Chapter III

Relationship Between Transit and Energy

Chapter 111 begins with a brief description of how de facto public policies in the past have encouraged inefficiencies in the use of fuel in urban transportation. Next, transit's present role is defined in relation to the overall national energy picture; first by examining the proportion of energy consumed by transit and then by comparing the opportunities for energy conservation in the transit field in relation to other modes of transportation. These discussions will show that transit's basic potential in energy conservation lies in providing a substitute for auto travel in urban areas.

This chapter completes a brief discussion of the general context in which this study of energy, the economy, and mass transit was conducted. The remainder of the report is devoted to an examination of the relationship between transit and future economic and energy conditions. Chapter IV describes a range of assumed possible future economic and energy conditions which were used to determine their effects on the transit industry. The remainder of the report describes in detail the ability of transit to save energy and create jobs under these and other future conditions.

THE ROLE OF CHEAP GASOLINE IN URBAN TRANSPORTATION

There is general agreement that the United States followed a "cheap energy" policy in the Post World War II period along with a "cheap auto transportation" policy. The real cost for both autos and fuel declined in the 1950-70 period. (That is, the rate of increase in these prices was less than the rate of increase in personal income after removal of inflation factors.) The taxes imposed on gas and automobiles were also very low by world standards. There was no publlc policy favoring conservation of any of the related resources. The combination of declining real cost and increasing real incomes produced a long run trend of increase of about 5.5 percent per annum for motor fuel consumed in urbanized areas.[1]

During this period, auto transportation increased its share of total energy consumption (Figure z). This increased share was due primarily to increases in the vehicle fleet (see Figure 3), and secondarily to increases in the average miles driven per vehicle (Figure 4) and decreases in average fuel consumption efficiency (Figure 5).

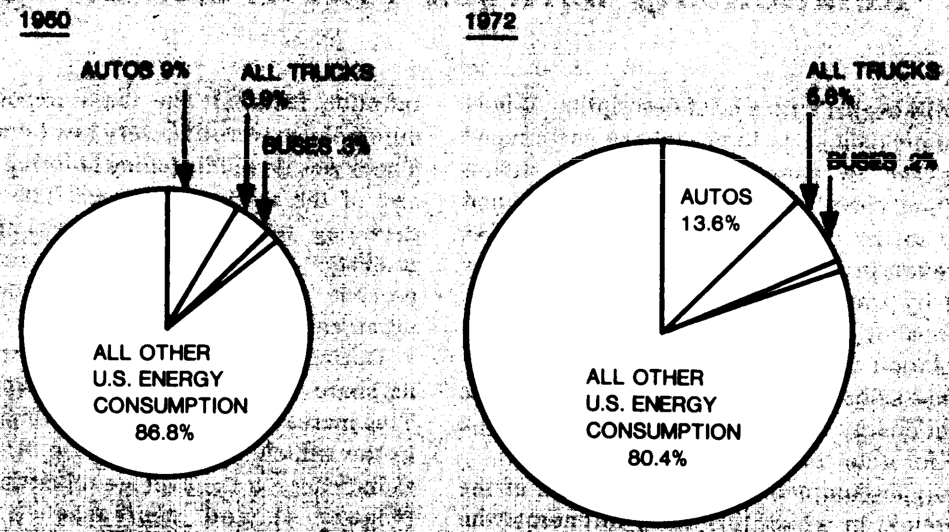
The continued increase in average fuel consumed per mile of auto travel is particularly interesting because there was a continuing decline in the number of large (standard) cars and an increase in the number of small cars bought by the public after 1965 (Figure 6). This would have decreased average fuel consumption except for the effect of Federal regulation of auto exhaust emissions which began in 1966. Prior to the 1975 model year the means chosen by the manufacturers to meet the required Federal standards resulted in sharply increased fuel consumption per mile in each engine size category. This more than offset the declining average engine size in the fleet as a whole.

The most important effect on transit of the de facto public policies has been to reduce transit ridership by encouraging the widespread use of cars, and to make transit fares appear relatively high. One of the effects of the continuing decline in transit ridership has been a parallel decline in the average number of passengers per vehicle mile (refer back to Table z). This in turn has caused a steady increase in transit's rate of energy consumption, measured in either gallons of fuel per passenger mile or kilowatt hours per passenger mile.

ICalculated from Highway Statistics, Federal Highway Administration, Washington, D.C.

FIGURE 2

SHARE OF U.S. ENERGY CONSUMED BY MOTOR VEHICLES IN 1950 AND 1972



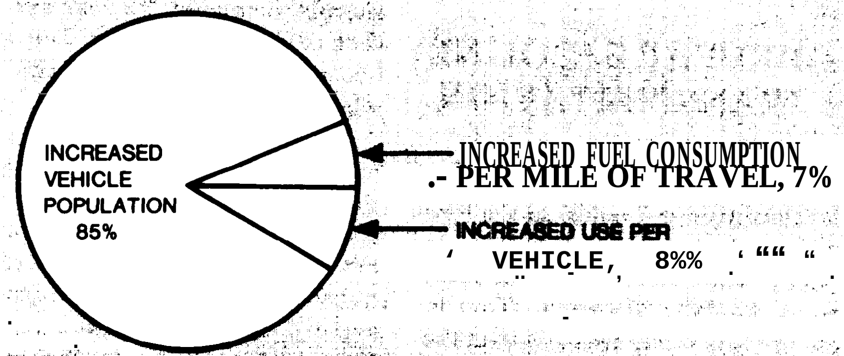
TOTAL ENERGY CONSUMPTION, ALL USES: 34 X 10^{15} (QUADRILLION) Btu's

TOTAL ENERGY CONSUMPTION, ALL USES: 72 X 10^{15} (QUADRILLION) Btu's

Source: (1) U.S. Bureau of Mines, *Minerals Yearbook*
(2) FHWA *Highway Statistics*, 1972

FIGURE 3

FACTORS CONTRIBUTING TO INCREASED PASSENGER CAR FUEL CONSUMPTION BETWEEN 1950 AND 1972

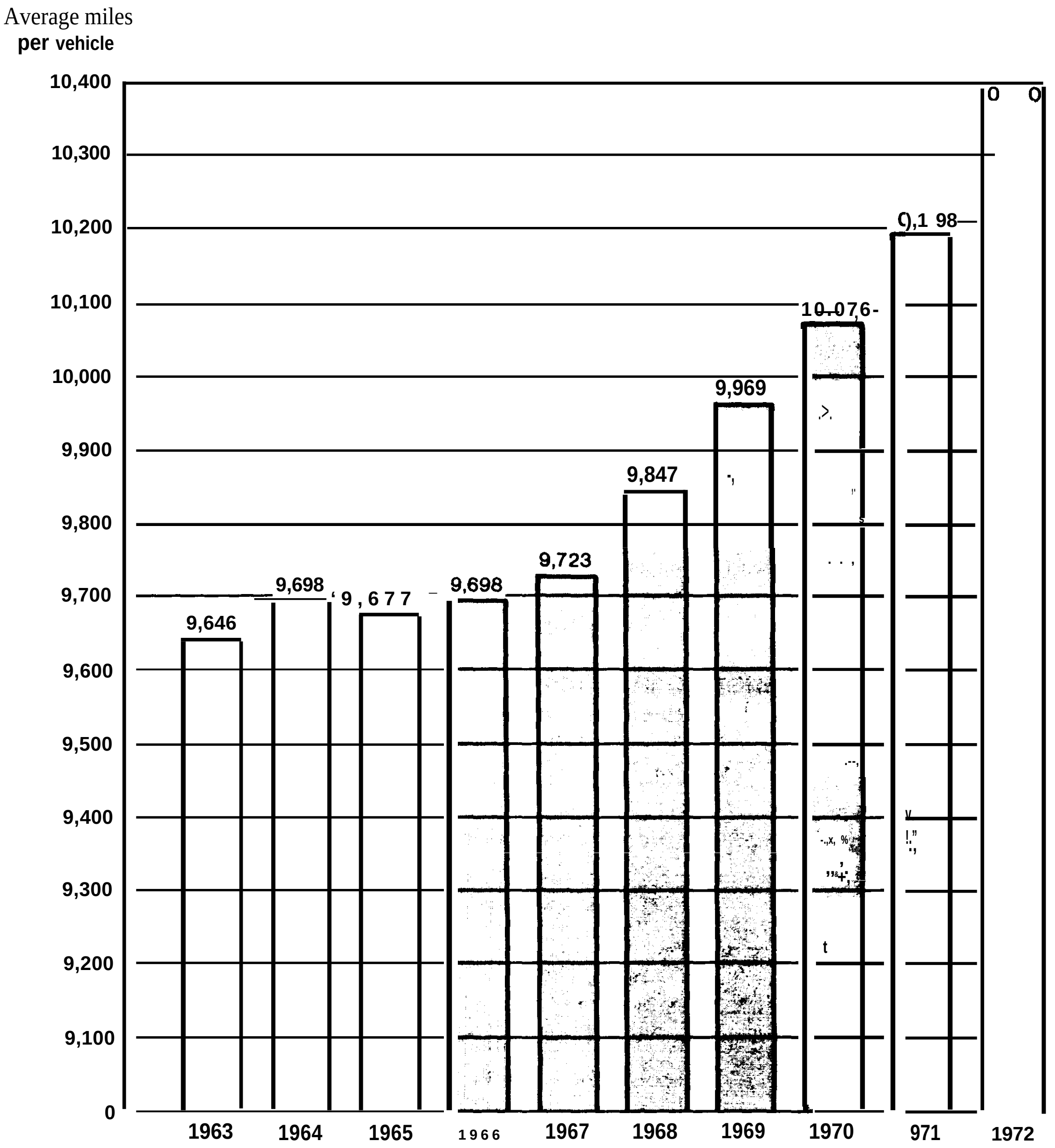


(ANNUAL GASOLINE CONSUMPTION IN PASSENGER CARS HAS MORE THAN TRIPLED FROM 1950 TO 1972.)

source: FHWA Annual Highway Statistics

FIGURE 4

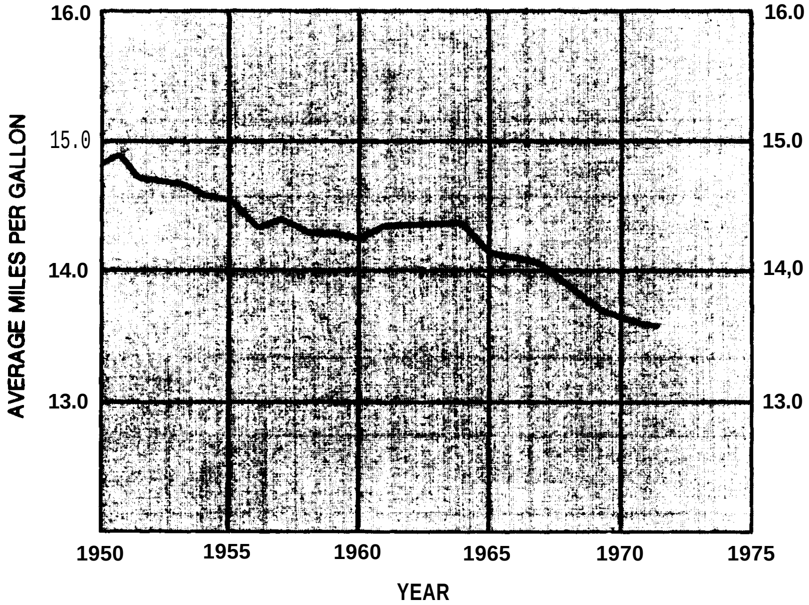
AVERAGE ANNUAL USE OF VEHICLES



SOURCE U.S. Department of Transportation, Federal Highway Administration, Table W-l.

FIGURE 5

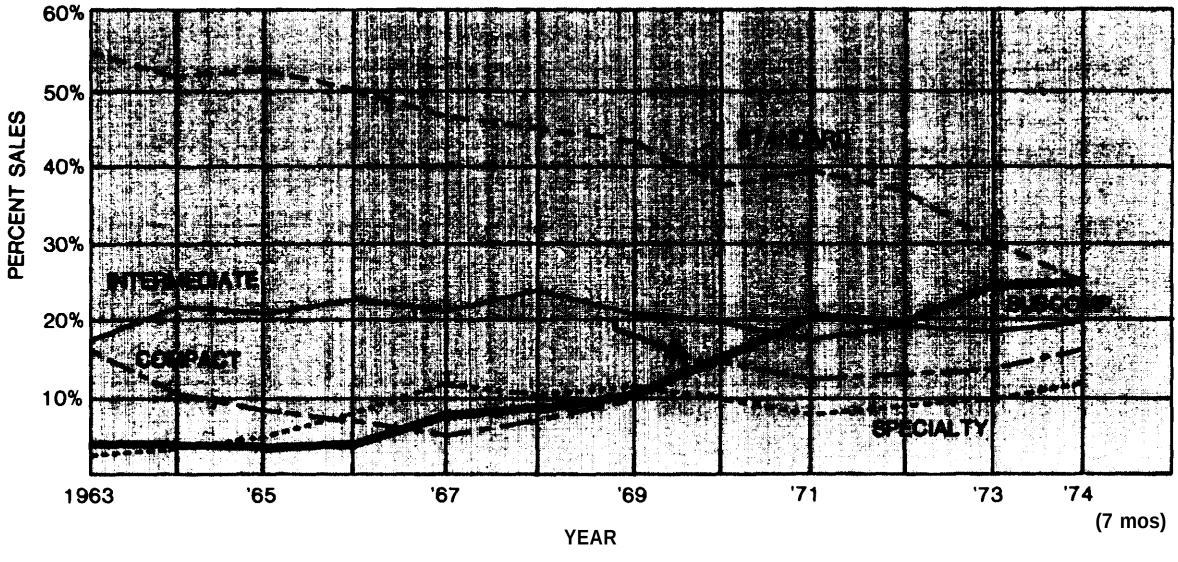
AVERAGE FUEL ECONOMY (MPG) OF U.S. PASSENGER CAR FLEET 1953-1972



SOURCE: FHWA Annual Highway Statistics

FIGURE 6

PASSENGER CAR SALES BY MARKET CLASS (Including imports)



SOURCE, Automotive News

The only significant period of time when gasoline was not readily available since World War 11 occurred between November 1973 to March 1974 for 1 to 4 months, depending on the region of the United States. The supply of motor fuel compared to the same months of the previous year was decreased by 3 percent to 15 percent. This fuel shortage, and increased gasoline prices during and after the shortage coincided with a significant increase in transit ridership. Figure 7 shows the number of transit riders and vehicle miles traveled by month for this period. Whether, and to what extent, transit ridership would have increased had there been no gasoline shortage and price increases is a difficult question. However, an analysis of the relationship between transit ridership and energy conditions reported in Chapter VII and Appendix A suggests that the shortages and price increases of gasoline more than account for the increase in transit ridership and, had they not occurred, transit ridership would have declined. However, more data over a longer time period is required to associate a high degree of confidence with this observation.

While these gains were important to transit operators, they do not represent a major change in the overall national urban travel picture, Transit accounts for only about 5 percent to 8 percent of total trips by vehicuIar transportation in the urbanized areas of the United States as a whole and it accounts for only 12 percent of the home-to-work trips in the urbanized areas of more than 250,000 population, transit's strongest market.[2] Thus an increase of 6 percent over prior periods in an 8 percent share of the national market affects only 0.5 percent of the total trips made in that market.

It is of interest that the increase in transit ridership seemed to accelerate in 1974 after the gasoline shortage was over (see Figure 7), but in 1975 ridership has remained steady with the previous year. This suggests that in the second half of 1974 people believed the price of gasoline would maintain its current level or increase further and have gradually restructured their trip-making habits to accommodate the higher cost of auto travel with less sacrificing of mobility. The lack of increased ridership in 1975 indicates that people are no longer responding to past shortages and price increases of gasoline by shifting to transit in significant numbers.

'Bureau of the Census, journey to Work, Report PC(2)6D, Census of Population 1970, Tables I and 2.

TRANSIT'S SHARE OF TOTAL ENERGY CONSUMPTION

Three points will be made in this section:

- Transit consumes less than one percent of U.S. transportation energy.
- Transit is a much more efficient user of energy than the automobile.
- Energy consumed in the construction of rapid rail systems may approach half of the total energy consumed by a system over a 50-year period of operation.

Preliminary figures[3] for 1973 show that the United States consumed 75,561 trillion Btu's in that year and that the transportation sector consumed 24.8 percent of that energy.

Figure 8 shows that mass transit and intercity buses together consume only 1 percent of the U.S. transportation energy, while automobiles in urban areas consume 34.2 percent. A more detailed study by Pollard, Hiatt, and Koplow[4] estimated that bus and rail urban transportation consumed only 0.66 percent of the total transportation energy, or 1.8 percent of all urban passenger transportation fuel.

Transit's importance in providing urban transportation is much greater than its low energy consumption implies because transit makes more efficient use of energy. Transit carries 5-8 percent of urban vehicular person trips while consuming less than 2 percent of all urban passenger transportation fuel.

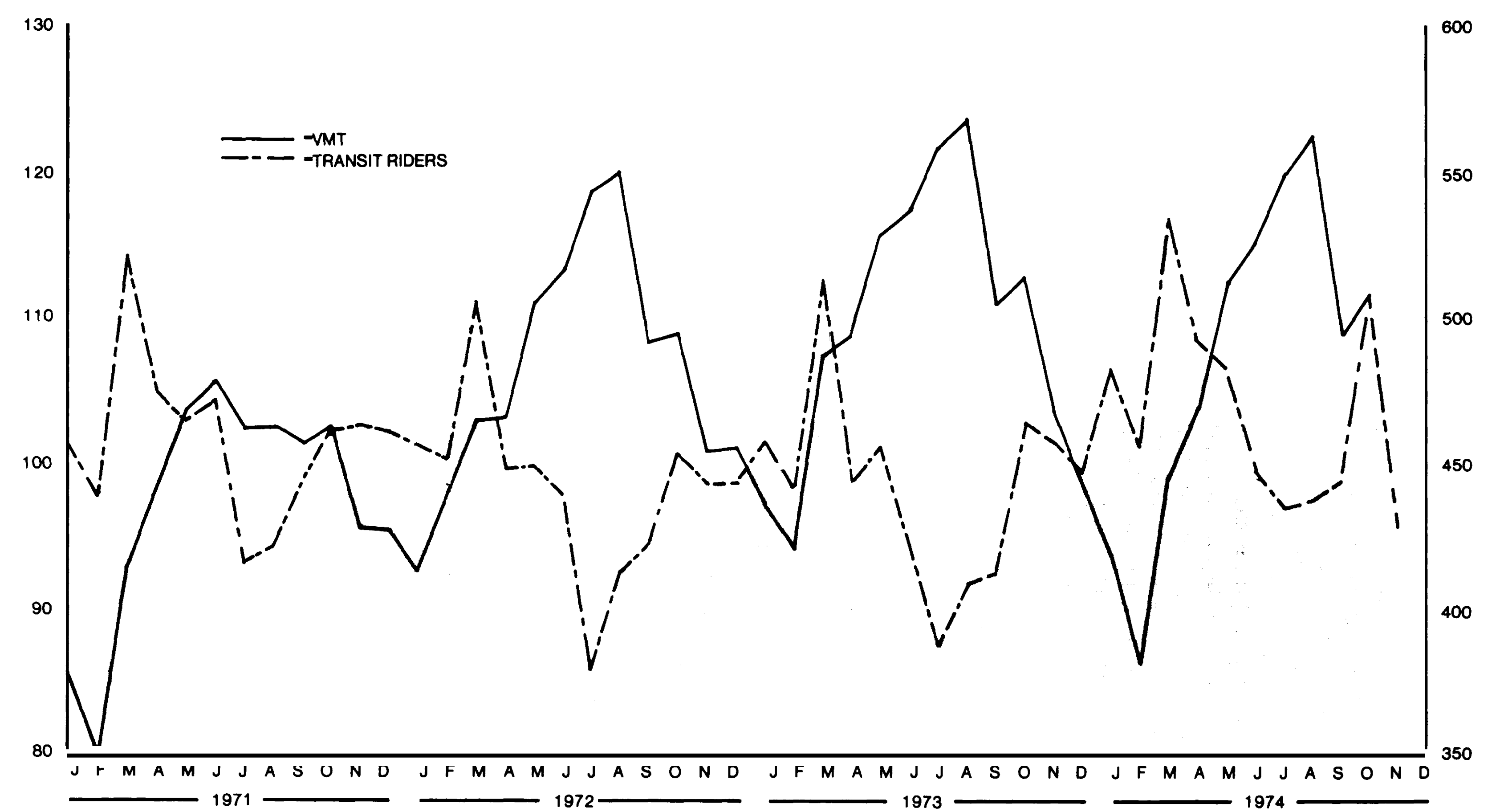
Table 4 (reproduced from the APTA 1974-75 Transit Fact Book) shows an array of urban

[3]U.S. Department of the Interior, News Release, March 10, 1974.

'Opportunities to Conserve Transportation Energy, Transportation Systems Center, U.S. Department of Transportation, 1974.

FIGURE

NATIONAL VEHICLE MILES TRAVELED (VMT) AND TRANSI RIDERS m *MONTH
1971-74



Source: Transit Riders—APTA monthly transit traffic bulletins
VMT—Traffic Volume Trends, Table 9A, Program Management Division, FHWA

transportation modes for which passenger-miles per gallon figures are available. The private car at usual peak-hour loading is by far the least efficient of alI modes. This reflects the price Americans have been willing to pay for individual personal transport with its high level of personal comfort, convenience, and reliability, eroded only by congestion.

All of the main urban transportation vehicles are represented at both peak and off peak passenger loadings in Table 4. The energy efficiency effect of varying average load factors is apparent for all modes. Although an off peak transit bus with 30 people is six times as efficient as the auto with an average of 1.4 people, the peak load transit bus with 75 riders is almost three times as efficient as the 30-rider bus.

Heavy Rail Transit (subways) is shown to be even more efficient than buses, With a load of 35 passengers per car, subways are more than 7 times as energy efficient as commuter autos. Under peak loads, subways are nearly 30 times as efficient. However, the energy consumed in operation shown here is only a portion of the energy required for rail rapid transit and construction energy should also be considered.

The construction of fixed guideway systems such as BART consumes a great deal of energy. Table 5 indicates that on a 50-year basis, 44 percent of BART's total energy requirement was expended during construction. Since this system represents the most expensive type of construction, including a long underwater tunnel, this may be considered an upper bound on the range of such requirements.

A study by Eric Hirst of the Oak Ridge National Laboratory includes an analysis of automobile energy requirements (see Table 6). The Hirst study showed the energy consumption in automobile vehicle manufacturing, repair, sales, and financing, as well as the energy consumed in refining the gasoline, but did not include highway construction energy. These functions reduce the average miles per gallon from about 14 to 7. If highway construction energy had been included the average miles per gallon would have been reduced even further.

It seems unquestionable that in determining national transportation policies the complete array of energy consumption requirements should be taken into account.

SOME ALTERNATIVE COURSES FOR ENERGY CONSERVATION IN TRANSPORTATION

The principal message from the above review is that conservation efforts must focus on the consumer of 98 percent of urban passenger transportation fuel—the automobile. Shifting travel to transit will have beneficial energy saving effects, but, as will be shown in Chapter IX the most effective ways of accomplishing this shift, from an energy conservation standpoint, involve emphasis on disincentives to auto use coupled with transit use incentives.

The need to concentrate on auto efficiency has been noted by both the Department of Transportations and the Federal Energy Administration (FEA).[5,6]

The FEA paper reported estimates of energy savings in 1980 for three transportation policies as shown in Table 7. For the increase in car occupancy, the savings represent less than 5 percent of the motor fuel consumed in I973 and for the increase in fuel economy the savings are over 8 percent, But doubling transit ridership by itself produces a less than 1 percent savings according to the FEA.

The Department of Transportation study is summarized in Table 8 in terms of the potential fuel savings of a wide variety of options considered, including vehicle design changes, car pooling (load factors), traffic operations improvements, as well as a wide range of shifts among modes. Note that the shift from urban auto to bus is given the greatest potential for fuel savings of all mode shifts by either 1980 or 1990, but much less potential than car pooling and an order of magnitude less effective than many vehicle design measures,

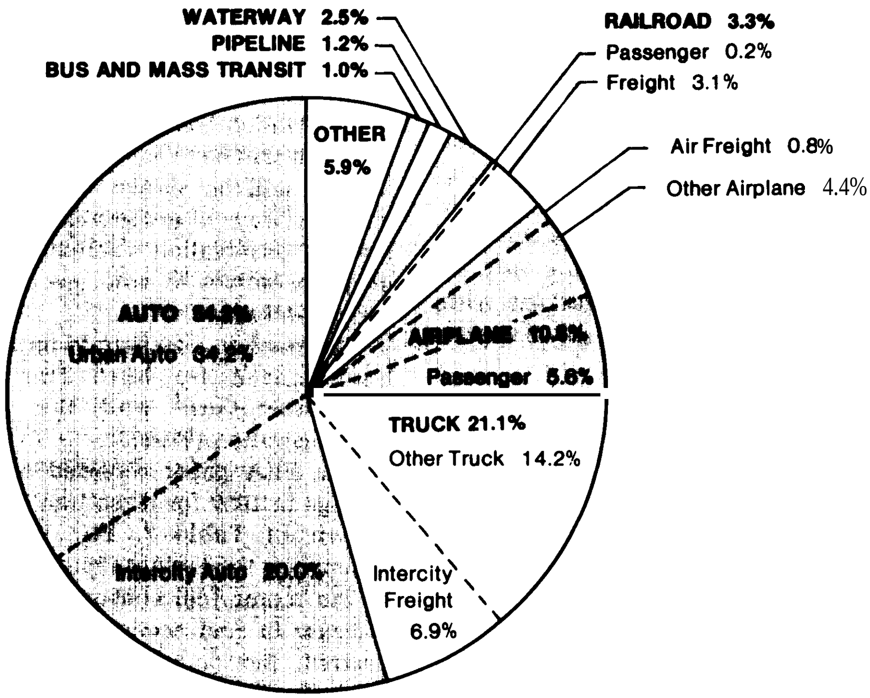
What is not often recognized or emphasized in many discussions is the complementarily of programs aimed at discouraging auto use in urban areas and programs to encourage transit use. From

[5] *Summary of* Opportunities *to* Conserve Transportation Energy, Pollard, Hiatt and Koplow, Transportation Systems Center, a Report for the Office of the Secretary of Transportation, Final Draft, January 1975.

[6] Stuntz Mayo S. Jr., Mass Transit and Energy Conservation, Federal Energy Administration, March 5, 1975.

FIGURE 8

ENERGY CONSUMPTION BY TRANSPORT MODE, 1970



SOURCE Lutin, J. M., Comparison of Energy Savings *for* Work *Trips,* Princeton University Transportation Program, 1974.

TABLE 4

ENERGY REQUIREMENTS OF PASSENGER TRANSPORTATION MODES

Type of Transportation	Faseenger	Vehicle Miles Per Gallon Of Fuel or Equivalent	Passenger Miles Per Gallon of Fuel or Equivalent
Heavy Rail Transit (Subway) Car, Peak Load (a)	135	4.00	540
Intercity Passenger Train (b)	540-720	0.50	270-360
Transit Bus, Peak Load (c)	75	4.10	307
Intercity Bus (d)	47	6.00	282
Commuter Rail Car, Diesel Powered (a)	125	2.00	250
Heavy Rail Transit (Subway) Car, Off-Peak Load (a)	35	4.00	140
Transit Bus, Off-Peak Load (c)	30	4.10	123
Rail Turbine Train (b)	320	0.33	110
Standard Size Automobile, Intercity, Maximum Load (e)	6	18.00	108
Standard Size Automobile, Urban, Maximum Load (e)	6	14.40	86
Wide-Body Commercial Jet Aircraft, 1,000-Mile Flight (9	256-385	0.1 4-0.2:	54-60
Twin Jet Commercial Aircraft, 500-Mile Flight (9	68-106	0.44-0.54	37-47
Average Commuter Automobile (a)	1.4	13.5	19

source:

(a) Commonwealth of Pennsylvania, Depirttibnt of Transportation
(b) National Railroad Passenger Corporation (Amtrak)
(c) Cleveland Transit System
(d) U.S. Department of Transportation, Transportation Systems Center
(e) U.S. Department of Transportation, Federal Highway Administration
(f) National Aeronautics and Space Administration

(Reproduced from American Public Transit Association '74-'75 TRANSIT *FACT BOOK)*

TABLE 5

TOTAL "BART" ENERGY REQUIREMENTS FOR ALL PURPOSES DURING 50-YEAR LIFE SPAN

Major purpose	Energy Used	Percent
Construction Energy:	1.1 x 10^{14} Btu	44
Traction Energy (Vehicle Operation):	1.0 X 10^{14} Btu	40
Station Operation and Maintenance Energy	0.4 X 10^{14} Btu	16
Total Energy Required:	2.5 X 10^{14} Btu	100

SOURCE: Heaiy and Dick; *Total Energy Requirements of the BART System*, Santa Clara University, July 1, 1974

TABLE 6

TOTAL ENERGY REQUIREMENTS FOR AUTOMOBILES IN THE U.S.

	1960 (10^{16} BtU)	1968 (10^{16} Btu)	1970[a] (10^{15} Btu)
1. Gasoline Consumption	5.60	7.96	8.95
2. Petroleum Refining	1.16	1.64	1.84
3. Automobile Manufacturing	0.78	1.05	0.71
4. Automobile Retail Sales	0.77	0.99	0.82
6. Repairs, Maintenance, Insurance, Replacement Parts, Accesssories, Parking, Tolls, Taxes, etc.	3.03	3.95	4.44
TOTAL (10^{16} Btu)	11 .33	15.59	16.76
Total Automobile Mileage (10^{9} miles)	588	814	901
Total Energy Required (Btu/mile)	19,270	19,150	18,620
. (miles/gal)	7.06	7.10	7.31
Total U.S. Energy Consumption (10^{15} Btu)	44.96	62.45	68.81
Percent of Total Energy Consumption Devoted to Automobiles	25.2	25.0	24.4

[a]The 1970 figures are low for manufacture and sale of automobiles. This is probably due to the economic condition of the country that year, and may not represent a long-term secular decline in automotive energy consumption.

SOURCE: Hirst, E.; *Energy Consumption for Transportation in the U.S.* Oak Ridge National Laboratories, March 1972

TABLE 7

ENERGY CONSERVATION POTENTIAL OF VARIOUS TRANSPORTATION POLICY ACTIONS

Policy	Estimated Energy savings (1980)
1. Double mass transit system size and ridership	40-50,000 barrels/day[1]
2. increase car occupancy to 2.0 PM/VM	350,000 barrels/day
3. 40% increase in new car fuel economy	640,000 barrels/day

[1]The American Public Transit Association (APTA) vehemently disputes this figure. In an undated paper entitled Energy Conservation and Public Transit: An Interim Rebuttal by *American Public Transit Association*, APTA implies that the savings should be at least 178,000 bbl/day and that much greater savings could be achieved if transit's efficiencies could be fully utilized.

The primary source of the disparity between the FEA and APTA estimates is that they make considerably different assumptions about the reduction in automobile vehicle miles of travel which would be associated with a doubling of transit ridership.

In actuality, the amount of energy saved will depend upon how transit ridership increases are achieved. As discussed later in this document, the mere doubling of the national transit system's size, in and of itself, would not cause a doubling of ridership-it would result in an estimated 20°6 to 40% increase in ridership. In order to achieve a doubling of ridership it would be necessary to take substantial actions to restrain auto use and/or to create substantial transit incentives in addition to the doubling of the transit system's size. Doubling transit ridership by auto restraint actions generates energy savings of not much more than 100,000 barrels/day through the diversion of auto drivers to transit. With most auto restraint actions, however, there would be substantial additional energy savings over and above the shift to transit because of more efficient use of autos and reduction in travel. On the other hand, doubling transit ridership by transit incentive actions alone, such as the elimination of fares, would be likely to produce energy savings of only about 60,000 barrels/day or less,

SOURCE Mayo S. Stuntz, Jr. *Mass Transit and Energy Conservation,* FEA, March 5, 1975.

both the public policy and political standpoints, it would be desirable for major transit incentives to be implemented first, while being clearly linked to a later auto restraint program. Insofar as possible, all nonfrivolous demands for transportation movement should be met. That is, there should be an approximate balance between the number of trips which are reduced by urban auto travel through any auto restraint measures and the number of trips which are attracted to transit by incentives such as service improvements and fare reductions.

TABLE 8

SUMMARY OF EFFECTS OF VARIOUS OPTIONS ON FUEL SAVINGS FROM DEPARTMENT OF TRANSPORTATION PROGRAM

OPTION	Fuel Savings As % of Total Direct Transport Fuel 1980	1990
DOMESTIC PASSENGER HIGHWAY		
Auto: Vehicular Efficiency Improvements		
1) Market Response:		
(a) 65¢ current	2.7	7.0
(b) 65¢ real	9.8	11.8
2) Small Cars (19 mpg)	9.4	13.9
3) Lean Bum Engines	3.8	0.3
4) Stratified Charge Engines	4.0	13.3
5) Diesel Engines	3.0	12.4
6) Cont. Vars. Transmissions	3.3	13.0
7) Intermediate w/Tech. Options	3.0	14.7
8) Small w/ Tech. Options	9.4	21.4
9) Battery Electric	“?	?
10) Retrofits (radials only)	0.7	0
Load Factor (49% participation in carpools)	2.5	2.1
Operational Improvements		
1) Speed limits (55 m.p.h.)	1.4	1.2
2) Maintenance	0.7	0.4
3) Driving Habits	2.4	2.1
4) Traffic Flow	0.5	0.9
Demand Reduction	2	3
URBAN AUTO SHIFTS		
urban Auto to Bus	0.8	1.3
Urban Auto to Rail	No Potential	
urban Auto to Bicycle	0.6	0.9
IC AUTO SHIFTS		
Intercity Auto to Bus	0.3	0.7
Intercity Auto to Rail	0	0
AIR PAX SHIFTS		
Air Passenger to Auto	0.2	0.3
Air Passenger to Rail	0.1	0.2
Air Passenger to Bus	0.1	0.4
AIR FREIGHT SHIFTS		
Air Freight to Truck	o	.0
IC TRUCK SHIFTS		
intercity Truck Freight to Rail	.0.1	0.5

SOURCE: Pollard, Hiatt, and Koplow, *Summary of Opportunities To Conserve Transportation Energy*, Transportation Systems Center, A Report for the Office of the Secretary, Final Draft, January 1975.