efficiency, employment, and population.

BACKGROUND

The Rochester, New York, metropolitan area is situated on Lake Ontario in western New York State. The area contains 1,085,000 people and 381,400 households and is basically circular shaped and focused on a strong downtown. The employment base is broad and oriented toward high technology.

Transportation planning in Rochester has followed a traditional pattern. Presently planning is conducted by a number of separate agencies, including the state DOT, GTC staff, the City of Rochester, Monroe County, the Rochester-Genesee Regional Transportation Authority, the Genesee-Finger Lakes Regional Planning Council, town planning boards, and so forth. Each of these agencies has a particular role in the overall process that is basically related to specific transportation facilities.

Smaller-scale projects usually follow a 3-year process that involves planning (alternatives analysis and consideration of all appropriate issues), design, and implementation. These are usually done by a single implementing agency, the one responsible for the system being studied. Larger-scale projects involve more participants throughout the entire process. Many require an environmental assessment and take 5 to 10 years to complete. The reduction in available funding in recent years has led to an increase in the number of short-range (1 to 5 year) solutions to transportation system problems. Funding has been spent more on rehabilitation and preservation of the existing system than on major expansion.

In evaluating projects, each agency follows the same basic steps:

1. Identify transportation problems. Establish system goals, define problem types, and monitor the transportation system or problem locations.
2. Rank problem sites. All the problem sites identified are ranked by priority, regardless of the type of problem.
3. Develop alternatives. For each problem, a number of alternative solutions, including the null, are identified.
4. Select the preferred alternative for each problem site. This is primarily based on economic efficiency or related factors.
5. Rank proposed projects in terms of priority. All selected projects are ranked by priority.
6. Apply funding constraints. Select those projects that best achieve area goals within the available budget.
7. Produce a final capital program (or TIP), organizing projects by funding category, along with more detailed narrative descriptions.
8. Implement the project. The capital project is constructed or acquired.

PLANNING

Energy planning in the Rochester area has taken the form of a series of responses to perceived crises in the availability of energy. At present, emergency energy planning focuses on the ability of the Rochester transit system to respond to an energy emergency by scheduling supervision and deploying radio-directed vehicles. The completion of the energy element of the Monroe County Comprehensive Plan is expected by mid-1983. Overall the planning process in Rochester is modally partitioned, project oriented, and well structured institutionally. In this regard it parallels the process in many other metropolitan areas.

METHODS

Based on past TIPs, a list was prepared of possible projects that implementers might propose for inclusion in the GTC 1983 to 1988 TIP. The projects listed were not only those required by federal regulations to be included in an approved TIP but also all projects in the GTC planning area that were expected to be programmed for implementation between 1983 and 1988. These additional projects are included in the GTC TIP for information purposes and to present a more complete picture of planned transportation improvements in the area. Basically, all projects contain the following components for which an energy evaluation may be necessary:

1. Vehicle or User
   - Traffic. The energy associated with changes in traffic flow speed, detours, improvements in capacity of the roadway, and so forth that change the way a vehicle is driven on, or in proximity to, the project location.
   - Pavement. The energy associated with vehicle operation that results from improvements to the pavement wearing surface or changes in speed that result from such surface changes.
2. Construction
   - Highway. The energy associated with construction activities related to the construction or rehabilitation of the roadway.
   - Structure. The energy associated with construction activities related to the rehabilitation of structural components (e.g., bridges and culverts).

The following sections describe more specifically the methods for each of these component- and project-type evaluations.

Vehicle or User Energy

Vehicle energy consumption was evaluated by the following dimensional relationship:

$$\text{Energy} = \text{AADT} \times \text{project length} \times \text{dpy} \times \Sigma_i \text{ vehicle type}_i \times \text{gpm}_i$$

where

AADT = annual average daily traffic;
Vehicle type_i = share of automobile, light trucks, heavy trucks (i = 1,2,3);
gpm_i = gallons per mile for each vehicle type, adjusted for the efficiency improvements for the model and year of the vehicle, speed and flow condition (free flow or stop-and-go), and grade;
Project Length = length of the project in miles; and
dpy = days per year (330 or 365).

Construction Energy

Estimates of energy used for roadway, structural, and other construction-related components were converted into equivalent gallons of gasoline by

1. Adjusting the component cost estimate to 1980 dollars, using the gross national product (GNP) implicit price deflator;
2. Multiplying the 1980 cost estimate by the appropriate construction action conversion factor [in British thermal units (Btu) per dollar] (1-4);
3. Dividing the Btu's obtained in Step 2 by 125,000 to convert the energy into equivalent gallons of gasoline; and
4. Dividing the component energy consumption by the corresponding service life to obtain annual energy estimates.

The energy analysis methods used for each of the project types contained in the GTC TIP are summarized in the three sections that follow.

Pavement Projects

The computations for vehicle energy were similar to those noted previously. Improvements to a pavement's structural condition may affect automotive fuel consumption in two additional ways:

1. Directly, through improved smoothness, which reduces rolling friction and variation in vehicle operation and
2. Indirectly, through a change in vehicle speed.

Existing literature is not definitive on the magnitude of the impact of road conditions on fuel consumption. The values range from a 30 percent increase in fuel consumption for a very rough, potholed road compared with a smooth pavement (5) to no change (6); it is believed that the latter finding was due to a defect in the design of the experiment. Currently the accepted value is a 1.5 percent increase in fuel consumption for a road rated at a pavement service rating (PSR) of 4.5 compared with a rating of 1.5.

Both changes are small; however, the change in fuel consumption that is attributable to smoothness is consistent over the whole range of PSRs (i.e., as condition improves fuel consumption drops). The change in fuel consumption that is attributable to speed has a saddle point between 25 and 35 mph (depending on the vehicle mix). Fuel consumption increases with improving pavement condition for speeds higher than the saddle point and decreases with improving condition for speeds below the saddle point. These peculiarities are due to the shape of the fuel consumption-versus-speed curve shown in Figure 1.

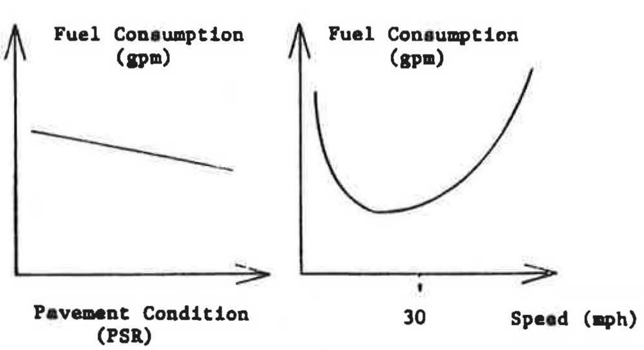

FIGURE 1 The effects of pavement condition and roadway speed on fuel consumption.

Construction components of pavement projects are evaluated as described earlier by selecting the appropriate Btu-per-dollar factor for each of the pavement actions undertaken.

Bridge Projects

Computations for vehicle energy were similar to those already noted. However, because the possibility exists that the bridge might have to be closed if unattended in its present condition, a more specific analysis was used to assess the change in energy used by vehicles during total or modified bridge closings.

1. AADT was separated into the three major vehicle components (cars, light trucks, and heavy trucks).
2. The energy impact of a total or partial vehicle detour due to a bridge closing or posting was calculated for each vehicle type as the product of the AADT x gpm x miles x days per year with respect to travel speed, flow condition, and model year efficiency improvements.
3. Geometric limitations on the bridge or its approaches often require a reduction in speed to cross the bridge or, if there is a detour, the alternate route may have a different speed. These effects are evaluated by determining the change in speed and the corresponding change in fuel consumption times the AADT for the types of vehicles affected.

Construction of the pavement and bridge portions of bridge projects is also evaluated as described earlier by selecting the appropriate Btu-per-dollar factor for each action.

TSM, Safety, and Other Projects

Construction and user impacts were computed using various methods depending on the actions undertaken. Because most of the transportation system management (TSM) projects analyzed dealt with traffic flow conditions and reducing delay, the vehicle energy computations noted previously are applicable. [Worksheets and other computation aids are documented elsewhere (7-11).]

Transit Vehicles

Transit vehicle acquisition projects result from the scheduled replacement cycle for these vehicles. The potential savings, if any, result from improvements in vehicular energy consumption. The energy consumption of both the replacement vehicles and the vehicles presently in service may each be computed, using the following dimensional relationship:

Energy = vehicles x annual mileage/mpg

Differences in vehicle efficiency (mpg) and annual mileage may work together or against each other to provide fuel savings or increases for a given vehicle replacement.

The resultant energy impact of each project was calculated, packaged along with other information concerning the project, and presented to each of the implementing agencies for use in either the internal project selection program or as part of the GTC TIP programming deliberations.

FINDINGS

The 1983-1988 GTC TIP contained 92 projects for which an energy assessment was undertaken. Figures

2-6 show these 92 projects by type, jurisdictional responsibility, and funding source. Most project types were improvements or repairs to deficiencies in the existing highway system. The transit projects represent normal scheduled replacement of vehicles, based on existing NYSDOT and UMTA performance standards and the specifications for those vehicles. Projects under the jurisdiction of New York State include all projects funded with federal dollars, as well as those using 100 percent state funds. Unlike local projects, which focus primarily on pavement rehabilitation, most New York State projects are for bridge rehabilitation. The remaining projects are

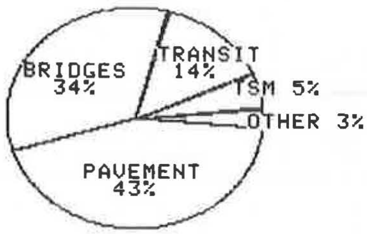

FIGURE 2 Types of projects.

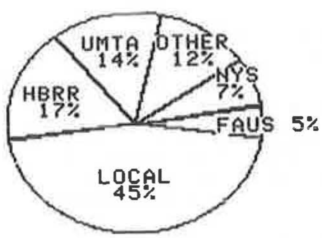

FIGURE 3 Category of funding for projects.

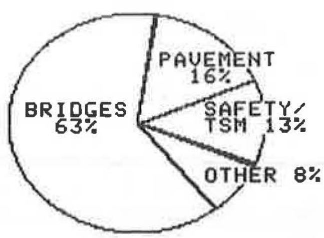

FIGURE 4 Projects for New York State jurisdiction.

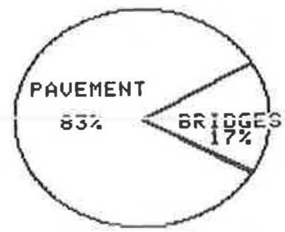

FIGURE 5 Projects for local jurisdictions.

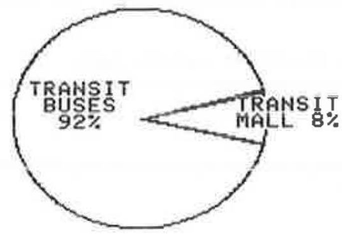

FIGURE 6 Projects for transit authority jurisdictions.

TABLE 1 Energy Analysis Findings

	Change in Average Annual Gallons (millions)
User energy	-5.9
Construction energy	2.1
Net energy	-3.8
1980 regional transportation network fuel consumption (millions of gallons)	293.2
Net energy improvement (%)	1.3
Project dollars ($1981)	198.9
Overall payback period (yr)	5.9

Note: Total number of projects is 92. Negative values imply savings.

TABLE 2 Findings of Energy Analysis Based on Project Type

			Total Annual Equivalent Gallons (000)				
Project Type	Service Life (yr)	No. of Projects	Vehicle or User	Construction	Net	Total Project Construction Energy (gal, 000)	Average Cost ($1981, millions)
Bridge	30	31	-7,272.0	528.3	-6,743.7	13,233	2.478
Pavement[e]	10	38	46.5	928.9	975.4	9,805	1.452
Speed			109.6				
Surface			-63.1				
Safety and TSM	15	5	-236.6	167.6	-69.0	2,323	3.809
New construction	30	1	1,667.5	347.3	2,014.8	7,303	17.557
Drainage	20	1	-1.3	0.1	-1.2	2	0.080
Other[f]	14.7	1	-51.4	87.5	36.1	1,674	11.511
Transit vehicle mini buses	4	33 (10)[g]	1.1	23.4	24.5	94	0.034
Standard buses	12	19 (2)[g]	20.4	13.0	33.4	156	0.163
Transit mall	30	1	-27.8	5.5	-22.3	165	11.167
All project types		92	-5,903.7[h]	2,137.2[h]	-3,766.5[h]	34,755	

Note: Negative numbers denote energy savings.

[a]Δ = difference between proposed and null alternatives.

[b]Ratios are based on the differences noted under average annual gallons.

[c]Vehicle gallons divided by construction gallons.

[d]Total project construction energy divided by annual vehicle energy.

split between correcting pavement and safety-related defects.

Local projects are primarily paving projects on the local highway system that are paid for with local funds, whereas projects proposed by New York State are primarily bridge projects that are on the federal-aid or state highway system and are generally eligible for funding from one of several federal funding sources.

The findings for all projects analyzed are summarized in Table 1. Tables 2 and 3 give summaries of the energy assessments by project type and funding category, respectively. The energy assessments described in these tables are based on the measured energy difference, or change, between the proposed project alternative and the expected null, or existing, situation. Three points should be noted when evaluating the results: (a) project type descriptions (Table 2) represent aggregated categories; (b) although there are 10 distinct funding categories (Table 3), several projects may be funded by more than one category of funds; and (c) negative numbers in Tables 1-3 represent reductions in energy use (i.e., energy savings resulting from the projects). Positive numbers represent increases in energy use (or energy losses resulting from the projects).

The general findings are as follows:

1. Projects proposed for implementation during the next 5-year period, as given in Table 1, have the potential for conserving 3.8 million gallons of gasoline annually; this is about 1.3 percent of the 293.2 million gallons of gasoline consumed on the transportation network for the region in 1980.

2. Bridge projects offer the greatest potential for energy conservation. This is due primarily to eliminating both traffic detours for bridge closings and rerouting for load limits and secondarily to improvements in flow over the structure.

3. For pavement projects, energy savings due to improvements in the pavement surface are frequently offset by increases in fuel consumption caused by increased operating speeds (Figure 1) and increased capacity gained by widening the road or improvements to the shoulder. The energy savings from surface replacement are almost always insufficient to offset the cost of the energy required to replace the pavement surface.

4. Safety and TSM projects offer the second greatest potential for energy conservation by improving traffic flow and reducing vehicle delay.

5. Purchases of transit vehicles usually increase energy use because although it is desirable to obtain more fuel-efficient replacement buses, other requirements and criteria may preclude this.

6. On the average, those projects that save energy will provide a payback of the total energy used in construction in less than 7 years in the form of annual vehicle energy savings.

7. Funding category is not indicative of energy conservation. Funding categories comprised of a significant number of bridge projects, and to a lesser extent safety and TSM projects, offer greater conservation potential.

LONG-RANGE ASSESSMENT

Energy consumed by travel on the highway system in the Rochester area is expected to change over time because of increasing vehicle efficiency, highway network improvements, and expected growth in traffic due to growth in the region. The New York State traffic simulation model was used to help determine the effect of these changes. Three separate assessments were analyzed to measure effects of both highway improvements and growth on changes in fuel consumption. The results of these three assessments are shown in Figure 7 and Table 4.

The following conclusions can be drawn from the long-range energy assessment:

1. The expected improvements in vehicle fuel efficiency between 1980 and 2000 could reduce annual highway system fuel consumption 85.7 million gallons by 1990 (29.2 percent of 1980 fuel consumption) and an additional 7.6 million gallons (2.6 percent of 1980 fuel use) by 2000. Fuel consumption between 1980 and 2000 would be reduced by 93.3 million gallons (31.8 percent).

2. The effects of traffic growth in the region would result in a fuel consumption increase of 60.4 million gallons (20.6 percent) of 1980 fuel consumption) between 1980 and 1990.

3. The net effect of these two changes could result in the saving of 25.3 million gallons by 1990 (8.6 percent of 1980 fuel consumption) and an additional savings of 9.6 million gallons (3.3 percent of 1980 fuel consumption) by 2000. The total saving

Average Traffic (AADT)	Δ[a] Average Annual Equivalent Gallons (000) Vehicle or User	Construction	Net	Net Gallon per Project Dollar[b]	Net Gallon per 1,000 vehicle[b]	Energy Benefit/Cost[b,c]	Payback Period (yr)[d]
13,680	-234.6	17.1	-217.5	-0.08	-48.2	-13.8	1.8
8,472	1.2	24.4	25.6	0.02	9.2	0.05	-
	2.9						
	-1.7						
13,056	-47.3	33.5	-13.8	-0.004	-3.2	-1.4	9.8
19,160	1,667.5	347.3	2,014.8	0.11	318.7	4.8	-
13,700	-1.3	0.1	-1.2	-0.01	-0.3	-9.7	2.0
54,100	-51.4	87.5	36.1	-0.003	2.0	-0.6	-32.6
-	0.033	0.710	0.743	0.022	-	0.046	-
-	1.076	0.683	1.759	0.011	-	1.576	-
-	-27.8	5.5	-22.3	0.002	-	-5.1	5.9

[e]40 projects were analyzed; however, 2 have been deleted as they are atypical and distort the vehicle energy values for this category.

[f]This project is atypical as portions of it could be categorized as bridge pavement or new construction.

[g]Number of projects.

[h]Totals include all 92 projects analyzed (see footnote e).

TABLE 3 Findings of Energy Analysis Based on Funding Source

Funding	No. of Projects	Total Annual Equivalent Gallons (000): Vehicle or User	Construction	Net	Total Project Construction Energy (gal, 000)	Average Cost ($1981, millions)
100% NYS[d]	6	-7.1	93.3	86.2	1,213	1.267
Highway bridge reconstruction	16	-3,905.5	196.8	-3,708.7	5,257	2.030
Federal-aid primary rural	2	-48.4	49.3	0.9	531	2.301
Federal-aid primary urban	1	1,667.5	347.3	2,014.8	7,303	17.557
Federal-aid urban system	5	-1,430.5	182.1	-1,248.4	2,435	3.786
Urban Interstate	3	-494.3	266.1	-228.2	6,675	12.787
UMTA[e]	13	-6.3	41.9	35.6	165[f] (414)	1.184
Interstate 4-R funds	1	-	70.2	70.2	1,104	6.867
Highway bridge reconstruction + Federal-aid urban system	3	-347.1	17.5	-329.6	468	0.910
100% local[h]	41	-1,325.3	867.2	-458.1	9,249	1.296
Hazard elimination and safety	1	-6.9	5.6	-1.3	105	1.200
All funding categories	92	-5,903.7	2,137.3	-3,766.6		

Note: For definitions of funding categories, see Section IV of "Incorporating Energy Analysis in the Transportation Improvement Process," FHWA, UMTA, U.S. Department of Transportation; U.S. Department of Energy, July 1984. Negative numbers refer to energy savings.

[a]Δ = Difference between proposed and null alternatives.

[b]Ratios are based on the differences noted under average annual gallons.

[c]Vehicle gallons divided by construction gallons.

by 2000 would be 34.9 million gallons (11.9 percent of 1980 fuel consumption).

4. The highway improvements to the transportation system contained in the 1990 GTC Transportation Plan could result in a savings of approximately 3.2 million gallons by 1990 (1.1 percent of 1980 fuel consumption).

The completion of the projects contained in the 1983-1988 TIP and 1990 GTC Transportation Plan could result in a reduction of vehicle or user energy requirements in the Rochester area of approximately

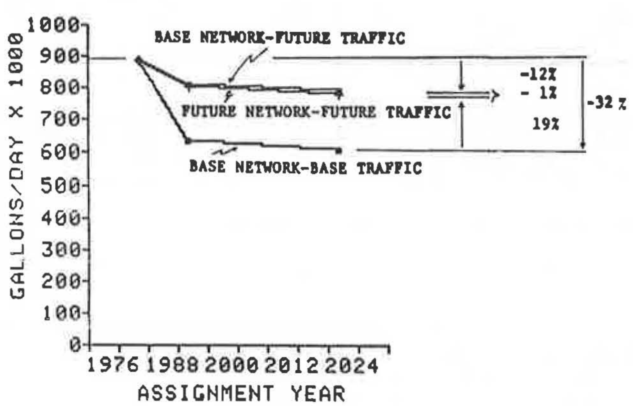

FIGURE 7 Long-range assessment.

9.1 million gallons (3.1 percent of 1980 fuel use) per year by 1990. This would be comprised of 3.2 million gallons from improvements in the 1990 plan and an additional 5.9 million gallons from TIP projects (Table 1) not already included in the network analysis of the 1990 plan. This assessment of vehicle or user energy, however, must be reduced by the capital energy costs for construction, which will offset some of the expected savings. The resultant annual construction energy expenditure would be approximately 2.4 million gallons per year.

Taking both the expected vehicle (user) energy savings and the estimate for the construction energy requirements into consideration, an overall net savings of approximately 6.7 million gallons of fuel per year (2.3 percent of 1980 fuel consumption) can be expected by 1990. When the effects of improved vehicle efficiency and increases in travel are accounted for, the total savings are 25.3 (Table 4) + 6.7 or 32.0 million gallons (10.9 percent of 1980 fuel consumption). The energy savings attributed to vehicle turnover still overshadow savings resulting from planned transportation improvements.

Based on this long-range energy assessment of improvements to the Rochester area highway system and the detailed energy assessment of the various projects included on the 1983-1988 TIP for implementation during that period, the following observations were made:

- Projects proposed for inclusion in the 1983-1988 TIP will assist (moderately) in making

TABLE 4 Network Traffic Assessments, Estimated Gallons per Year (millions)

	Assessment 1		Assessment 2		Assessment 3	
Year	Base Network Base Traffic	Change from Previous Period	Base Network Future Traffic	Change from Previous Period	Future Network Future Traffic	Change from Previous Period
1980	293.2	-	293.2	-	293.2	-
1990	207.5	85.7 (-29.2)[a]	267.9	25.3 (-8.6)[a]	264.7	28.5 (-9.7)[a]
2000	199.9	7.6 (-3.7)	258.3	9.6 (-3.6)	255.2	9.5 (-3.6)
Total change from 1980		93.3 (-31.8)		34.9 (-11.9)		38.0 (-13.0)

Note: Numbers may not add due to rounding.

[a]Percentages are shown in parentheses; negative values imply savings.

Average Traffic (AADT)	Δ[a] Average Annual Equivalent Gallons (000)			Net Gallon per Project Dollar[b]	Net Gallon per 1,000 Vehicle[b]	Energy Benefit/Cost[b,c]	Payback Period (yr)[d]
	Vehicle or User	Construction	Net				
5,646	-1.2	15.6	14.4	0.01	7.7	-0.03	170.5
6,710	-244.1	12.3	-231.8	-0.11	-104.7	-19.8	1.3
13,850	-24.2	24.6	0.4	0.0002	0.10	- 1.0	11.0
19,160	1,667.5	347.3	2,014.8	0.11	0.32	4.8	-
47,920	-286.1	36.4	-249.7	-0.07	-40.4	-7.9	1.7
79,867	-164.8	88.7	-76.1	-0.006	-2.9	-1.9	13.5
-	-0.5	3.2	2.7	0.002	-	-0.15	5.9[g]
-	-	70.2	70.2	0.01	-	-	-
14,420	-115.7	5.8	-109.8	0.12	-23.1	-19.8	1.4
8,410	-32.3	21.2	-11.2	-0.009	-4.0	-1.5	7.0
14,000	-6.9	5.6	-1.3	-0.001	-0.3	-1.2	15.2

[d]Total project construction energy divided by annual vehicle energy.
[e]The project types contained in this category are dissimilar and severely distort these values.
[f]The 13 projects include 52 buses and 1 transit mall.
[g]Payback period shown is for transit mall only.
[h]Same as footnote[e]; here 7 bridge projects are providing the savings to offset the 34 pavement projects.

progress toward the goal of reducing energy consumption.

- Improvements in vehicle operating efficiency brought about by the public buying new vehicles will alter energy consumption much more significantly than capital investments to improve or maintain the infrastructure.
- Savings due to improvements in vehicle efficiency are likely to be 12 times greater than the net savings from combined network and specific project improvements expected to be in place by 1990.

OBSERVATIONS ON INSTITUTIONAL ELEMENTS

Agency views on the usefulness and appropriateness of the project energy analysis were obtained by means of a series of meetings and questionnaires. Agencies were first asked whether they collected similar energy impact information for their project development process, whether the provided information was used, and, if so, how. They were also asked about instances in which the information was not useful because of such issues as the inappropriateness of the timing or form of the information. Each agency described the effect the information had on both the selection of individual projects and on the capital programming process as a whole and also identified specific points in the process where the information presented would be most effective.

The major results of the meetings held to discuss the energy impact information generated for projects listed in the TIP and sent to project implementers are summarized below. The reader should note that almost all of the projects examined had a positive energy impact, with an energy payback of less than 7 years. Most agencies viewed these results as supporting their previous decisions.

1. In general, energy information is more useful for larger-scale highway projects, which involve a number of location and design alternatives. In most cases energy information is developed currently when appropriate.

2. For medium- or small-scale rehabilitation and preservation, and safety and bridge projects, project energy information was judged generally not to have any bearing on the decision as to whether to fund a project.

3. For TOPICS- or TSM-type projects, the use of energy impact information as a basis for decision making is good in theory, but the reality is that in many cases these projects expand to include such additional components as moving or replacing utilities, so costs could easily expand to exceed the original energy benefits of the project.

4. Although energy information is useful in some cases at the TIP stage, it would be more useful in evaluating possible future actions at the system level and in selecting methods and materials in project design.

5. Decisions as to whether to purchase new vehicles for transit projects are based generally on the age and fleet-size standards of the transit industry and energy impact information for new vehicles is irrelevant. Energy considerations are most useful in decisions concerning vehicle options such as air-conditioning.

6. Project information might have been more useful if it had been presented at different stages in the project development process. Two possible points in the process that were identified are the policy planning stage and the project design and implementation stage.

CONCLUSION

A major finding of the study was that for medium- and small-scale roadway projects the energy impact data were not generally relevant to the decision to implement the projects. This result might be expected because almost all projects examined were found to save energy with an average payback period of less than 7 years. Several factors generally account for this result.

The first factor is the relationship between project energy benefits in general and between energy consumption and construction costs in dollars. User costs usually increase with increased congestion and with increased operating costs, both of which are positively correlated with energy use. For construction, the methods and materials used have dollar costs that correlate positively with energy costs.

The second factor is that many financial and institutional considerations surround project selection. Projects selected for inclusion in the TIP generally are designed to be the best solutions of the most serious problems in the region (and frequently the most energy efficient). The projects developed and proposed are also designed to make maximum use of outside resources. For such projects, energy concerns are not likely to be decisive; thus, few decisions to reject a project are made at the TIP stage.

The third factor is that the additional information on the energy impacts of each of these projects generally enhanced their acceptance. However, although the use of the materials often served to highlight the energy savings of proposed transportation projects it also tended to overemphasize the importance of energy savings relative to other factors.

Finally, because most of the projects already saved energy, the overall conclusion of this study was that no decisions were changed solely because of the energy impact information provided. It is the belief of the authors that when this type of energy impact information is incorporated into the TIP process on a regular basis and is presented along with other impact data, it may be more useful.

ACKNOWLEDGMENTS

This study was supported by the Federal Highway Administration, Urban Mass Transportation Administration and the U.S. Department of Energy. The authors thank the following individuals for their assistance with this project: Janis M. Gross, NYSDOT; Jeffrey Nidetz, GTC; Robert Tylock, Michael Meyer, and Robert Slaver, NYSDOT Region 4; George Stamm, City of Rochester, Department of Engineering; Scott Leathersich, County of Monroe, Department of Public Works; William Evans, R-GRTA; William Sage, County of Ontario, Highway Department; and Doug Spring and other NYSDOT main office staff. The authors also thank Tammy Zitzmann, Charron Many, Tedi Toca, Sue Carbone, and Karen DeLaney for their assistance in the preparation of the manuscript.

REFERENCES

1. J.A. Apostolos, W.R. Shoemaker, and E.C. Shirley. Energy and Transportation Systems. California Department of Transportation, Sacramento, Dec. 1978.
2. J.A. Epps, D.N. Little, R.J. Holmgreen, and R.L. Terrel. Guidelines for Recycling Pavement Materials. NCHRP Report 224. TRB, National Research Council, Washington, D.C., Sept. 1980.
3. J.A. Epps, C.E. Caltrider, P.E. Cunningham, and D.L. Morgan. Energy Requirements Associated with Highway Maintenance and Rehabilitation. In Transportation Research Record 674, TRB, National Research Council, Washington, D.C., 1978, pp. 31-36.
4. J.A. Epps and F.N. Finn. Energy Requirements Associated with Pavement Construction, Rehabilitation, and Maintenance. Research Report 214-19. Texas Transportation Institute, Texas A&M University, College Station, Aug. 1980.
5. P. Claffey. Running Costs of Motor Vehicles as Affected by Road Design and Traffic. NCHRP Report 111. TRB, National Research Council, Washington, D.C., 1971.
6. J.P. Zaniewski, G.E. Elkins, B.C. Butler, M.S. Paggi, G. Cunningham, and R. Machemehl. Vehicle Operating Costs, Fuel Consumption and Pavement Type Condition Factors. FHWA, U.S. Department of Transportation, June 1982.
7. N. Erlbaum, D. Boyle, and S. Kupferman. Project Level Energy Costs for Transportation Actions. Preliminary Research Report 203. New York State Department of Transportation, Albany, Oct. 1981.
8. D. Boyle, J. Trombly, and S. Kupferman. Energy Impacts of Transportation Systems Management Actions. Office of Planning Assistance, UMTA, U.S. Department of Transportation, Oct. 1981.
9. J.M. Gross, D.K. Boyle, G.S. Cohen, N.S. Erlbaum, M.A. Kocis, and K.W.P. Koeppel. Energy Impacts of Transportation Systems Management Actions in New York State, 1978-1980. Preliminary Research Report 151. New York State Department of Transportation, Albany, May 1979.
10. G.S. Cohen. TSM Actions: A Study of the Energy Costs. Preliminary Research Report 155. New York State Department of Transportation, Albany, June 1979.
11. Energy Saving Traffic Operations Project Guide. Illinois Department of Transportation, Springfield, May 1981.

Publication of this paper sponsored by Committee on Energy Conservation and Transportation Demand.