COST-EFFECTIVENESS ANALYSIS OF TVA EMPLOYEE TRANSPORTATION INCENTIVE PROGRAM

Federal Energy Administration

Office of Conservation

State Energy Conservation Programs

May 1977

FEA/D-77/297

Introduction

The traditional approach in transportation planning has been to increase the supply of transportation facilities and services to match the growing levels of travel demand. Recent events and trends, such as the energy crisis and the fiscal constraints faced by public agencies in financing capital improvement projects, have led to the reexamination of the traditional planning approach. Today a greater emphasis is being given to transportation alternatives that can respond to the immediate travel needs and achieve a greater utilization of the facilities and services already available to a community. Promoting the use of high occupancy vehicles, such as buses and vans, while simultaneously increasing the occupancy of private automobiles are examples of such alternatives.

Many community-wide demonstration projects on carpools and vanpools, sponsored by public agencies, have been implemented across the country, and in addition there are several rideshare programs that were developed and supported by private employers for their own employees. One of the employer-based programs, which has received national attention, is the Commuter Pooling Demonstration Program of the Tennessee Valley Authority (TVA) in Knoxville, Tennessee. Although these programs have been apparently successful, there is a lack of readily accessible data on their benefits and costs. With an increased interest in rideshare programs, questions are being raised on the effectiveness of the implemented programs, and it is appropriate to develop the needed information. The objective of this report is to quantify the benefits and costs and identify the nonquantifiable implications of TVA's employee rideshare program in Knoxville.

Program Development

The commuter rideshare program in Knoxville evolved gradually over the past three to four years (1973 to 1977). Prior to the inception of express buses and vanpools, TVA employees participated in ridesharing primarily in the form of carpooling and to a lesser extent through the use of regular bus service. The first proposal for an express bus was brought up at a citizens' meeting in West Knoxville with city traffic engineers and planners. The citizens were concerned with the traffic congestion on I-40 and the sole reliance being placed on the automobile to meet all current and future needs in the corridor. The citizens' group represented an area that had a large concentration of TVA employees and the group seriously pursued the proposal for an express bus.

A commuter express bus was initiated in Knoxville on December 3rd, 1973 and was highly successful. Joint efforts between the city administration and TVA employees proved effective in promoting ridesharing and by the end of 1974, there were a total of ten express buses and six vanpools, all of which were serving primarily TVA employees.

A major change in the rideshare program occurred in January, 1975 with the initiation of TVA's incentive program, which was called the Commuter Pooling Demonstration Program. This incentive plan called for:

1. A one-third discount on commuter bus tickets.
2. Issuance of a $5 monthly municipal parking ticket to each bona fide carpool. (A carpool for this purpose was defined as a group of three or more riders with at least two being TVA employees.)
3. Credit to vanpool accounts of $3 per month for each TVA employee participating in vanpooling.
4. Reimbursement to handicapped employees for the direct cost of parking in a commercial lot convenient to their place of work.

The impact of the incentive program was significant. There was an immediate reduction of 12 percent in the number of TVA employees driving alone to work and

the number of express bus and vanpool riders continued to increase. Two private bus operators had to be utilized in addition to Knoxville Transit Corporation (KTC) to meet the increased need for express bus service during peak hours. By January, 1977, there were 23 express buses -- 13 public and 10 private -- and 18 vanpools serving the TVA employees. A detailed account of the development of TVA employee rideshare program and related activities in Knoxville is given in a recent article by Stokey, Stanley R., et.al. (1).

Stages of Development

There are three stages of the development of TVA's rideshare program which are significant for the purpose of comparison and evaluation. The first stage is represented by the rideshare status that existed during November, 1973, when there were no express buses and vanpools. The second stage began with the introduction of express buses and vanpools which were encouraged by TVA but without any formal incentives. The status of ridesharing during December, 1974 represents the last observation prior to the initiation of the incentive program in January, 1975. Since that date, the magnitude of ridesharing has increased continuously and only recently has begun to level off. The current level of ridesharing can be represented by the usage of ridesharing modes during January, 1977. The modal distribution of TVA employees during the key time periods are shown in Table 1. The benefit/cost analyses will be based on a comparison of the modal usage patterns of the two time periods, November, 1973 (prior to any organized ridesharing), and December, 1974 (prior to the incentive program), respectively, with that of January, 1977.

Table 1. Modal Usage Patterns of TVA Employees

Mode of Transportation	Percent of Work Force			
	Nov., 1973	Dec., 1974	Jan., 1975	Jan., 1977
Drive Alone	65.0	42.0	30.0	18.0
Regular Bus	3.5	3.0	5.0	3.0
Express Bus	0.0	11.0	18.0	28.0
Carpool	30.0	40.0	42.0	41.0
Vanpool	0.0	2.3	3.0	7.0
Bike, Walk etc.	1.5	1.7	2.0	3.0
Total Work Force	2,950	3,000	3,100	3,400
No. of Express Buses	0	10	12	23
No. of Vans	0	6	6	18

Impact on Vehicles Used for Commuting and Employer's Benefits

One of the direct impacts of TVA's rideshare program is the reduction in the number of vehicles used by the employees to commute to work, which had several implications from the standpoint of the employer, employees and the community. In this section, the actual number of vehicles eliminated from commuting is estimated and the resulting benefits accruing to the employer are quantified.

Number of Automobile/Vans Eliminated

The actual number of automobiles and vans utilized by TVA employees was estimated for three time periods -- November, 1973, December, 1974 and January, 1977 as shown in Table 2. The estimates of vehicles for each time period are based on the number of persons employed during the respective time period. Table 2 clearly indicates that in spite of increasing employment at TVA, ridesharing has led to the removal of a substantial number of vehicles from the roadway and a reduction in the demand for all-day parking in downtown Knoxville. In comparison with the situation in 1973, TVA employees now require 1129 fewer parking spaces, while employment has risen by 450 persons. Since the beginning of the commuter pooling demonstration program, the reduction in the demand for spaces is 575 even when the employment increased by 400 persons.

A more meaningful approach is to compare the automobiles and vans needed for commuting for a common employment level. Table 3 shows the estimated numbers of commuting vehicles required for the current level of employment of 3,400 with different modal usage patterns. A comparison of the projected estimates with the current situation reveals clearly the magnitude of the impact of ridesharing. Without any express bus and vanpooling and with TVA's employment rising to 3,400, an additional 1463 parking spaces would have been needed in the downtown area. With the level of ridesharing just prior to the incentive program projected to January, 1977, the additional parking spaces required would have been 793.

Table 2. Automobile and Vans Utilized for Commuting at Different Time Periods

Mode of Transportation	November, 1973		December, 1974		January, 1977	
	Employees	Auto/Van	Employees	Auto/Van	Employees	Auto/Van
Drive Alone	1,918	1,918	1,260	1,260	612	612
Regular Bus	103	--	90	--	102	--
Express Bus	0	--	330	--	952	--
Carpool[1]	885	277	1,200	375	1,394	436
Vanpool	0	--	69	6	238	18
Bike, Walk, etc.	44	--	51	--	102	--
Total	2,950	2,195	3,000	1,641	3,400	1,066

[1]Average occupancy of carpools of TVA employees is 3.2

Table 3. Estimated Number of Automobiles and Vans for Commuting at Different Modal Usage Patterns at Current Level of Employment

Mode of Transportation	At Modal Usage of November, 1973		At Modal Usage of December, 1974		At Modal Usage of January, 1977	
	Employees	Auto/Van	Employees	Auto/Van	Employees	Auto/Van
Drive Alone	2,210	2,210	1,428	1,428	612	612
Regular Bus	119	--	102	--	102	--
Express Bus	0	--	374	--	952	--
Carpool[1]	1,020	319	1,360	425	1,394	436
Vanpool	0	--	78	6	238	18
Bike, Walk, etc.	51	--	58	--	102	--
	3,400	2,529	3,400	1,859	3,400	1,066

Difference = 793

Difference = 1,463

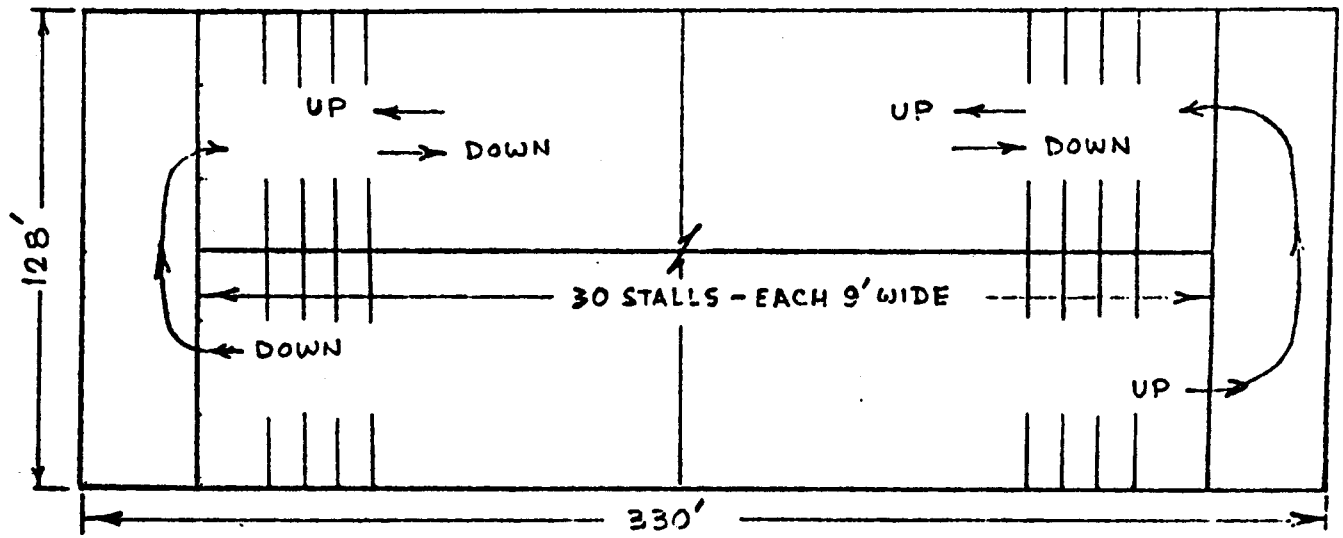
[1]Average occupancy of carpools of TVA employees is 3.2.

Employer's Benefits Due to the Reduction in Parking Needs

Automobile parking in the downtown area of Knoxville always has been a problem. The parking supply in this area consists primarily of small surface lots, which have been decreasing in number due to the construction of new office buildings. The only parking garage in the area is located at the new Civic Auditorium/Coliseum complex, which is not within easy walking distance to the center of downtown. The parking situation grew worse in recent years as several major developments -- TVA office complex, United American Bank highrise building and City-County Building -- eliminated about 1,500 parking spaces.

For years, TVA employee unions were trying to negotiate parking for employees, and their case was made stronger when it was evident that the new twin towers office complex for TVA alone would remove more than 1,000 parking spaces. There were two alternatives that were given serious consideration: 1) building parking garages for the employees and 2) providing a public transportation oriented solution with the employer subsidizing a part of the cost. The probable cost of the first alternative, TVA's building and operating parking garages for the employees, can be analyzed at two levels of automobile usage -- the modal usage patterns of November, 1973 and December, 1974. As it was estimated in the previous section, if the modal usage of 1973 prevailed, there would be a need for 1463 additional parking spaces today at the current level of employment, and the number of additional spaces required would be 793 if the modal usage pattern of 1974 continued to hold.

The cost of TVA's providing employee parking was estimated based on a typical design for a parking garage shown in Figure 1. The detailed cost calculations and a summary of costs are presented below:



TOTAL NUMBER OF STALLS IN EACH FLOOR = 120

Figure 1: Typical Floor Plan of a Parking Garage
(Sloping Floor Design)

Cost of Providing 1,463 Parking Spaces :

1. Number of Stalls Needed = 1,463

2. Number of Floors = $\frac{1,463}{120}$ = 12
   Need 2 garages with 6 floors each

3. Land Area Required = 2 parcels of 330' x 128' area
   = 84,480 sq. ft. (≈ 2 acres)

4. Initial Cost of Land = 84,480 sq. ft. x $20.00 per sq. ft.[1]
   = $1,689,600

5. Initial Cost of Construction of Structure = 1,463 spaces x $3,500 per stall[2]
   = $5,120,500

6. Annual Cost for Land (@ 8% annual interest rate and perpetual life)
   = $1,689,600 x 0.08 = $135,168

7. Annual Cost for Structure = Debt Service for Construction Cost (@ 8% annual interest rate and 30 year life) + Cost of Operation and Maintenance = $5,120,500 x 0.0916 + $24,000
   = $469,038 + $24,000 = $493,038

8. Total Annual Cost of Providing 1,463 Parking Spaces
   = $135,168 + $493,038 = $628,206

[1,2] The unit costs for land and structure were based respectively on the current land value in downtown Knoxville, and costs of parking garages being constructed in this area.

Cost of Providing 793 Parking Spaces :

1. Number of Stalls Needed = 793

2. Number of Floors = $\frac{793}{120}$ = 6.6 ≃ 7
   Need 1 parking garage of 6/7 floors

3. Land Area Required = 1 parcel of 330' x 128' area
   = 42,240 sq. ft. (≃ 1 acre)

4. Initial Cost of Land = 42,240 sq. ft. x $20.00 per sq. ft.
   = $844,800

5. Initial Cost of Construction of Structure = 793 spaces x $3,500 per stall
   = $2,775,500

6. Annual Cost for Land (@ 8% annual interest rate and perpetual life)
   = $844,800 x 0.08 = $67,584

7. Annual Cost for Structure = Debt Service for Construction Cost (@ 8% annual interest rate and 30 year life) + Cost of Operation and Maintenance = $2,775,500 x 0.0916 + $16,000
   = $254,236 + $16,000 = $270,236

8. Total Annual Cost of Providing 793 Parking Spaces = $67,584 + $270,236
   = $337,820

Summary of Costs for Parking Garages and Employer's Benefits

The annual cost of constructing and maintaining parking garages for 1,463 and 793 spaces would be $628,206 and $337,820 respectively. These cost savings can be regarded as benefits derived by TVA by virtue of relying on a rideshare approach.

Impact on Magnitude of Travel and Employees' Benefits

The ridesharing program basically represents an adjustment in the mode of travel utilized by TVA employees in commuting to work. As such, the program did not have any impact on passenger miles of travel. Nevertheless, there was a substantial impact on the vehicle miles of travel (VMT) because of reductions in the number of vehicles utilized for commuting. This reduction in VMT has several types of implications. It directly affects the persons participating

in ridesharing as well as other motorists and the community in general. In this section, estimates of the reduction in VMT will be presented and the resulting benefits accruing to TVA employees will be outlined.

Reduction in Vehicle Miles of Travel

The approach used in the estimation of changes in the vehicle miles of travel of TVA employees was similar to that used in estimating the number of vehicles used for commuting. The vehicle miles of travel were estimated for the current level of employment of 3,400 employees with the modal usage patterns of three different time periods -- November, 1973 (pre-rideshare), December, 1974 (pre-incentive program) and January, 1977 (current).

The VMT calculations with the modal usage of January, 1977 are presented in Tables 4 and 5. The estimates shown in Table 4 represent the VMT generated by the primary ridesharing modes of travel, whereas those shown in Table 5 are VMT's attributable to accessing the ridesharing modes. Examples of travel for accessing rideshare include driving to a park-and-ride lot, travel to pick up carpool passengers, and the VMT generated by such travel was termed as excess VMT. The travel estimates with the modal usage of November, 1973 are shown in Table 6 and those reflecting the modal usage of December, 1974 are presented in Tables 7 and 8. All vehicular modes of travel utilized by TVA employees -- auto, van and bus -- are included in the VMT estimates.

In the calculations for VMT with different modal usage patterns, current passenger miles of travel was used as a control total, which implicitly assumes that the availability of increased ridesharing did not have any significant impact on altering residential location decisions. This assumption is not entirely correct since it is known that new TVA employees indeed have tended to find housing in areas with express bus service. However, since the express bus routes cover the suburban areas quite extensively, the average work trip length of TVA employees has not changed to any significant extent.

Table 4. Daily VMT by Primary Ridesharing Modes Based on the Modal Usage Pattern of January, 1977

Mode of Transportation	Employees	Vehicles	Daily Passenger Miles of Travel	Daily VMT		
				Auto	Van	Bus
Drive Alone	612	612	13,464	13,464	--	--
Regular Bus	102	--[1]	1,020	--	--	--
Express Bus	952	23	20,944	--	--	1,082[3]
Carpool	1,394	436	30,668	9,592	--	--
Vanpool	238	18	10,948	--	828	--
Bike, Walk, etc.	102	--[2]	612	--	--	--
Total	3,400		77,656	23,056	828	1,082

Total VMT by all Primary Modes = 24,966

[1] Employees travelling on regular buses do not contribute any additional VMT

[2] VMT contributed by motorcycles is insignificant

[3] Includes deadhead miles

Table 5. Daily Excess VMT for Access to Primary Modes Based on the Modal Usage Pattern of January, 1977

A. For Access to Regular and Express Bus Stops

Mode of Access	Modal Usage[1]	Employees	Number of Autos	One-Way Trip Length in Miles[1]	Daily VMT by Auto
Car Drop-Off	12%	126	126	2[2]	504
Park-and-Ride:					
(1) Drive Alone	28%	295	295	3	1,770
(2) Carpool	18%	190	59[3]	2	236
Other	42%	443	--	-	—
Total		1,054			2,510

B. For Access to Vanpool Pick-Up Points

Mode of Access	Modal Usage[1]	Employees	Number of Autos	One-Way[1] Trip Length In Miles	Daily VMT by Auto
Car Drop-Off	7%	17	17	5[2]	170
Park-and-Ride	40%	95	95	3.3	627
Other	53%	126	--	--	--
Total		238			797

C. For Picking Up Passengers of Carpools

Daily Excess VMT by Auto = 10% of Primary VMT = 0.10 x 9,592 = 959

D. Total Daily Excess VMT by Auto = 2,510 + 797 + 959 = 4,266

[1] Based on bus and vanpool rider surveys.

[2] In the case of car drop-off, the daily travel of some vehicles involves two round trips from home, while some persons are dropped off by others on their way to other destinations. It is assumed that on the average the daily travel will be two times the one-way trip length.

[3] Average occupancy of carpools is 3.2.

Table 6. Daily VMT Based on the Modal Usage Pattern of November, 1973

A. By Primary Ridesharing Modes

Mode of Transportation	Employees	Vehicles	Daily Passenger Miles of Travel	Daily VMT		
				Auto	Van	Bus
Drive Alone	2,210	2,210	51,897	51,897	--	--
Regular Bus	119	--	1,190	--	--	--
Express Bus	0	0	--	--	--	0
Carpool	1,020	319	24,263	7,588	--	--
Vanpool	0	0	--	--	0	--
Bike, Walk, etc.	51	--	306	--	--	--
Total	3,400		77,656	59,484	0	0

B. For Picking Up Passengers of Car Pool

Daily Excess VMT by Auto = 10% of Primary VMT = 10% of 7,588 = 759

C. Total Daily VMT (Primary and Excess) by Auto = 59,484 + 759 = 60,243

Table 7. Daily VMT by Primary Ridesharing Modes Based on the Modal Usage Pattern of December, 1974

Mode of Transportation	Employees	Vehicles	Daily Passenger Miles of Travel	Daily VMT		
				Auto	Van	Bus
Drive Alone	1,428	1,428	32,649	32,649		
Regular Bus	102	--	1,020	--	--	--
Express Bus	374	10	8,228	--	--	412[1]
Carpool	1,360	425	31,823	9,945	--	--
Vanpool.	78	6	3,588	--	276	--
Bike, Walk, etc.	58	--	348	--	--	--
Total	3,400		77,656	42,594	276	412

Total VMT by All Primary Modes = 43,282

[1]Includes deadhead miles

Table 8. Daily Excess VMT for Access to Primary Modes Based on the Modal Usage Pattern of December, 1974

A. For Access to Regular and Express Bus Stops

Mode of Access	Modal Usage	Employees	Number of Autos	One-Way Trip Length in Miles	Daily VMT by Auto
Car Drop-Off	12%	57	57	2	228
Park-and-Ride:					
(1) Drive Alone	28%	133	133	3	798
(2) Carpool	18%	86	27	2	108
Other	42%	200	--	--	--
Total		476			1,134

B. For Access to Vanpool Pick-Up Points

Mode of Access	Modal Usage	Employees	Number of Autos	One-Way Trip Length in Miles	Daily VMT by Auto
Car Drop-Off	7%	6	6	5	60
Park-and-Ride	40%	31	31	3.3	205
Other	53%	41	--	--	--
Total		78			265

C. For Picking Up Passengers of Carpools

Daily Excess VMT by Auto = 10% of Primary VMT = 0.10 x 9,945 = 995

D. Total Daily Excess VMT by Auto = 1,134 + 265 + 995 = 2,394

A comparison of the VMT estimates shows that the present level of ridesharing can be credited with a reduction of (60,243 - 29,232) or 31,011 daily VMT's per weekday in comparison with the situation since November, 1973. The reduction in daily VMT by all modes that can be attributed to the incentive program is (45,676 - 29,232) or 16,444. A breakdown of these changes in VMT by mode is given below.

In Comparison with Modal Usage of November, 1973 :

Changes in Daily VMT.

Auto	=	Reduction of 32,921
Van	=	Increase of 828
Bus	=	Increase of 1,082
All Modes	=	Reduction of 31,011

In Comparison with Modal Usage of December, 1974 :

Changes in Daily VMT.

Auto	=	Reduction of 17,666
Van	=	Increase of 552
Bus	=	Increase of 670
All Modes	=	Reduction of 16,444

Reduction in User Cost

One of the direct consequences of a reduction in VMT is the savings in vehicle operating cost, and TVA employees participating in ridesharing realized a direct benefit in this respect. Recent statistics released by the Federal Highway Administration indicate that the average cost of operating a vehicle is 17.9 cents/mile for a standard size auto, 14.6 cents/mile for a compact and 12.6 cents/mile for a subcompact (2). These charges include depreciation, maintenance, fuel, parking, insurances and taxes. The following analysis is based on a compact car and excludes from the cost the 2.2 cents/mile charge attributed to parking,* thus resulting in a cost of 12.4 cents/mile. If the

*Parking cost is eliminated to avoid double counting with parking structure costs, previously discussed.

vehicles eliminated from commuting are sold, all of the savings in operating cost (@ 12.4 cents/mile) are passed on to TVA employees thereby increasing their disposable income. If a TVA employee does not sell his/her second car because of ridesharing, but only uses it less, his savings would be about half of those quoted.

Savings in vehicle operating cost, however, were off-set to some extent by the cost of ridesharing. The various estimates needed to derive the net benefits to TVA employees are presented in the following sections.

User Cost Savings in Comparison with Modal Usage of November, 1973:

	Savings
1. Annual reduction in automobile VMT =	$8,230,000
2. Cost reduction for less auto driving @ 12.4 cents per mile =	1,020,520
3. Bus fares paid (1977 vs 1973) =	-151,810
4. Van fares paid (1977 vs 1973) =	-83,016
5. Van and carpool subsidies	28,800
TVA employee savings =	$814,500

If the commuting automobile is still retained, the annual savings to TVA employees would be $213,700.

User Cost Savings in Comparison with Modal Usage of December, 1974:

	Savings
1. Annual reduction in automobile VMT =	$4,416,500
2. Cost reduction for less auto driving @ 12.4 cents per mile =	548,000
3. Bus fares paid (1977 vs 1974) =	-14,960
4. Van fares paid (1977 vs 1974) =	-55,340
5. Van and carpool subsidies	28,800
TVA employee savings =	$506,500

If the commuting automobile was still retained, the annual savings to TVA employees would be $183,741.

Reduction in Accidents

The potential for physical injury and property damage to the TVA commuters because of traffic accidents is substantially reduced because of ridesharing. The largest proportion of traffic accidents in the city occur during the peak hour. Assuming the national average accident rates of 5.26 accidents per million vehicle miles of travel on the arterial highway system and 1.86 accidents per million vehicle miles of travel on the freeway system, and with an approximate 50/50 split of travel on freeways and arterials, the TVA rideshare program is helping to avoid about 30 accidents per year by TVA employees while commuting to work. Just considering the incentive program (since December, 1974), the accident reduction would be 15 accidents per year.

Increase in Convenience

Opinion surveys of TVA employees who are ridesharing indicate many additional desirable aspects of the program. As summarized by Table 9, bus riders and vanpoolers are particularly conscious of the reduced costs of commuting and reduced energy consumption. Also significant, but more difficult to quantify, is the perceived relief from the tensions of driving each day. Another important factor noted was the ability to make the commuting vehicle available for other family members during the day.

Other Consequences: Benefits to Community and Other Travellers

Besides TVA and its employees, the community at large and particularly the travellers in certain corridors of Knoxville also benefited from the program. The quantification of these consequences is difficult in some cases. Nevertheless, an attempt has been made in the following sections to outline these benefits in as much detail as practicable.

Table 9. Perceived Benefits of Bus Riders and Van Poolers

Bus Riders

Perceived Benefits	Frequency of Response 1974 Survey	1975 Survey
Conserves Gasoline	27.3%	22.1%
Freedom from Tensions of Driving an Auto	26.1%	27.0%
Less Expensive Means of Travel	22.7%	37.7%
Less Damaging to the Environment	9.0%	2.8%
Safer in Case of an Accident	5.8%	1.8%
Faster Means of Travel	4.4%	1.9%
More Comfortable Riding	3.5%	1.0%
Other (Car Can Be Used by Others, Parking Difficulties, etc.)	1.2%	5.7%
Total	100.0%	100.0%

Van Riders

Perceived Benefits	Frequency of Respons 1976 Survey
Saves Money	70.2%
Conserves Gasoline	68.4%
Avoids Driving Every Day	62.0%
Increased Availability and Reduced Cost of Parking	56.7%
Makes Vehicle Available During the Day	18.1%
Avoids Buying a Second Car	10.5%
More Dependable than Bus Service	7.6%
Other	7.6%
Do not Own a Car	0
Total	100.0%

Impact on Energy Consumption

The transportation sector of the national economic system is one of the major users of energy, and urban transportation's share is substantial. It is estimated that in 1971, travel by private automobiles in the United States consumed 70 billion gallons of gasoline, which is 31 percent of the domestic petroleum consumption. During the same year, automobile driving in urban areas accounted for 63 percent of the nationwide fuel consumption by automobiles (4). Thus, urban transportation is a prime area for energy conservation.

The TVA employee rideshare program contributed toward energy conservation by reducing the vehicle miles of travel, which can be translated to savings in fuel consumption. It is estimated that 460,358 gallons of fuel are saved annually because of the present level of ridesharing as opposed to the modal usage pattern of November, 1973. In comparison with the level of ridesharing during December, 1974, the reduction in fuel consumption is estimated to be 238,758 gallons annually. A breakdown of changes in fuel consumption by mode is given below:

In Comparison with Modal Usage of November, 1973:

1. Changes in Annual VMT
   - Auto = Reduction of 8,230,250
   - Van = Increase of 207,000
   - Bus = Increase of 270,500

2. Changes in Annual Fuel Consumption:
   - Auto (@ 15 miles per gallon) = Reduction of 548,683 gallons
   - Van (@ 10 miles per gallon) = Increase of 20,700 gallons
   - Bus (@ 4 miles per gallon) = Increase of 67,625 gallons

3. Net Change in Annual Fuel Consumption:
   - All Modes[1] = Reduction of 460,358 gallons

[1] Ignoring that buses use diesel, while autos and vans use gasoline

In Comparison with Modal Usage of December, 1974

1. Changes in Annual VMT:
   Auto = Reduction of 4,416,500
   Van = Increase of 138,000
   Bus = Increase of 167,500

2. Changes in Annual Fuel Consumption:
   Auto (@ 15 miles per gallon) = Reduction of 294,433 gallons
   Van (@ 10 miles per gallon) = Increase of 13,800 gallons
   Bus (@ 4 miles per gallon) = Increase of 41,875 gallons

3. Net Change in Annual Fuel Consumption:
   All Modes = Reduction of 238,758 gallons

The estimates on fuel savings would be more meaningful if they are expressed in terms of automobile usage for all trip purposes. An automobile for private use is driven approximately 10,000 miles per year and consumes 667 gallons of gasoline annually. The estimated fuel savings thus can be expressed as providing sufficient fuel for operating 690 automobiles and 358 automobiles annually since November, 1973 and December, 1974, respectively.

Impact on Public Transportation System

The employee rideshare program of TVA has had a stimulating impact on both public and private bus systems in Knoxville. The express bus riders, who mostly are TVA employees, represent approximately 8 percent of the annual ridership of Knoxville Transit Corporation (KTC). TVA employees using the express buses and the subsidy of the incentive program contribute 15 percent of KTC's annual revenue derived from the farebox.

Private bus operators in the Knoxville area, as in other areas, are faced with serious economic plight and prospects for their future growth prior to TVA ridesharing were bleak. However, the TVA rideshare program has helped improve their situation by giving them the opportunity to generate additional revenue by providing express bus service in several routes. The addition of private suppliers has not adversely effected the public transit system as this

approach was taken only after KTC had exhausted its available supply of peak hour buses. Vanpooling also did not compete with the public bus system since their riders came from areas without any bus service. The implications of the revitalization of private operators and the demonstration of the use of a mix of public and private suppliers are significant and it may be a model for other ridesharing efforts.

Air Pollution

There exist direct relationships with vehicle miles of travel and air pollution, and there is no doubt that the reduced vehicle miles of travel attributable to the TVA employee rideshare program resulted in less emission of pollutants in the air. The precise quantification of the effects of such a reduction on the concentration of air pollution at various locations is difficult and beyond the scope of this analysis, since the procedure would involve the use of complex dispersion models along with data on background concentration, meteorological condition and so on. However, the contribution of the rideshare program toward a reduction in air pollution, especially in the I-40 corridor, can be approximated. The impact of pollution can be estimated by considering the tons of pollutant using the Environment Protection Agency's maximum allowable emissions for 1975-76 model vehicles as the standard (4).

1.5 gr per mile Hydro Carbons
15.0 gr per mile Carbon Monoxide
3.1 gr per mile Nitrogen Oxide
.25 gr per mile Evaporation

19.85 gr per mile Total

The reduction in air pollution would approximate 170 tons of emissions per year for the full extent of the rideshare program (with reference to November, 1973) and 90 tons of emissions per year for the incentive program (since December, 1974).

Effects on Traffic Flow

It was estimated earlier that the employee rideshare program eliminated a substantial number of commuting vehicles from the roadways in Knoxville. The estimated number of vehicles eliminated were 1,463 and 793 in comparison with the modal usage patterns of November, 1973 and December, 1974, respectively. Based on the knowledge that approximately 33 percent of TVA employees live in the West Knoxville area, the reduction in vehicle trips is likely to be most significant in this travel corridor. Also, considering the fact that 50 percent of the express buses both before and after the incentive program serve the West Knoxville area, it is reasonable to assume that the propensity of ridesharing is higher in this area relative to the other sectors of Knoxville. Based on these considerations, it is estimated that 40 percent of the vehicle trips eliminated by ridesharing used to take place in this western corridor.

The major roadways in West Knoxville corridor are Middlebrook Pike, I-40, Kingston Pike and Lyons View Drive.. However, due to the configuration of these roadways and the location of the TVA offices, the majority of the commuting trips along this corridor utilizes I-40. It is estimated that 75 percent of the work trips by TVA employees living in the West Knoxville area use the section of I-40 between the Papermill Road interchange and downtown. Thus, the elimination of 1,463 commuting vehicles means a reduction of (1,463 x 40% x 75%) or 439 vehicles from I-40 during the morning as well as afternoon commuting hours of travel. Similarly, the removal of 793 vehicles can be translated to a reduction of 238 vehicles on I-40 during A.M. and P.M. rush hours.

The working hours of TVA in Knoxville are not staggered and the work trips of TVA employees on I-40 can be assumed to be concentrated within a time span of 20 minutes in the morning and also in the afternoon. The traffic volumes on I-40 in the peak directions during the commuting hours of two different days are shown in Table 10. The average highest hourly volume in the peak direction

Table 10. Traffic Volume Counts on I-40 at Papermill Road

A. Morning Traffic in Peak Direction (East Bound)

Time: A.M. Hours	Number of Vehicles (All Types)			
	On 2/23/77 (Wednesday)	On 4/13/77 (Wednesday)	Average	
6:30-6:45	--	373	373	
6:45-7:00	278	495	387	
7:00-7:15	408	574	491	
7:15-7:30	757	867	812	
7:30-7:45	692	893	793	Peak
7:45-8:00	588	795	692	Hour
8:00-8:15	656	826	741	
8:15-8:30	627	768	698	

B. Afternoon Traffic in Peak Direction (West Bound)

Time: P.M. Hours	Number of Vehicles (All Types)			
	On 2/23/77 (Wednesday)	On 4/13/77 (Wednesday)	Average	
4:30-4:45	650	718	684	
4:45-5:00	800	788	794	
5:00-5:15	898	932	915	Peak
5:15-5:30	834	899	867	Hour
5:30-5:45	794	850	822	
5:45-6:00	722	668	695	
6:00-6:15	669	705	687	
6:15-6:30	617	617	617	

in the morning is 3,038, which occurs during 7:15 to 8:15 A.M., and that in the peak direction in the afternoon is 3,398 occurring between 4:45 and 5:45 P.M. The two 20-minute periods containing TVA employees fall within these peak hours, and considering the variation in traffic during A.M. and P.M. hours the average volume during a 20 minute period is 1,073.

The operating condition of I-40 on the section between the Papermill Road interchange and downtown during the commuting time periods of TVA employees can be described by the level of service D, which represents an operating speed of 40 miles per hour and a situation approaching unstable flow. The capacity analysis of I-40, which is a four lane freeway with several closely spaced on/off ramps in the downtown area, shows that if 439 vehicles were not eliminated from I-40, during a 20-minute period, the operating condition would have been similar to that of level of service E, which represents unstable flow with an operating speed of 30 mph (5). Thus, the current users of I-40 during the 20-minute periods of commuting of TVA employees enjoy a better driving condition and their operating speed is 10 miles per hour higher than what it would have been without any ridesharing. The improvement attributable to the elimination of 238 vehicles is estimated to be an increase in the average operating speed of 5 miles per hour from 35 miles per hour reflecting the situation during December, 1974, to 40 miles per hour which represents the current situation.

The benefits of the improved level of service and increased operating speed on I-40 can be quantified in terms of a reduction in vehicle operating cost accruing to the current road users. Since these benefits would not be as large as others that have been estimated already, they need not be quantified in detail. Nevertheless, the positive contribution of the rideshare program towards easing the traffic congestion on I-40 during the rush hours, which is one of the most severe traffic problems in Knoxville, must not be overlooked.

Annual Cost of Incentive Program

The costs involving the TVA rideshare program can be categorized by the items summarized below:

1. Subsidy for bus tickets

Bus lines:	KTC	=	$47,156
	Autrey	=	$16,603
	B and C	=	$10,960
			$74,719

2. Guarantees paid to bus lines

Bus lines:	KTC	=	$ 1,993
	Autrey	=	$ 2,491
	B and C	=	$ 5,699
			$10,183

3. Administrative fee to credit union

= $11,231

4. Parking for carpools

= $ 1,860

5. Subsidy for vanpools (18 vans)

= $27,000

6. Total Cost

= $125,000

Summary

By virtue of supporting the rideshare demonstration program, TVA is able to avoid constructing a new downtown parking structure. The benefit/cost analysis of this strategy is presented below:

Benefit/Cost Comparison for TVA Incentive Program

Benefit = cost avoided for building a parking structure for 793 spaces = $337,820 per year.

Direct Cost to TVA = $125,000 per year.

Benefit/Cost Ratio = 2.70

Other Benefits

In addition to the savings of the cost for a parking structure, the following benefits are received by TVA employees and the community:

	November 1973 vs 1977 (Total Rideshare Program)	December 1974 vs 1977 (Incentive Program Only)
1. Reduced Annual VMT of Travel by TVA Employees	7,752,750 VMT	4,111,000 VMT
2. Increased Disposable Income to TVA Employees Because of Reduced Community Costs*	$273,780/yr.	$216,020/yr.
3. Reduction in Annual Roadway Accidents Involving TVA Employees Commuting to Work	30 Accidents	15 accidents
4. Annual Reduction in Fuel Consumption by TVA Employees While Commuting	460,360 gals.	238,760 gals.

*Assumes from survey of TVA bus riders and vanpoolers that 10 percent either sold a car or deferred purchasing a new car because of ridesharing.

	November 1973 vs 1977 (Total Rideshare Program)	December 1974 vs 1977 (Incentive Program Only)
5. Increased Financial Viability of the Public and Private Bus System in Knoxville	Non-Quantifiable	Non-Quantifiable
6. Reduced Annual Levels of Atmosphere Pollution	170 tons of emissions	90 tons of emissions
7. Improved Peak Hour Operating Condition of Traffic on Key Segment of I-40 West	+ 10 mph	+ 5 mph

References

1. Stokey, S.R., Wegmann, F.J., Chatterjee, A. and Hauldin, H.D., "An Employer Based Commuter Ride Share Program in a Medium Size Urban Area." Traffic Engineering, Institute of Transportation Engineers, Vol. 47, No. 1, January 1977, pp. 19-24.

2. Liston, L. and Aiken, C., Cost of Owning and Operating an Automobile -- 1976. Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1976.

3. Fortune, William, "A Marketing Concept for Van Pooling." Unpublished Paper. Conoco, Houston, Texas, February 1976.

4. Hirst, Eric, Direct and Indirect Energy Requirements for Automobiles. Oak Ridge National Laboratory, Oak Ridge, Tennessee, February 1974.

5. Highway Capacity Manual - 1965, Highway Research Board Special Report 87, National Academy of Sciences - National Research Council, 1965.