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Transportation Energy Conservation Policies

Higher gasoline taxes and new car fuel economy standards are effective energy saving policies.

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Between the end of World War II and 1972, transportation fuel use grew steadily and rapidly because of increases in both passenger and freight traffic, shifts toward the use of less energy-efficient modes, and declines in energy efficiency for individual modes (*1*). However, since 1972 a number of forces have emerged that may significantly alter these trends in the future.

These forces include the Arab oil embargo and subsequent sharply higher prices for gasoline. After nearly two decades of falling "real" prices, the price of gasoline increased 26 percent between 1972 and 1974; since then prices have risen even higher (*2*). Because of these higher gasoline prices, personal consumption expenditures devoted to gasoline increased 23 percent between 1972 and 1974 (to $36 billion in 1974). Prices of new automobiles are also rising rapidly—up from an average of $3700 in 1972 to $4000 in 1973 (*3*)—although they are rising no faster than the overall Consumer Price Index.

In addition to these economic forces, a number of institutional changes are under way or under serious consideration. The National Mass Transportation Assistance Act of 1974 authorized the expenditure of nearly $12 billion during the period 1975 to 1980. Unlike previous federal programs for mass transit, the 1974 legislation authorized operating, as well as capital, grants for transit systems. The automobile industry, under pressure from the federal government, agreed to improve new car fuel economy 40 percent between 1974 and 1980 [from about 14 to 20 miles per gallon (mpg)]; recent federal legislation (*4*) requires 20 mpg in 1980 and 27.5 mpg in 1985. Modifications to the Federal Highway Trust Fund allow funds to be used for mass transit improvements and to encourage carpooling; several communities are beginning to institute significant carpool programs.

The extent to which these and other new forces will operate on traditional patterns of personal travel and land use to change the energy intensiveness and energy use of our transportation system is the subject of this article. I examine the period 1950 to 1972 with respect to personal travel and energy use for it, review the relative energy efficiencies of different urban and intercity passenger systems, discuss several policies for reducing transportation fuel use, and compare the energy savings likely with each of these policies in 1980 and 1985.

Four policies were selected for discussion here: (i) improving mass transit, (ii) increasing carpooling, (iii) raising gasoline prices, and (iv) imposing new car fuel economy standards. I chose these because they are important and widely discussed, and because there are analyses with which to evaluate their effectiveness. However, there are several other options, such as stricter enforcement of a speed limit of 55 miles per hour, wider adoption of right-turn-on-red, better urban traffic control systems, and a host of changes related to air traffic and freight traffic.

I conclude that, during the next decade at least, significant passenger transportation energy savings can be achieved only by improving new car fuel economy; such improvements can either be required by legislation or induced by increases in gasoline prices. Behavioral changes (greater use of mass transit and carpooling) are surprisingly insensitive to purely economic forces unless they are so strong as to be politically infeasible. Table 1 summarizes major results of the analyses discussed in this article. These results suggest the need for more and better programs to encourage people to change their attitudes toward energy use and personal transportation.

Historical Trends in Passenger Travel and Energy Use

Total transportation fuel use grew from 8.9 QBtu (8.9×10^{15} Btu) in 1950 to 18.3 QBtu in 1974 (*5, 6*) with an average annual growth rate of 3.0 percent. Between the mid-1960's and 1972 the growth rate was much higher at 4.7 percent a year. However, transportation fuel use increased only 3.3 percent between 1972 and 1973 and actually declined 3.2 percent between 1973 and 1974 (*5*). The 1974 decline was due to a combination of sharply higher fuel prices, spot shortages during the summer, the Arab oil embargo that winter, and the 2 percent decline in real gross national product (GNP) between 1973 and 1974.

Figure 1 shows actual transportation fuel use from 1965 through 1974 and projections to 1985 from three different sources. The Department of the Interior (DOI) projection (*7*) was prepared in 1972—long before recent oil price increases. The other two sets of forecasts, by Jack Faucett Associates (*8*) and the Federal Energy Administration (*6*), were

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Table 1. Energy impacts of transportation conservation measures. Energy savings are calculated relative to a baseline in which auto travel is 1.2×10^{12} vehicle-miles (VM) in 1980 and 1.4×10^{12} VM in 1985, urban travel accounts for 55 percent of this total, and average auto fuel economy is 14 mpg for both years and 12 mpg in urban areas. Average automobile occupancy is 2.2 PM/VM and urban occupancy is 1.6 PM/VM (PM = passenger-miles).

Policy	Estimated energy savings (thousand barrels per day)	
	1980	1985
Increase percentage of urban travel carried by mass transit from 2.5 percent in 1973 to 5.0 percent in 1980 and 7.5 percent in 1985	52	122
Increase carpooling sufficiently to reduce work-trip auto travel by 10 percent in 1980 and 1985	69	105
Increase gasoline prices by 20 percent starting in 1975	484	700
Increase new car fuel economy from 14 mpg in 1974 to 20 mpg in 1980 and 22 mpg in 1985	568	1327

prepared during the summer of 1974 as part of the Project Independence effort. These forecasts used crude oil prices (in 1973 dollars) of \$7 and \$11 a barrel. The variation among forecasts is considerable. The DOI forecast is much higher than the others, presumably because it assumes the low oil prices of the 1960's; its growth is equal to the long-run growth rate over the past two decades. The other forecasts show growth rates far below the historical trend. If these latter forecasts prove correct, considerable fuel savings will be achieved in the transportation sector because of fuel price increases alone (due almost entirely to increases in new car fuel economy).

Intercity passenger traffic is carried primarily by automobile and, to a lesser extent, by airplane, bus, and train (*1*). The variation in energy intensiveness (EI) among these modes (Table 2) is considerable. Buses and trains are the most efficient modes, followed by autos and airplanes. In 1972, EI for airplanes was five times higher than for buses. However, airplanes are the fastest mode and automobiles are the most convenient.

Between 1950 and 1972, the fraction of intercity passenger traffic carried by airplane climbed rapidly at the expense of trains and buses. Energy consumption rose 192 percent as a result of a 156 percent growth in traffic and a 14 percent increase in overall EI (*1, 9, 10*). This increase in EI was due to increases in EI for individual modes and to the shift from buses and trains to airplanes.

Urban passenger traffic is carried almost exclusively by car, with only a small and declining fraction carried by mass transit (buses and electric) (*1*). As Table 2 shows, mass transit is two to three times as energy-efficient as cars (*10–12*). Urban EI values are double comparable intercity values because of poorer vehicle performance (fewer miles per gallon) and poorer utilization (fewer passengers per vehicle) in cities.

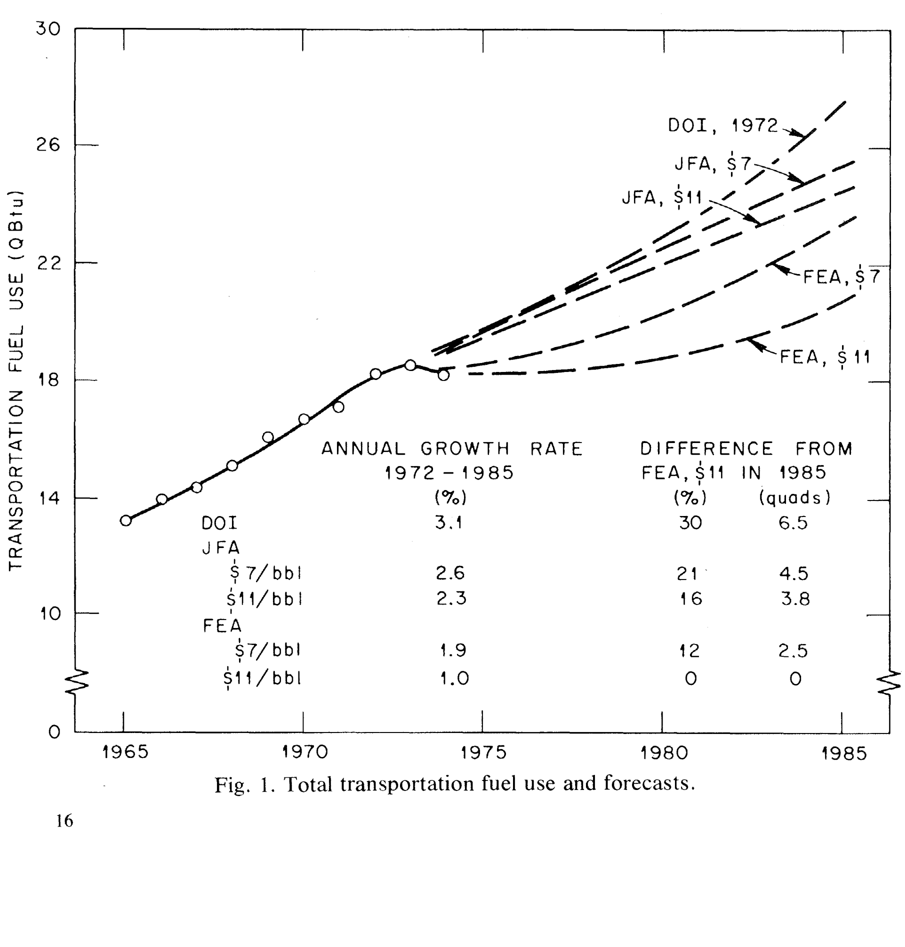


Fig. 1. Total transportation fuel use and forecasts.

Table 2. Energy intensiveness of passenger modes, 1972. Values were updated using data sources and methodologies discussed in (*1*). These national averages—ratios of total fuel used to total traffic carried by each mode—depend strongly on each mode's operating characteristics (load factor, trip length, speed, equipment type, and so forth). Approximate load factors (fraction of seats occupied) for these modes were: intercity airline, 0.5; automobile, 2.4 PM/VM; rail, 0.4; bus, 0.5; urban automobile, 1.6 PM/VM; rail transit, 0.4; and bus transit, 0.2.

Mode	EI (Btu/PM)	Mode	EI (Btu/PM)
Intercity		Urban	
Airline	7700		
Automobile	3100	Automobile	6700
Rail	2700	Rail transit	2600
Bus	1500	Bus transit	3000

Between 1950 and 1972, the fraction of urban passenger traffic carried by cars steadily increased. Energy use grew 219 percent, caused by a 161 percent rise in traffic and a 22 percent increase in EI (*1, 10–12*). Increased EI was due to higher individual modal EI and to the shift from mass transit to automobiles.

Figure 2 shows how EI for urban modes increased between 1950 and 1973. Similar increases in energy intensiveness occurred for the intercity modes, except for railroads.

Improved Mass Transit

Although mass transit is considerably more energy-efficient than are automobiles, it now accounts for such a small fraction of total urban passenger travel (2.5 percent in 1973) that its short-term potential contribution to energy conservation is slight. The data shown in Table 3, from three recent mass transit programs (*13, 14*), suggest that the energy impacts of transit fare reductions and service improvements [such as expanded area coverage and reduced time between vehicles (headway)] are almost negligible.

There are several reasons for the slight energy impacts shown in Table 3. First, mass transit accounts for a tiny fraction of urban travel and an even smaller fraction of the urban travel energy budget.

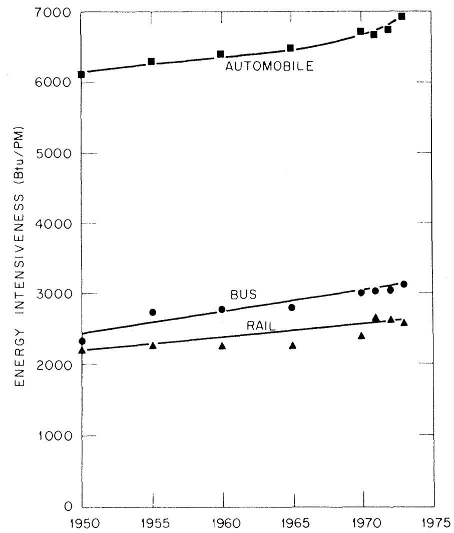
Thus sizable increases in mass transit traffic will have only slight impacts on total urban traffic and energy use. Second, while reduced fares and improved service will increase ridership, the experience cited above suggests that less than half the increase comes from former automobile drivers. The remainder are auto passengers, walkers, users of other transit systems, and people who formerly stayed home. Only shifts of auto drivers to mass transit reduce overall energy use. Third, expanded route coverage and reduced headways lower system load factors; this increases EI and energy use. Fourth, automobiles are often used to gain access to transit systems; the energy used for this must be subtracted from the energy savings due to the shift from auto to transit.

Figure 3 shows the sources of increased bus ridership (*14, 15*) due to the improvements in the bus system of Atlanta, Georgia, summarized in Table 3. In 1972, fares were reduced from 40 cents to 15 cents and a number of service improvements were instituted: some lines were extended, some were revised, new routes were established, and headways were reduced overall. The net impact of these changes was an increase in annual coverage from 19 to 22 million bus-miles.

Bus patronage increased 28 percent after the fare reduction and service improvements. Reducing fares increased load factors by increasing ridership with no increase in bus-miles. Service improvements, on the other hand, lowered load factors because ridership, in Atlanta at least, increased more slowly than did bus-miles. Overall, the combination of reduced fares and increased service raised load factors slightly. Because more than half of the new riders were not formerly auto drivers, the fuel saving—9300 gallons a day—is slight.

The major conclusion that can be drawn from Table 3 and Fig. 3 is that transit improvements alone offer little hope of large energy savings. Improving mass transit can save energy only if the increased transit ridership comes primarily from automobile drivers. Increasing transit patronage by attracting people from nonauto modes (such as other transit systems, walking, and bicycling) will probably increase urban passenger energy use. Thus saving energy through increased transit requires both the carrot and the stick. The carrot is to induce people to travel by mass transit and the stick is to force people out of their cars.

Even if transit improvements and auto disincentives are effective, mass transit



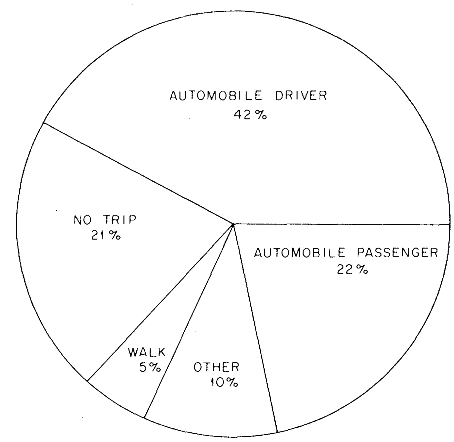


Fig. 2 (left). Energy intensiveness of urban travel modes, 1950 to 1973. Fig. 3 (right). Previous travel modes of new bus riders in Atlanta.

is unlikely to provide substantial energy savings during the next decade. The potential energy savings are limited by the small size of the present transit plant and the small fraction of urban travel moved by transit. Doubling the percentage of urban travel carried by transit from 2.5 percent in 1973 to 5.0 percent in 1980 would require 100,000 new buses during this 7-year period, compared with the 1973 national fleet of 46,000 buses (*11*).

Assuming that funds can be found to finance the purchase of these buses; that drivers, mechanics, and managers can be trained during this period; that ridership will increase; and that the new riders will come from automobiles; the energy savings for 1980 are equivalent to 52,000 barrels of crude oil a day (*10–12*). If the percentage of urban passenger travel carried by transit increases to 7.5 percent in 1985 (a tripling of its 1973 share), the national savings would be equivalent to 122,000 barrels of crude a day. As shown later, these savings are small relative to those possible with other transportation measures.

Although the short-term energy conservation potential of increased mass transit is slight, this does not mean that transit improvement programs should be abandoned. Changes in urban travel patterns are likely to require at least a decade because of long lags associated with changes in land use patterns, auto ownership, and individual attitudes toward public transportation. Thus, unless improvement projects are undertaken now, the long-term potential benefits of mass transit will never be realized. Also, mass transit offers other benefits besides reduced energy use: less congestion during peak periods, fewer traffic fatalities, and increased mobility for those with limited access to autos. Finally, combining transit improvements with auto disincentives provides a transportation alternative to those dislodged from their automobiles.

Table 3. Energy conservation impacts of transit improvements. Numbers in parentheses are percentages of regional transportation fuel use saved. Data are from (*13, 14*).

Strategy	Estimated savings (gallons per day)
Regional bus—Atlanta Fare reduced from 40 to 15 cents Service increased from 19 million to 22 million bus-miles per year Ridership increased 28 percent	9,000 (0.5)
Corridor service, bus—Washington, D.C. Shirley Highway (Route I-95), 11-mile busway in median Ridership increased from 1,900 to 11,500 per day in 5 years 40 percent of riders were auto drivers 30 percent of riders get to bus by car	3,000 (0.1)
Corridor service, rail—Philadelphia Lindenwold line Line carries 30,000 riders per day 28 percent of riders were auto drivers 90 percent of riders get to line by car	− 450 (0)

Carpooling

The average automobile load factor for urban work trips is presently only 1.2 passenger-miles per vehicle-mile (PM/VM) (*12*). Thus there is an enormous energy conservation potential in the empty seats in automobiles traveling during the daily peak hours. Increasing this load factor from 1.2 to 1.6 PM/VM would save 440,000 barrels of crude oil a day in 1980. However, there are serious questions concerning the methods available to induce greater auto occupancy and the effectiveness of these methods.

Cambridge Systematics, Inc. (CSI), has analyzed a variety of carpool promotion options (*16*), using a modification of their disaggregate travel demand models to estimate auto ownership and changes in work and nonwork travel in response to these policies. Their model has been applied to Washington, D.C., using data collected during the D.C. 1968 Home Interview Travel Survey. They have examined a number of carpool alternatives related to the cost and supply of parking, costs of auto travel (tolls, gasoline taxes, carpool subsidies), direct regulation of urban travel (auto-free zones, gasoline rationing), and employer incentives.

The preliminary outputs of the CSI model for a number of such alternatives are shown in Table 4. These results are short-run impacts; that is, they do not include long-run changes in auto ownership that will occur because of these policies.

Table 4 shows that parking incentives for carpools and major increases in parking costs substantially reduce the amount of solo driving and increase both carpooling and mass transit use. However, these reductions in commuter travel are partially offset by increases in nonwork auto travel, which arise because more automobiles are available for nonwork travel. In the long run many of these "extra" cars will probably not be replaced; thus the long-run energy savings are likely to be larger than the short-run savings.

As an example, consider the predicted impacts of an increase in areawide parking costs of $3 per day. The parking surcharge reduces work-trip miles traveled by 10 percent, a 3.9 percent reduction in overall urban travel. However, the induced nonwork travel amounts to 1.4 percent of the urban total. Thus the net impact of the surcharge is only a 2.5 percent reduction in urban auto travel.

The percentage reduction in fuel use is less than the percentage reduction in travel because of fuel penalities associated with the increased trip circuity and extra weight in carpooling and increased number of cold-starts in nonwork trips. Thus, urban auto fuel use is cut by only 2.1 percent compared with the 2.5 percent reduction in travel due to the parking surcharge. This is equivalent to a national fuel saving of 69,000 barrels of crude oil a day in 1980.

Let us assume that, in the long run, only half the induced short-run nonwork auto travel occurs. Then, if long-run equilibrium is achieved in 1985, the 3.9 percent reduction in urban travel due to increased carpooling, coupled with the 0.7 percent increase in nonwork travel, reduces urban travel by 3.2 percent. This amounts to a 2.7 percent reduction in urban auto fuel use, equivalent to 105,000 barrels of crude oil a day in 1985.

These results—fuel savings of 2.1 and 2.7 percent in 1980 and 1985, respectively—show a remarkable insensitivity of commuters to changes in travel costs. Adding $3 a day to the base cost of parking increases the overall cost of commuting by 100 to 200 percent. The response to this enormous change in cost is only a 10 percent reduction in work-trip travel.

Policies that affect all automobile travel (both work and nonwork) are likely to be more effective in saving energy for two reasons. First, work trips account for only a third of all auto travel (although they account for about 40 percent of all auto gasoline use). Second, nonwork trips are likely to be more discretionary than are work trips and therefore more sensitive to changes in dollar and time cost.

The results of this ongoing CSI study should be interpreted cautiously. The data used to construct the model are from 1968, a time when fuel prices were low, Washington's transit service was poor and deteriorating, Americans loved their cars, and incomes were rising steadily. Thus the data are from an era in which our attitudes and behavior strongly favored automobile ownership and use. Also, models such as that developed by CSI capture the major demographic and economic variables affecting travel decisions, but they cannot explicitly model changes in attitudes. To the extent that attitudes toward energy use, carpooling, and automobiles have changed since 1968, the model's results are in error. Finally, CSI's model evaluates only the short-run impacts of policy changes. As households adjust their auto ownership and home location in response to these policies, the impacts of the policies may increase.

Table 4. Energy impacts of carpooling policies in Washington, D.C. "Parking incentives" refer to the restriction that close-in parking spaces are reserved for carpoolers. "Parking incentives and parking costs" add a $2-per-day parking charge for solo drivers. Data are from (*16*). Base values (row 1) are those used to compute the percentage changes given below them.

Policy	Work-trip mode share (%)			Vehicle-miles traveled			Fuel consumption (gallons per day)
	Drive alone	Car-pool	Mass transit	Work	Non-work	Total	
Base values (excluding weekend travel)	52.9	25.4	14.5	10.4	16.7	27.1	2.58
	Percentage change from base value						
Parking incentives	−10.69	22.05	0.40	−3.37	1.02	−0.64	−0.55
Parking incentives parking costs	−22.27	43.82	4.55	−9.82	2.50	−2.24	−1.83
Base parking cost + $1 (areawide)	−5.07	4.50	10.61	−3.27	0.71	−0.81	−0.68
Base parking cost + $3 (areawide)	−15.61	13.93	32.57	−10.20	2.29	−2.49	−2.07
Base parking cost + $3 (central business district only)	−6.52	2.97	17.83	−4.04	1.04	−0.92	−0.78
Carpool subsidy, 5 cents/PM	−4.04	11.31	−5.06	−2.47	0.43	−0.68	−0.50

Gasoline Taxes

One policy that is often discussed but rarely embraced is an increase in the federal tax on gasoline, currently at 4 cents a gallon. Those favoring an increase argue that it would reduce gasoline use, allow maximum consumer choice (in terms of changes in both vehicle use and vehicle ownership), and be simple and inexpensive to administer. Opponents argue that its economic burden on low-income families would be intolerable, that consumer demand for

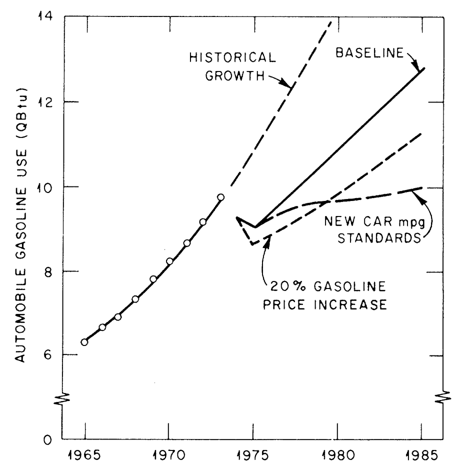


Fig. 4. Automobile gasoline use forecasts to 1985.

gasoline is insensitive to price changes, and that further increases in gasoline prices would adversely affect economic recovery.

The Office of Energy Systems in the Federal Energy Administration (FEA) developed a simple econometric model for estimating changes in automobile travel, fuel economy, and ownership in response to changes in gasoline prices (and also to exogenous changes in new car fuel economy) (*17*). The model contains three behavioral equations that estimate annual demands for automobile travel, new car sales, and new car fuel economy as functions of income, unemployment, gasoline price, and the average age of the automobile stock.

Automobile gasoline use from 1965 to 1973 and several projections to 1985 (using the FEA model) are shown in Fig. 4. The gasoline tax in these simulations is expressed as a constant percentage of the base price to avoid problems with inflation (in which a current dollar tax becomes weaker each succeeding year); the tax (20 percent) is imposed in 1975 and remains in effect during the 10-year simulation.

Between 1965 and 1973, automobile gasoline use increased at an average annual rate of 5.6 percent. The top curve in Fig. 4 shows the continuation of this historical trend. The curve marked baseline represents the output from the FEA model, assuming that the "real" price of gasoline remains constant at its assumed 1975 level (55 cents a gallon) and that no new federal policies are imposed that would affect auto ownership and use. The baseline curve shows that recent increases in gasoline prices are expected to substantially reduce growth in gasoline use: from 5.6 to 3.5 percent annually. Increasing gasoline prices by an additional 20 percent further slows the annual growth rate to 2.7 percent. Relative to the baseline fuel use, the 20 percent tax saves the equivalent of 484,000 barrels of crude oil a day in 1980 and 700,000 barrels a day in 1985. These fuel savings are nearly an order of magnitude larger than those due to programs that increase carpooling or mass transit use.

The short-run price elasticity of demand for gasoline implied by the FEA model is −0.21; the long-run elasticity is −0.72 (*17*). These elasticities are in good agreement with those derived in other studies (*18*).

Figure 5 shows changes in new car fuel economy predicted by the model. In the baseline, fuel economy improves from 14 mpg in 1974 to 15 mpg in 1978 and then drops back to about 14.3 mpg during the next 7 years. This decline in fuel economy is due to the assumed rise in personal incomes: as incomes grow, the price of gasoline becomes a less important determinant of new car purchase decisions. The 20 percent gasoline tax simulated here causes a sharp increase in new car fuel economy to 17 mpg in 1978. Then fuel economy drops to an average of 16.2 mpg during the next 7 years.

The curves of Figs. 4 and 5 show that the major response to higher gasoline prices is an increase in new car fuel economy rather than a decline in auto travel. During the first year, however, approximately three-fourths of the change in gasoline use is due to reduced driving and only one-fourth is due to improvements in fuel economy (*18*). Auto travel is reduced 4 percent in 1975 and 1976, 2 percent in 1980, and 1 percent in 1985 because of the 20 percent increase in gasoline price (*17*). Thus, as more and more new cars (purchased after the gasoline price increase) enter the fleet, changes in auto travel become negligible.

New Car Fuel Economy Standards

The FEA model (*17*) can also be used to evaluate the impacts of mandated improvements in new car fuel economy. Figure 4 shows the model's predictions of automobile gasoline use when standards are imposed that require average new car fuel economy to increase from 14 mpg in 1974 to 20 mpg in 1980 and to 22 mpg in 1985. Figure 5 shows the imposed fuel economy schedule.

The gasoline savings due to these improvements in new car fuel economy are substantial—even higher than those due to the 20 percent gasoline price increase. However, because only about 10 percent of the automobile stock is "rolled over"

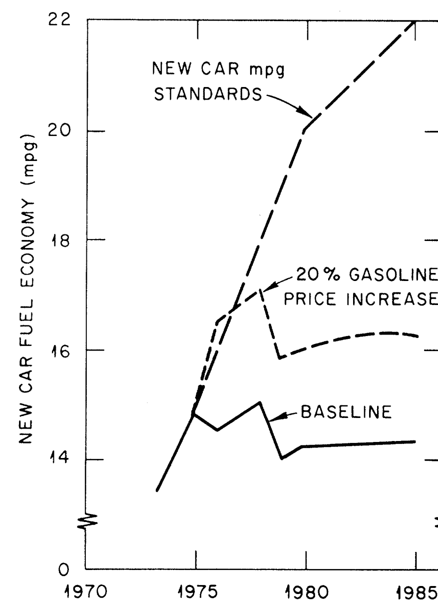


Fig. 5. New car fuel economy forecasts to 1985.

each year, it takes a few years before the standards have a major impact on fuel use. The schedule simulated here saves the equivalent of 568,000 barrels of crude oil a day in 1980 and 1,327,000 barrels a day in 1985.

Because improvements in new car fuel economy reduce the cost of driving per mile, one impact of the standards is a slight increase in the amount of auto travel; 3 percent in 1980 and 5 percent in 1985.

Figures 4 and 5 show that the 20 percent increase in gasoline price initially has a stronger effect on both new car fuel economy and auto fuel use than do the new car fuel economy standards considered here. However, as a larger and larger fraction of the automobile stock is influenced by a stricter and stricter fuel economy standard, the savings due to the standard equal and then surpass those due to the fuel price increase: the crossover point for the policies simulated here is in 1979. These results suggest that a gasoline tax increase is a potent short-run measure, while new car fuel economy standards are powerful in the long run.

Although the FEA model is an interesting and useful tool with which to analyze automobile gasoline use policies, it contains several weaknesses that must be considered in interpreting its outputs. The equations estimating demands for new cars and new car fuel economy are independent of automobile prices. This implicitly assumes that improvements in fuel economy will not affect vehicle prices and that automobile prices will change in the future (relative to the other explanatory variables in the model) as they have in the past. The model also assumes that a prespecified fraction of the existing automobile fleet is scrapped each year. Thus the dynamics of the new and used car markets and auto ownership are quite restricted. Finally, the model treats all automobiles as homogeneous entities; there is no market class distinction between, say, compacts and luxury cars. In spite of these deficiencies, the FEA model is probably the most useful tool available for analyzing these policy alternatives.

Conclusions

Table 1 summarizes the estimated energy savings for 1980 and 1985 due to the four transportation policies discussed here. Clearly, policies that directly affect automobile ownership and use (gasoline taxes and fuel economy standards) are much more effective in saving energy than are policies designed to shift travelers to energy-efficient alternatives (mass transit and carpools).

This suggests that, during the next decade at least, attention should be focused on technological means to reduce transportation fuel use. If the numbers in Table 1 are approximately correct, they show that behavioral changes (with respect to personal travel) are quite difficult to effect: people are extremely resistant to purely economic forces that seek to change their travel modes and extent of travel.

These results also suggest (implicitly) the need for much greater emphasis on informing people about energy problems and the need for conservation and demonstrating the attractiveness and viability of energy-efficient practices. These activities will encourage consumers to change their tastes and attitudes; changes in consumer behavior will then follow. In other words, social norms need to be modified so that people will want to carpool, will want to use mass transit, and will want to own small cars.

The analyses on which these conclusions rest involve techniques and data that are far from satisfactory. The models generally capture the important economic variables (such as prices and incomes). However, intangibles such as comfort, convenience, reliability, safety, what the neighbors think, and whatever else goes into individual decisions on how, when, and where to travel are not captured by these models. Therefore the models can predict behavior only when these intangibles (the variables not included in the models) do not change.

The models are generally based on data from the 1960's. To a surprising, perhaps frightening, degree, the United States today is quite different from what it was 10 years ago. This is true for fuel prices and also true with respect to individual expectations for the future and attitudes toward the environment, energy conservation, and automobiles. Thus decade-old data (even when used with very good models) may yield inaccurate estimates of behavioral changes. Also, the FEA model (*17*) is estimated by using time-series state-level data. CSI, on the other hand, uses detailed cross-sectional data for a single city for 1 year (*15*). Because of these differences in data, the results of these two models may not be consistent with each other.

Finally, a comprehensive model with which to evaluate these policies in combination does not now exist. Therefore, it is not possible to evaluate potential synergisms among the four policies considered individually in this article. Combinations of auto disincentives (such as an increased gasoline tax) and improvement of alternatives (carpooling, mass transit) are, intuitively at least, quite appealing. Such combinations are likely to maximize energy savings while minimizing adverse impacts of auto disincentives on mobility.

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