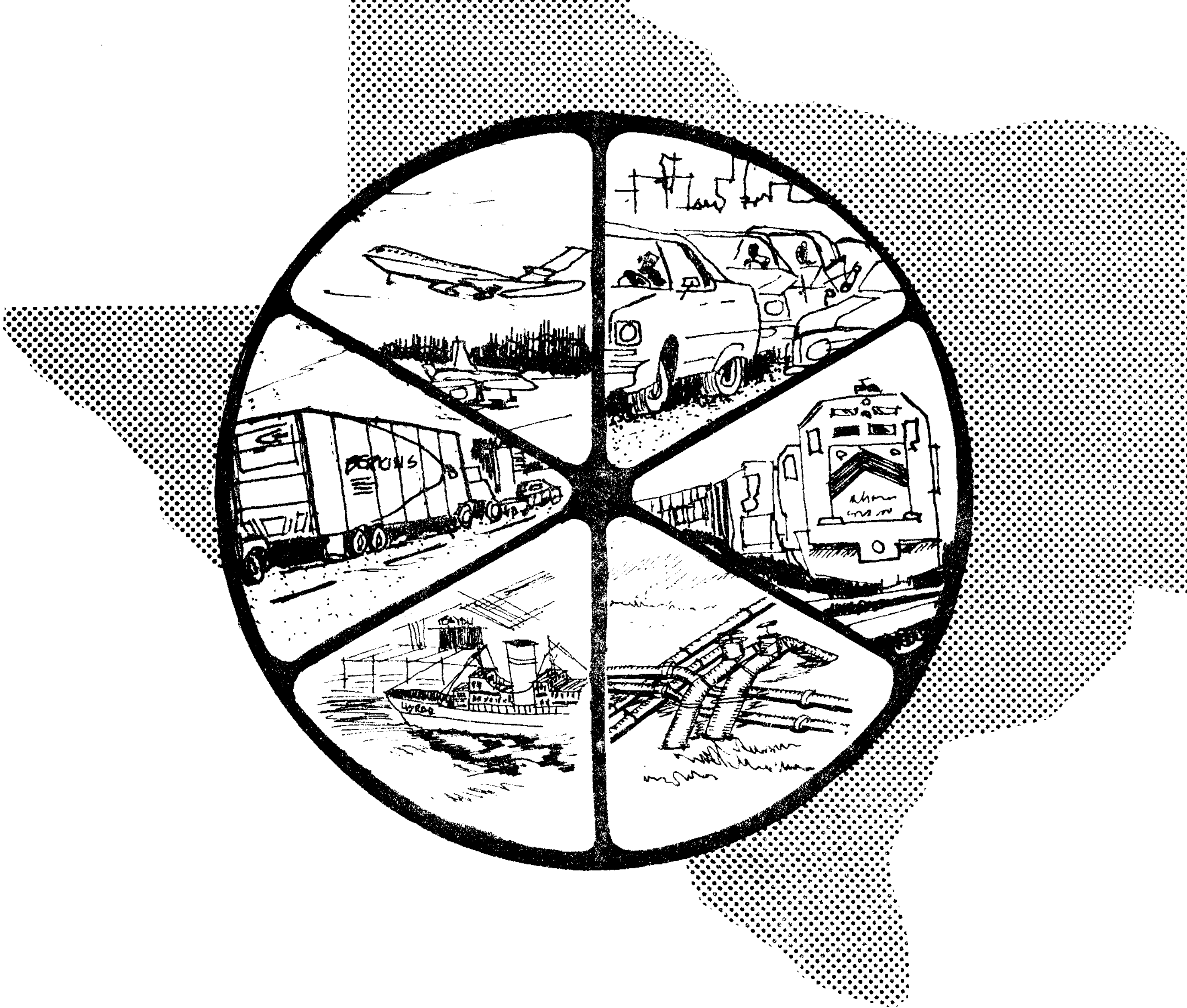
FINAL REPORT
VOLUME I

FUEL CONSERVATION MEASURES: THE TRANSPORTATION SECTOR



THE STATE OF TEXAS
GOVERNOR'S ENERGY ADVISORY COUNCIL

TTI
TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY

FUEL CONSERVATION MEASURES: THE TRANSPORTATION SECTOR

PROJECT S/D-9

FINAL REPORT, VOLUME I

EFFECT OF THE ENERGY SHORTAGE

MANDATORY FUEL CONTROL MEASURES

VOLUNTARY CONSERVATION MEASURES

Prepared For
Governor's Energy Advisory Council

by

Texas Transportation Institute
Texas A&M University
College Station, Texas

September 1974

PREFACE
Final Report, Volume I

Dimensioning the Problem

Transportation is essential to the nation's economy, and tremendous amounts of fuel are needed to sustain it. However, the United States is confronted with an energy shortage. The actual magnitude and duration of this shortage are dependent upon several non-transportation related considerations such as foreign policy and the lead time required to implement new technology. Faced with the energy crisis, Texans will be called upon to carefully examine their energy usage and pursue programs that will help bring the demand for fuel in line with the available supply.

The following approaches might be considered for reducing the consumption of transportation related energy:

1. mandatory governmental controls could be imposed to force a reduction in energy consumption;
2. an economic pricing system could be allowed to force an equality of energy supply-demand relations; and-or
3. citizens could be encouraged to voluntarily reduce their energy consumption.

Whereas each of the alternative methods would produce certain energy savings, there are also definite advantages and disadvantages associated with each (Table P-1).

This report presents the evaluations of numerous suggested conservation measures that might be initiated to conserve transportation energy. Estimates

Table P-1: Alternative Approaches to Reducing Transportation Fuel Consumption

Type of Control	Advantages	Disadvantages
1. Mandatory government controls	Amount of fuel consumed can be closely controlled	Not fair to all parties concerned. Severity of economic impact could be worse than degree of control provided.
2. Economic Pricing System	Decrease demand for fuel, thus equating demand and supply.	Adverse effect on low income persons, while not inconveniencing upper income households.
3. Voluntary Reduction	Can produce fuel savings without severely affecting the economy.	Must convince the population that energy shortage exists--this is primary disadvantage.

of potential fuel savings for each are also documented. For those instances in which data are available, an evaluation of the success of programs instituted since the energy shortage became public knowledge (such as reduced highway speed limits) is presented. This information should be of use to individuals responsible for formulating fuel conservation measures for the State of Texas.

This report is divided into four major sections. Section I summarizes the findings of this report. Section II discusses the relationship between transportation and energy. Sections III and IV evaluate mandatory and voluntary fuel conservation measures.

Fuel Conservation Terminology

Several key phrases will appear in the report. A definition of these terms is provided below.

- Statewide consumption of transportation fuel--all fuels used by all modes of transportation in Texas.
- Statewide highway motor fuel consumption--all fuels used by all highway-oriented modes of transportation. Included in this value is gasoline, diesel, liquified petroleum gas (LPG), and other special highway fuels.
- Statewide gasoline consumption--all gasoline used by highway-related transportation modes in Texas.

Dennis L. Christiansen
Ronald W. Holder

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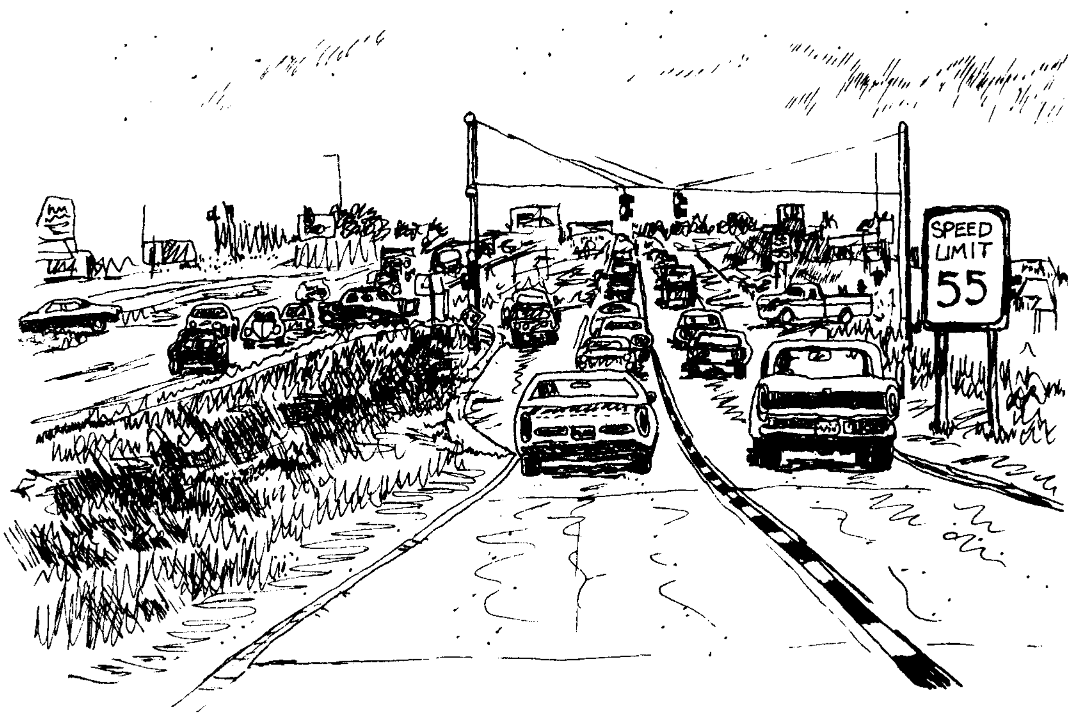


I. THE EFFECT OF THE ENERGY SHORTAGE ON STATEWIDE TRANSPORTATION FUEL CONSUMPTION

I. THE EFFECT OF THE ENERGY SHORTAGE ON STATEWIDE TRANSPORTATION FUEL CONSUMPTION

The consumption of highway transportation fuel in the State of Texas traditionally has shown an annual increase of between 6 and 8 percent (1, 2). However, the recent energy shortage experienced by the nation has altered this trend. Total motor fuel consumption for the first six months of 1974 has fallen 3.2 percent below 1973 levels for the same period.

For gasoline consumption alone, the percent of decrease is considerably more significant for the six month period, dropping 4.2 percent below 1973 consumption rates. Table I-1 shows a breakdown of the consumption data (3).

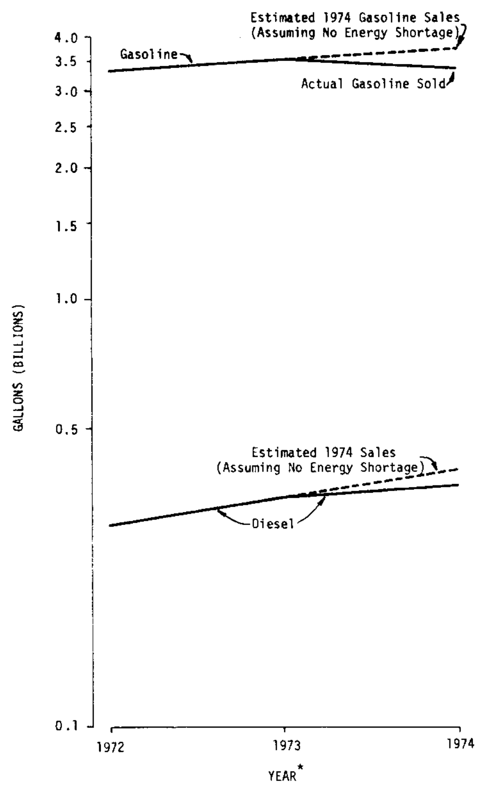
Table I-1: Trends in Highway Fuel Consumption

Year	Fuel Consumption During First Six Months					
	Gasoline		Diesel		Liquefied Petroleum	
	Gallons (Millions)	Percent Change	Gallons (Millions)	Percent Change	Gallons (Millions)	Percent Change
1972	3328		299		10.2	
1973	3533	+6.2	347	+16.3	11.6	+13.0
1974	3385	-4.2	368	+ 6.0	12.1	+ 5.0

Source: Texas Highway Department, Planning Survey Division

It is evident from Table I-1 that absolute energy savings in highway-related fuel were attributable to a decrease in the absolute consumption of gasoline. Consumption of both diesel and liquefied petroleum fuels continued to increase in 1974, though at a lesser rate than in 1973.

However, it is of interest to note that the percent of increase (decrease) in consumption for all the fuels shown in Table I-1 is, for the 1973 to 1974 period, approximately 10 percent less than it was in the 1972 to 1973 period. If fuel consumption had continued to increase at 1972 to 1973 rates, significantly more fuel of all types would have been consumed during the first half of 1974; in fact, if the 1972 to 1973 rates of increase in consumption had continued into 1974, an additional 367 million gallons of gasoline, 36 million gallons of diesel, and one million gallons of liquefied petroleum would have been consumed during the first half of 1974. Figure I-1 presents trends in fuel consumption.



* Data for first 6 months of year

FIGURE I-1: Gasoline and Diesel Fuel Consumption In Texas, 1972-1974

The analyses presented in this report suggest that a combination of factors was responsible for the reduction in fuel consumption in the first half of 1974. An accurate determination of specific factors is limited by deficiencies and inconsistencies in the sample data. However, the available information indicates general trends.

The principal factor responsible for reduced gasoline consumption appears to be the 4.7 percent reduction in vehicle miles of travel that occurred in the first six months of 1974 compared to the same period during 1973. Again, an increase rather than a decrease would have been expected, as vehicle miles of travel from January through June of 1973 were 6.5 percent higher than during these same months of 1972 (4). Table I-2 compares the vehicle miles of travel and the percent changes for these periods. Trends in vehicle miles of travel are graphically presented in Figure I-2.

Table I-2: Trends in Vehicle Miles of Travel in Texas, 1972-1974

Year	Vehicle-Miles of Travel During First Six Months	
	Millions of Vehicle Miles	Percent Change
1972	36,829	
1973	39,225	+6.5
1974	37,362	-4.7

The implementation of a reduced speed limit slowed traffic on Texas highways and, consequently, contributed to a reduction in fuel consumption. Available data presented in Section III of this report suggest that this reduced fuel consumption by, at most, 3.0 percent.

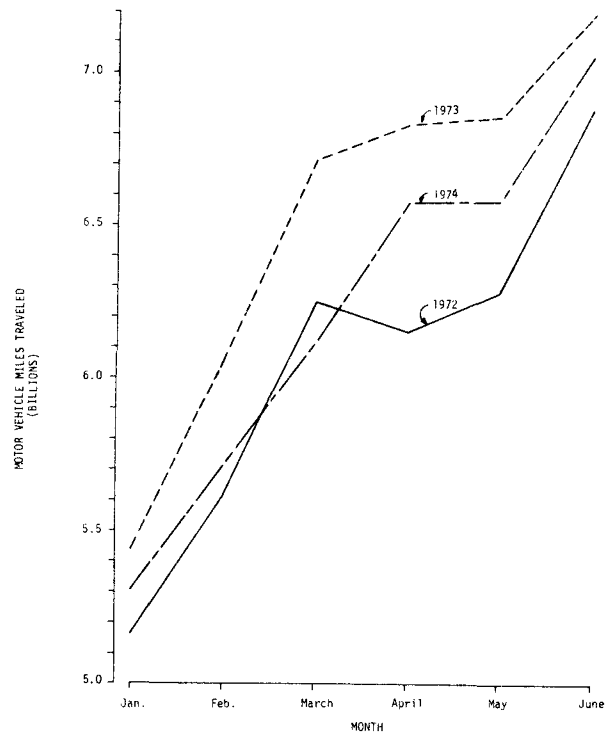


FIGURE 1-2: Total Vehicle Miles in Texas, 1972-1974

In summary, fuel consumption showed an absolute reduction for the first six months of 1974, as compared to the same period of 1973. Available data suggest that reduced travel accounts for a decrease of 4.0 to 5.0 percent, whereas a reduced highway speed limit is responsible for a 3.0 percent decrease. Analysis of the primary causative factors (reduced travel and lower speed limits) indicates that total fuel consumption should have been reduced by 7 to 8 percent; however, an absolute reduction of only 3.2 percent was realized. Although the data apparently indicate an overestimate of the actual gasoline savings, the significant point is that gasoline consumption declined, rather than increased, in an effort to cope with the energy shortage.

As mentioned previously, reduced travel was a principal factor in the gasoline consumption decline. There were two primary reasons individuals drove their automobiles less. First, many individuals desired to keep their gasoline tanks reasonably full and voluntarily curtailed automobile trips. The other reason is the result of mandatory fuel controls by governmental agencies. In this category, the Sunday closing of gasoline stations and the allocation of gasoline to service stations would appear to have had the greatest influences on travel. The unavailability of gasoline on Sunday decreased gasoline consumption in Texas by an estimated one percent. The fuel allocation program created difficulties and uncertainties for the individual in purchasing fuel. This no doubt contributed to the "voluntary" reduction in travel. Also, the reduced speed limit probably discouraged some intercity auto trips because of increased travel time.

Finally, if the energy shortage had not occurred, fuel consumption could have been expected to increase by 7 percent for the first half of 1974. However, consumption of fuel decreased by 3.2 percent during this time period. Consequently, it appears that the energy shortage reduced fuel consumption for the first six months of 1974 by approximately 10 percent. This trend may not continue during the remainder of 1974. The greatest fuel savings in 1974 occurred in the month of February (Figure I-3). Since that time, the fuel savings have been much less each month; with fuel consumption up to the 1973 level in the month of June.

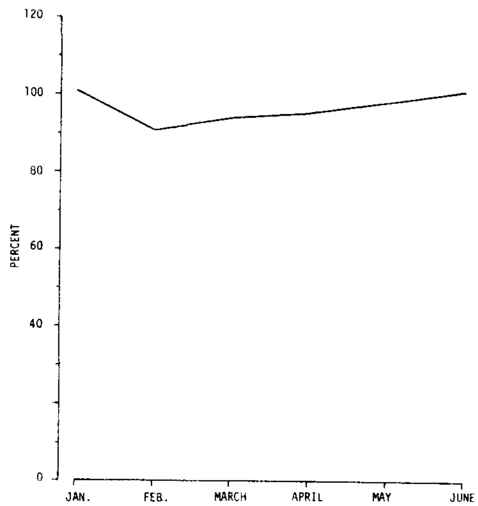


Figure I-3: Total 1974 Motor Fuel Consumption As a Percent of 1973 Consumption, Texas Data, By Month

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3. Texas Highway Department, Planning Survey Division, Motor Fuel Consumption and Tax Receipts for Texas, 1972-1974. Unpublished Data.

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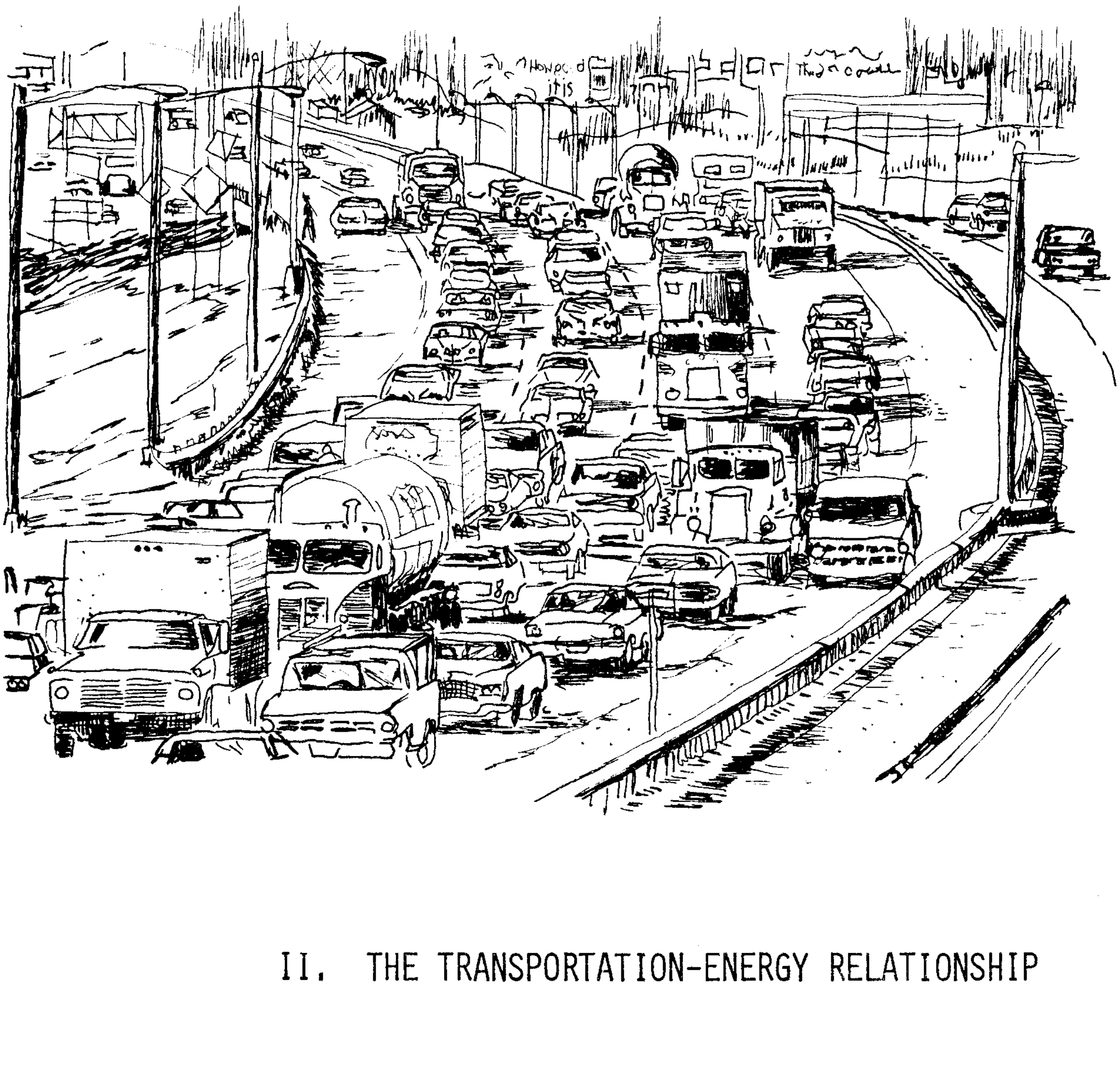


II. THE TRANSPORTATION-ENERGY RELATIONSHIP

II. THE TRANSPORTATION - ENERGY RELATIONSHIP

This section contains data related to transportation-energy activities and provides the basis for many of the evaluations included in subsequent sections of the report.

Energy Consumed by the Transportation Sector

Crude petroleum, used to produce over 95 percent of all transportation fuels, represents about 40 percent of all mineral fuel resources consumed in the United States (6). The transportation sector utilizes about 25 percent of total U.S. fuel consumption. Therefore, transportation uses about 60 percent of all crude oil consumed in the United States (1). Projections of transportation fuel needs suggest that this percentage will remain reasonably constant (2).

Fuel Consumption and Efficiency of the Various Modes of Transport

Highway-oriented transportation consumes the majority of transportation fuel (Table II-1). Passenger automobiles consume the greatest percentage (60 percent) of total transportation fuel.

Table II-2 illustrates the magnitude of passenger and freight transport served by the different modes of travel. Highway travel serves the great majority of passenger movement, whereas freight transport is served primarily by rail and water (1, 3).

It is evident from Table II-3 that certain modes of travel use fuel more efficiently than others. Bus and train transportation are most efficient for passenger movement, whereas water, pipelines, and rail are most efficient for freight transport (2).

Table II-1: Consumption of Transportation Fuel by Alternative Modes of Transport, United States Data, 1971

Mode of Travel	Percent of Total Transportation Fuel Consumed	
Highway Use	84	
Passenger Cars		60
All Trucks		23
Buses		1
Non-highway Use	16	
Railroad		4
Scheduled Domestic Air Carriers		7
General Aviation		1
Water, Inland and Coastal		4
TOTAL	100	100

Table II-2: Percent of Passenger and Freight Traffic Served By Alternative Modes of Transportation In The United States

Mode of Travel	Percent of Passenger-Miles Served	Percent of Ton-Miles of Freight Served
Highway (Car, Bus, Truck)	88.8	18.2
Railroad	0.7	34.7
Water, Inland and Coastal	0.3	27.8
Aviation	10.2	0.2
Pipeline	0.0	19.1
TOTAL	100	100

Source: References 1 and 3

Table II-3: Fuel Efficiency of Alternative Modes of Transportation

Passenger: Transport type	Passenger miles per gallon	Freight: Transport type	Cargo ton miles per gallon
Large jet plane (Boeing 747)	22	One-half of a Boeing 707 (160 tons, 30,000 hp)	8.3
Small jet plane (Boeing 704)	21	One-fourth of a Boeing 747 (360 tons, 60,000 hp)	11.4
Automobile (sedan)	32	Sixty 250-hp, 40-ton trucks	50.0
Cross-country train*	80	Fast 3000-ton, 40-car freight train	97.0
Commuter train†	100	Three 5000-ton, 100-car freight trains	250.0
Large bus (40 foot)	125	Inland barge tow, 60,000 gross tons	220.0
Small bus (35 foot)	126	Large pipeline, 100 miles, two pumps	500.0
Suburban train (two-deck)‡	200	100,000-ton supertanker, 15 knots	930.0

*One 150-ton locomotive and four 70-seat coaches plus diner lounge and baggage coach. †Ten 65-ton cars and two 150-ton 2000-hp diesel locomotives. ‡A ten-car gallery-car commuter train, 160 seats per car.

Reproduced from reference 2.

Although Tables II-1 through II-3 are based on U.S. data, these values should be reasonably representative of transportation characteristics in Texas.

Characteristics and Trends in Highway Transportation

The private automobile is the major means of transportation in the State of Texas. Indicators of travel show that the per capita vehicle miles traveled in Texas and vehicle ownership by Texans exceed the national average by 9 and 11 percent, respectively, as shown in Table II-4. Compared with data from other states, Texans have for a number of years exceeded the national average in their miles of autmobile travel.

Table II-4: Indicators of Travel, Texas and the United States

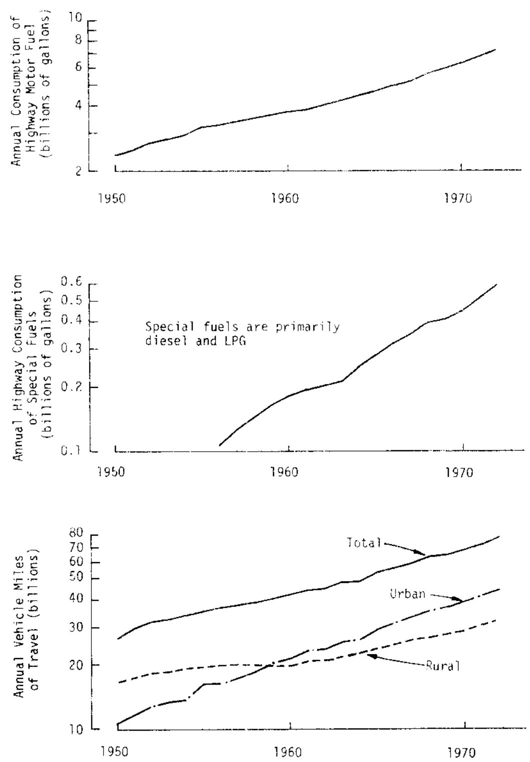
Travel Indicator	Texas		United States	
	1960	1970	1960	1970
Population (millions)	9.6	11.2	179.3	200.3
Licensed Drivers (millions)	4.4	6.4	87.3	111.5
Registered Vehicles (millions)	4.5	6.7	73.9	108.4
Vehicles Per Person	0.47	0.60	0.41	0.54
Vehicles Per Licensed Driver	1.02	1.05	0.85	0.97
Gallons of Highway Motor Fuel Consumed Per year (billions)	3.7	6.3	57.9	92.3
Highway Motor Fuel Consumed Per Vehicle Per Week (gallons)	16.1	18.1	15.1	16.4
Vehicle Miles of Travel Per Year (billions)	41.3	68.0	718.9	1,120.7
Percent Urban Vehicle Miles	52	58	46	51
Vehicle Miles Per Person Per Year	4,300	6,100	4,000	5,600

Source: References 4-12

Per capita travel in Texas has, historically, been increasing. Between 1960 and 1970, the population of Texas increased at an annual rate of less than two percent. During this same period, however, factors such as vehicle miles of travel per person and gallons of gasoline consumed per vehicle have increased at annual rates of three to four percent (5, 6, 7, 10).

The increase in per capita travel has also resulted in an increase in fuel consumption. Although gasoline consumption has been increasing, an even greater increase has occurred in the consumption of special fuels such as diesel and LPG (Figure II-1).

The upward trend in per capita travel is not expected to continue at the same rate that has been evident over the last decade. (4-12). By the year 1980, it is anticipated that registered vehicles and licensed drivers should be equivalent to eligible drivers in Texas (Figure II-2). Thus, regardless of the energy situation, the rate of increase in per capita travel can be expected to decrease in the future because a saturation level of licensed drivers per capita should exist in Texas by 1980. Consequently, the future demand for auto fuel in Texas should not increase as rapidly as has been the case.



Source: References 5,6,7

FIGURE II-1: Trends in Fuel Consumption and Vehicle Miles of Travel in Texas, 1950-1972

A breakdown in vehicle miles of travel by type of roadway is provided in Table II-5. Urban vehicle miles of travel constitute nearly 60 percent of statewide vehicle miles of travel. However, due to the lower fuel efficiency that is characteristic of urban driving, it is estimated that 70 percent of statewide fuel consumption occurs in urban areas (5,7).

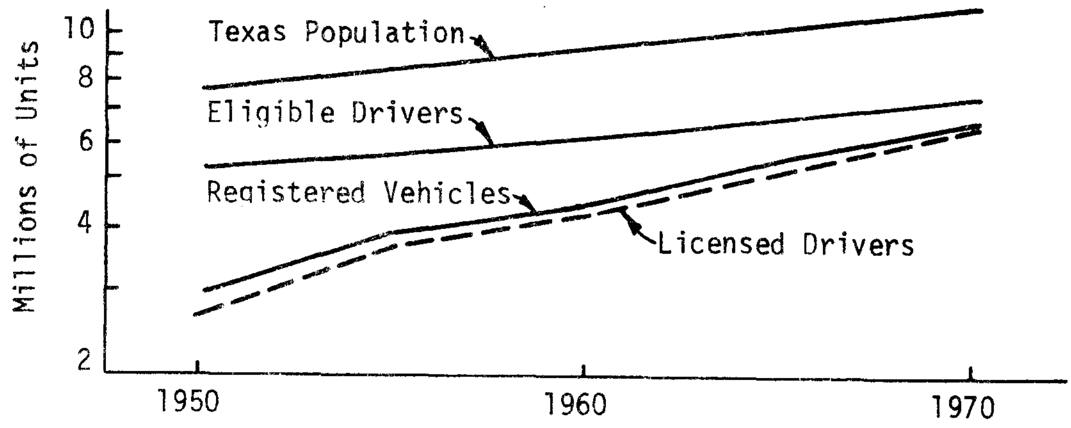


FIGURE II-2: Characteristics of the Texas Driving Population, 1950-1970

Table II-5: Vehicle Miles of Travel in Texas By Type of Road System, 1972

TYPE OF ROAD	RURAL		URBAN	
	Annual Veh. Miles (MVM)	% of Rural Veh. Mi.	Annual Veh. Miles (MVM)	% of Urban Veh. Mi.
State Highways, total	23,280	73	24,417	55
Interstate (FAI)	7,192	22	10,273	23
FAP less FAI	11,574	36	9,634	22
FAM	0	0	1,781	4
FAS	4,319	14	2,039	5
Non FA	195	1	690	1
Farm to Market, total	5,518	17	1,992	5
FAM	0	0	229	1
FAS	4,372	14	1,374	3
Non FA	1,146	3	389	1
County Roads and Streets	3,154	10	0	0
FAM City	0	0	524	1
FAP II Topics	0	0	568	1
City Streets	0	0	17,127	38
Total	31,952	100	44,628	100

Source: Reference 7

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2. Lincoln, D. A. *Energy Conservation.* Science, Vol. 180, No. 4082, April 13, 1973.

3. Holder, et al. *Transportation in the Texas Coastal Zone.* Prepared for the Office of the Governor by the Texas Transportation Institute, Texas A&M University, March 1973.

4. Texas Highway Department. *Urban Transportation Studies and Origin-Destination Surveys for Various Texas Cities.* 1956-1970.

5. U.S. Department of Transportation. Federal Highway Administration. *Highway Statistics, Summary to 1965.* 1967.

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7. Texas Highway Department, Planning Survey Division. *Daily Vehicle-Miles, All Texas Road Systems, 1950-1971.* Unpublished Data, 1972.

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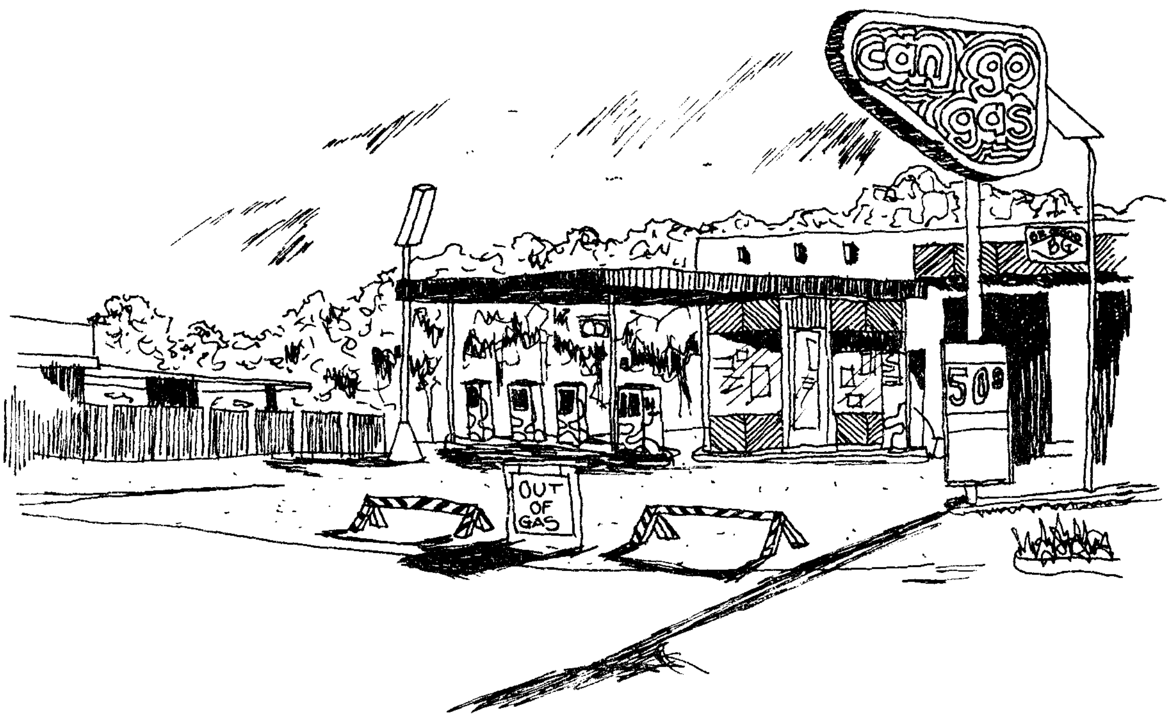
12. Christiansen, Dennis L. and Vergil G. Stover. *A Preliminary Evaluation of the Temporal Stability of Trip Generation Rates.* Texas Transportation Institute Research Report 167-6, Prepared for the Texas Highway Department and the Federal Highway Administration, April 1973.

III. MANDATORY FUEL CONTROL MEASURES



III. MANDATORY FUEL CONTROL MEASURES

Governmental bodies have the authority to initiate certain actions that will result in reduced fuel consumption. These actions may require new legislation or may be enacted by using existing legal powers. Measures such as reduced speed limits, gasoline rationing, and motor fuel allocation schemes, are included in these powers. These actions are mandatory, and failure to comply is a violation of the law. A discussion of some of these measures is presented in this section.

Reducing Speed Limits on Rural Roads

Initiation and Compliance

In January 1974, a federal law was enacted requiring all states to reduce speed limits to 55 mph in order to continue to qualify for federal highway aid. Due to the magnitude of speeds involved, this law has very little effect on urban driving.

Accordingly, in January 1974, Texas established 55 mph as the maximum legal speed limit. The previous speed limit on state and federal numbered highways outside of urban districts is presented in Table III-1(1).* The new speed limit was initiated to save fuel; motor vehicles require additional fuel to travel at higher speeds. This resulted in approximately a 3 percent reduction in the statewide consumption of highway motor fuel.

Table III-1: Speed Limits on Texas Highways, 1973

	Type of Vehicle	
Time of Day	Cars	Trucks and Buses
Daytime	70	60
Nighttime	65	60

The new speed limit, combined with the public awareness of an energy shortage, has resulted in a marked decrease in travel speeds on Texas highways (Figure III-1). Speeds on Texas highways have been historically

* Denotes number of reference listed at end of section.

increasing. This trend was dramatically reversed in 1974 (2). It should be noted, however, that speeds are beginning to rise. Highway speeds in July were noticeably higher than in April.

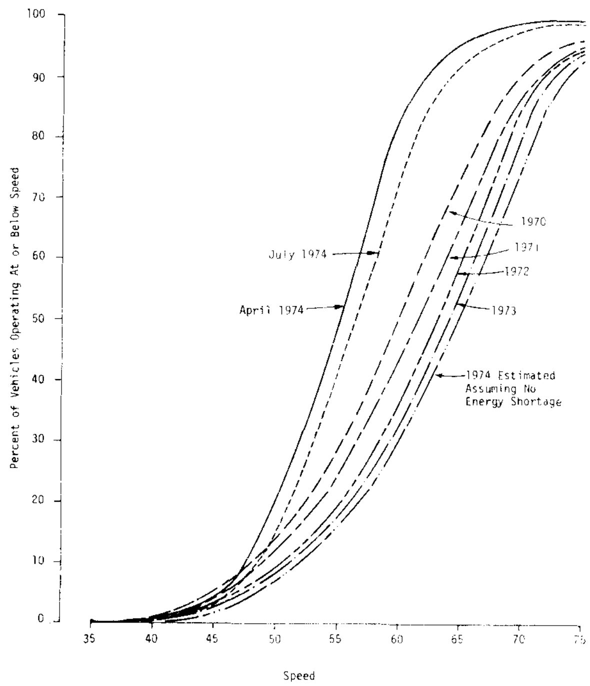


Figure III-1: Daytime Speed Distributions on Texas Highways
All Vehicles, 1970 - 1974

Although the new speed limit has significantly reduced highway speeds, it has also resulted in a greater percentage of vehicles operating at speeds above the legal limit (Table III-2). Nearly 55 percent of the vehicles operating on Texas highways were traveling faster than the legal speed limit in April, while over 60 percent of the vehicles were in violation of the speed limit in July (2).

Table III-2: Percent of Vehicles Operating at or Below the Posted Speed Limit, April 1974

Type of Vehicle	Percent Operating at or Below Speed Limit	
	1973	1974 (April)
Automobile	79.1	45.3
Panel/Pickup	89.7	49.8
Other Single Unit Truck	66.2	66.7
3-Axle Truck Comb.	65.3	59.4
4 or More Axle Truck Comb.	55.5	42.6
Buses	37.0	44.7
All Vehicles	--	46.8

Pertinent Information/Assumptions

At speeds of above 40 mph, a nearly linear relation exists between operating speed and miles per gallon (Figure III-2) (3,4). Table III-3 presents the percent of vehicles operating in the various speed ranges and the gallons per mile required to operate at the mean speed of each speed range (2,3,4).

An indicator of fuel consumption before and after the speed limit change can be derived from the information in Table III-3. By multiplying the percent of vehicles operating in a speed range by the gallons per mile characteristic of that range, an indication of the fuel consumed by the range can be obtained (e.g. in the 35 to 45 mph range, 0.050 gallons per mile multiplied by 3.2

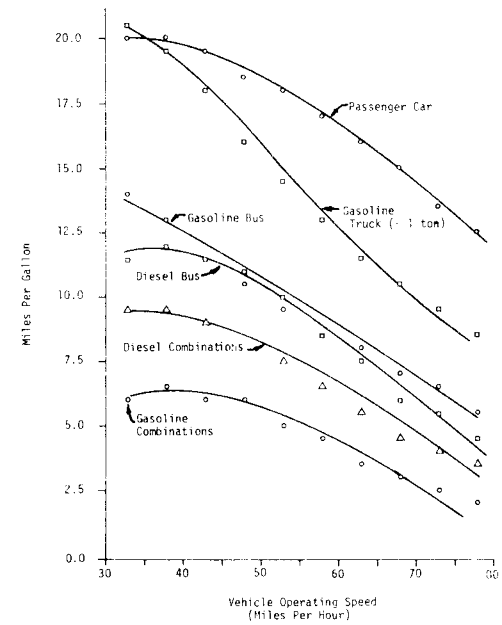


Figure III-2: Estimated Fuel Consumption of Selected Vehicles

Table III-3: Operating Speed and Fuel Consumed as Related to Texas Speed Distribution

Speed Range (mph)	Gallons of Fuel Consumed Per Vehicle Mile	Percent of Vehicles Operating in Speed Range	
		1974 (Actual)	1974 (Estimated Assuming No Energy Shortage)
35-45	.050	3.2	2.0
45-55	.053	43.6	14.0
55-65	.059	48.8	35.5
65-75	.068	4.1	42.0
75-	.082	0.3	6.5

percent of the vehicles equal 0.16). The sum of these products for each situation is then determined. The sum for 1974 (actual) was 5.65 and the sum for 1974 (estimated assuming no fuel shortage) was 6.33, indicating the lower speed reduced fuel consumption by 10.7 percent [(6.33 - 5.65) ÷ 6.33]. Since rural travel accounts for 30 percent of statewide fuel consumption, this results in a 3.2 (10.7% x 30%) percent reduction in statewide highway fuel consumption.

It might be argued that the reduced speed limit discouraged some inter-city travel and, thus, reduced fuel consumption by an even greater amount. However, any additional savings that might have resulted from the reduced speed limit discouraging travel will have at least been compensated for by the estimating procedure used to evaluate the effect of the speed limit. This procedure will tend to overestimate fuel savings for the following reasons.

- The estimate is based on daytime speed distributions. Speeds are higher during the day and thus, so is the potential for fuel savings.
- The April speed distribution curve was used in the estimate. Highway speeds have increased since April.

Enforcement of Speed Limit

The Texas Department of Public Safety has made a concerted effort to enforce the new speed limit. The number of speeding citations issued in 1974 has increased significantly over previous years (Figure III-3) (5). This has no doubt had an influence on the number of motorists observing the reduced speed limit. However, comparison of Figures III-1 (increase in speeds from April to July) and III-3 substantiates the conclusion that enforcement alone cannot bring about compliance with an unpopular law.

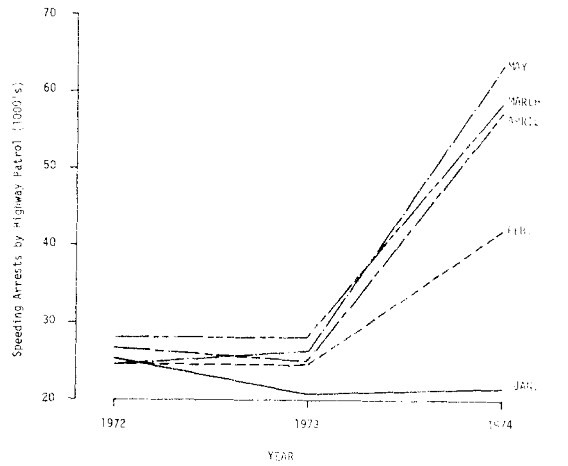


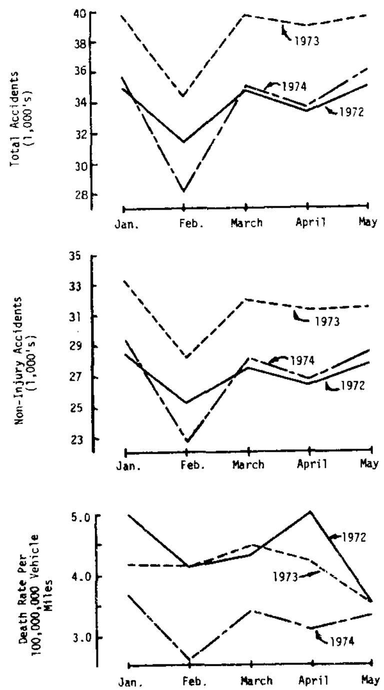
Figure III-3: Trends In Speeding Arrests On Texas Highways

The increase in speeding citations will result in a substantial amount of additional revenue. The Texas Department of Public Safety is currently issuing about 30,000 speeding citations per month more than were issued in 1973 (5). If this trend continues, some 360,000 additional citations will be issued per year. If each of these citations yields $20 in revenue, in excess of $7 million will be realized in new revenue.

Effect on Accidents

After the reduced speed limit was implemented, a substantial decrease in traffic accidents and traffic fatalities occurred (Figure III-4) (6). Many transportation experts have attributed this entire decrease to the reduced speed limits.

However, a more detailed analysis of the accident data suggests that not all of this decrease is the result of the reduced speed limit (Figure III-5). The 55 mph speed limit had little influence on urban travel; nevertheless, in comparing 1974 with 1973, the average monthly percent reduction in urban accident fatalities (23%) has been nearly equivalent to the



Source: Texas Department of Public Safety

FIGURE III-4: Accident Trends on Texas Roadways

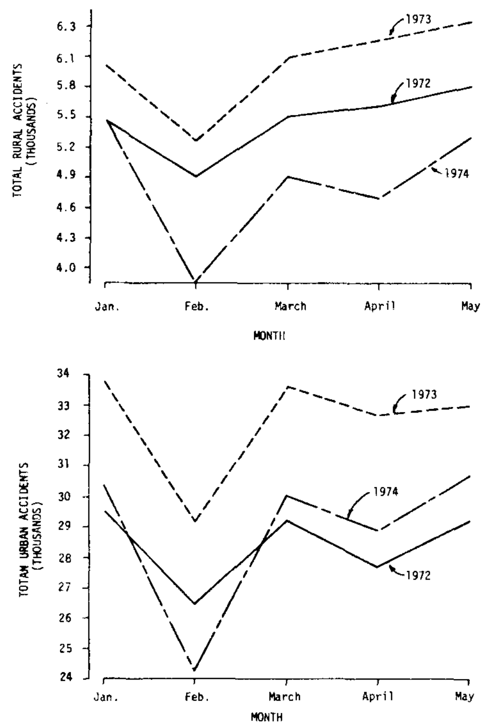
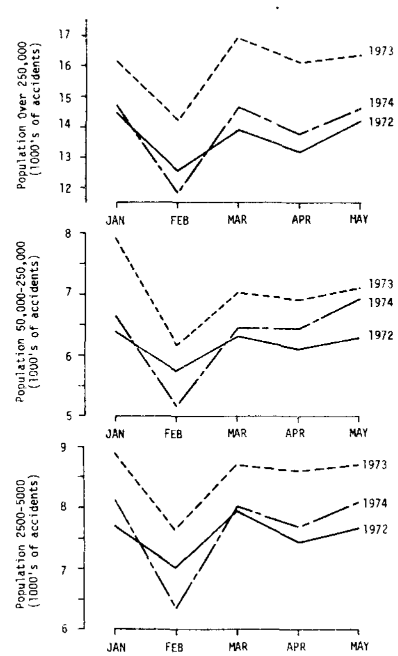


FIGURE III-5: Accident Trends, Rural and Urban Areas, 1972-1974



Source: Texas Department of Public Safety

FIGURE III-6: Accident Trends in Texas Urban Areas by Size of Urban Area, 1972-1974 reduction in rural accident fatalities (25%). A larger decrease (19%) in total accidents has occurred in rural areas relative to urban areas (14%) (6).

Texas accident data suggest that the decrease in total accidents has been approximately the same in all sizes of urban areas (Table III-4 and Figure III-6). The percent decrease in fatal accidents has been greater in the smaller urban areas.

Table III-4: Accident Reductions In Various Size Urban Areas, 1973 to 1974

Size of Urban Areas	Total Accidents (Jan. thru May)		
	1973	1974	% Reduction in 1974
2,500-50,000	42,525	36,919	13.2
50,000-250,000	35,199	30,130	14.4
Over 250,000	84,762	71,687	15.4
Rural Areas	29,964	24,142	19.4

Source: Texas Department of Public Safety

Apparently, several factors have contributed to the reduced accident rates. These factors would appear to be the following.

- Reduction in vehicle miles of travel. For the first six months of 1974, vehicle miles of travel in Texas are 4.7 percent below the 1973 level.

- The reduced speed limit has certainly contributed to the reduced accident rate. The reduced speed limit probably accounts for the difference in total accident reduction between rural and urban areas.

- It appears that other factors pertaining to the driver have also influenced accident rates. Although such factors are not directly the result of the speed limit, they apparently are at least indirectly related to the energy situation.

Travel Time

The reduced speed limit has increased travel time. The 50th percentile speed was 68 mph in 1973 and 56 mph in April 1974.(2). Thus, on the average, required travel time increased by about 20 percent.

Fuel Rationing Measures

Fuel rationing is, perhaps, the ultimate mandatory control available for reducing gasoline consumption by private vehicles. Since private vehicles account for about 60 percent of transportation fuel consumption, imposition of rationing can greatly reduce fuel usage. If the required reduction in fuel consumption is to be achieved by imposing mandatory controls, and if this required reduction is greater than that which can be achieved through speed limit reductions and/or fuel allocation, then rationing will be necessary.

The impact of rationing on Texas travel would be dependent on the allotment scheme utilized. For example, some suggested rationing schemes would have allocated about ten gallons per week per vehicle. Since the average Texas vehicle uses 18.9 gallons per week (7), such a scheme would have forced over a 40 percent reduction in personal vehicular travel, which represents 60 percent of transportation fuel consumption. The net result would have been in excess of a 25 percent reduction in total transportation fuel.

Fuel rationing can be implemented in either of the following manners.

- Direct apportionment of fuel to individuals. This is similar to the approach used during World War II when individuals were alloted a certain number of gallons per time period.
- Time rationing. This type of rationing restricts the time during which fuel can be sold (e.g. Sunday gas station closings).

Direct Apportionment Rationing

Impact on Rural Areas

Approximately 20 percent of Texans reside in rural areas (8). Rural travel per vehicle does not appear to differ appreciably from urban travel; each vehicle travels approximately 200 miles per week or 10,400 miles per year (8,9). Assuming that each rural household is generally similar to urban households, the average dwelling unit has 3.2 persons and 1.4 vehicles. Thus, the average rural household travels about 280 miles per week (200 x 1.4).

Rationing of 10 to 15 gallons per vehicle per week would allow the average household to travel (assuming 14 mpg) 200 to 300 miles per week. One car families would be restricted to 150 to 200 miles per week. Thus, although the "average" household may not be greatly inconvenienced, the term "average" implies that 50 percent of the households will need to travel more than 280 miles per week.

It should also be noted that, for the average urban family making several short unorganized trips, reducing travel should not be extremely difficult. However, for the rural resident who is probably making fewer but better organized and longer trips, reducing travel may be extremely difficult. A rationing scheme that forces these families to significantly curtail existing travel could have serious economic implications.

Impact on Urban Areas

The average urban household in Texas owns 1.4 private vehicles (10),(11) and each vehicle consumes 18.9 gallons per week. The estimated average weekday travel by purpose per dwelling unit in Texas is summarized in Table IV-2, p. 50.

Work travel alone requires considerable gasoline. The average home to work distance is 7.2 miles in large urban areas and 2.9 miles in small urban areas. Assuming that an urban driver averages 10 mpg, the fuel requirements to serve the work trip are estimated in Table III-5.

These figures suggest, for example, that if fuel were rationed at 10 gallons per week per family, approximately 22 percent of the families in large urban areas would not have sufficient gasoline to allow one worker to drive to work for a full week. Obviously, many of these families would have the alternative of using transit or car pooling and could continue their work travel in spite of rationing. However, a substantial portion of these families would probably have no other available means of travel to work.

Table III-5: Effect of Various Rationing Schemes On Fuel Availability for the Work Trip

Gasoline/Week	Percent of Workers Requiring More Than the Specified Amount of Gasoline Per Week to Drive to Work	
	Large Urban Areas	Small Urban Areas
5 gallons	63.5%	11.9%
7.5 gallons	39.5%	2.5%
10 gallons	22.0%	0.7%
15 gallons	5.5%	less than 0.1%

These figures also suggest that gasoline rationing would have the least impact on the smaller urban areas (i.e., urban areas of less than 175,000 population). Indeed, less than one percent of the families in small urban areas would require more than 10 gallons per week to send one family member to work.

Assuming a ten gallon per vehicle per week rationing, it can be seen from Table III-5 that, not only would 22 percent of the employees in large urban areas be unable to drive their vehicle to work, but 41.5 percent (i.e., 63.5 percent minus 22 percent) of the employees would use from half to all of their allocated gasoline if they did drive their vehicle to work. Even under a 15 gallon per vehicle per week allocation, 39.5 percent of the employees in large urban areas would need more than half of this amount (i.e., more than 7.5 gallons) to drive their vehicle to work, and 5.5 percent of the employees in large urban areas would need more than 15 gallons per week to drive their auto to work.

When considering gasoline rationing, it is useful to review the estimated absolute minimum fuel requirements for the average urban family in Texas. The following assumptions were made to obtain such an estimate.

- Auto-miles of travel for work purposes may be cut in half by use of car pooling and transit.
- Auto-miles of travel for personal business can be cut in half by careful planning and by the use of car pooling and transit.
- The average urban family would limit shopping travel to one grocery shopping trip per week and one other shopping trip per month per automobile.

- Auto-miles of travel for school, social-recreational, and eat-meal purposes will be completely eliminated.
- Medical-dental will continue with only slight reductions for transit usage.

Under these austerity assumptions, the average family in large urban areas would still need to travel about 68 miles per week, or about 38 percent of current weekday travel. The average family in small urban areas would still need to travel about 33 miles per week which represents about 47 percent of their current weekday travel. Using a 10 mpg assumption, this suggests that the minimum allocation to the average family in large urban areas should be 6.8 gallons and 3.3 gallons for families in small urban areas.

In essence, a 10 gallon per week per family allocation in large urban areas would provide the average family with only 3.2 gallons more than that required by these austerity assumptions. If the average family were limited to 10 gallons per week and wanted (or needed) to make a 200-mile intercity trip (i.e., a 400-mile round trip), they would have to limit their activities to austerity conditions for approximately nine weeks in order to save enough gasoline for such a trip (assuming 14 mpg for intercity travel).

Time Rationing

Sunday Gasoline Station Closings

Closing of gasoline stations on Sunday represents a means of imposing time rationing that has been utilized. In an effort to conserve fuel, the President strongly encouraged gasoline stations to close on Sunday. This voluntary Sunday closing resulted in an estimated 1.5 percent saving of statewide consumption of highway motor fuel and a 1.3 percent reduction in total statewide transportation fuel consumption in Texas. However, as this was not a legally enforceable program, all stations did not close. As a result, the actual fuel savings that did occur were not as great as they might have been under a completely mandatory closing program.

Limited data are available on the impact on fuel consumption of the Sunday closing of gasoline stations. Significant closings of stations began in December 1973. The approximate percentage of Texas service stations open on Sunday during the critical months of the energy crisis is presented in Table III-6.

Traffic data obtained by the Texas Highway Department at automatic traffic recorder stations (13) were used to identify trends in Sunday travel. During the first four months of the year, Sunday travel in 1973 was 2.2 percent greater than in 1972. Without an energy shortage, it appears

Table III-6: Percent of Texas Service Stations Open on an Average Sunday

Month	Percent of Stations Open
December, 1973	8.0
January, 1974	8.7
February, 1974	9.0
March, 1974	9.7
April, 1974	22.8
May, 1974	28.5
June, 1974	34.0

Source: American Automobile Association, Texas Division reasonable to assume that a similar increase would have occurred between 1973 and 1974.

However, a significant decline in Sunday travel occurred in 1974 (Figure III-7). For the first four months of the year, Sunday travel was 16.6 percent less than in 1973. Assuming that, without an energy shortage, a 2.2 percent increase in travel would have occurred, the actual decrease in Sunday travel would appear to be almost 19 percent.

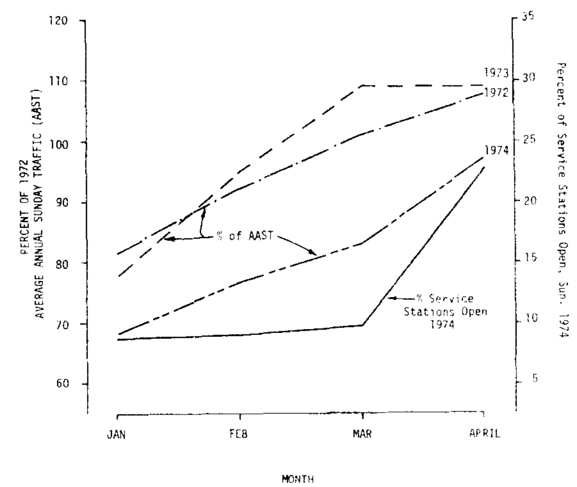


Figure III-7: TRAVEL TRENDS IN SUNDAY DRIVING ON TEXAS ROADS

Not all of the decrease in Sunday travel is the result of service station closings. Travel during weekdays also decreased. For the first four months of the year, weekday travel in 1973 was 6.6 percent above that of 1972 (13). For this same four-month period, weekday travel in 1974 was 2.8 percent below that of 1973 (13). Thus, it appears the energy related factors other than service station closings have curtailed weekday travel in 1974 by some 9.4 percent (6.6 + 2.8).

In evaluating Sunday travel, it can be assumed that factors other than station closings, such as lack of fuel and voluntary curtailment of travel, would eliminate any increase in 1974 travel over 1973 and would actually cause 1974 Sunday travel to be approximately 2.8 percent less than

1973 travel. Thus, it appears that the closing of service stations on Sundays reduced Sunday travel by about 13.8 percent (16.6%-2.8%). It should be emphasized that all stations were not closed on Sunday. Figure III-7 suggests that some correlation does exist between the volume of Sunday travel and the percent of service stations open.

Automatic traffic recorder data collected by the Texas Highway Department (13) indicate that 11 percent of total weekly travel in Texas occurs on Sundays. Consequently, a 13.8 percent reduction in Sunday travel represents a 1.5 percent reduction in total statewide street and highway travel. A corresponding reduction in statewide gasoline consumption can be assumed. Since highway transportation consumes 84 percent of total transportation fuel, Sunday closings reduced total consumption by some 1.3 percent. If all service stations had closed, this reduction in fuel consumption would probably have been greater.

Motor Fuel Allocation

The distribution of motor fuel can be controlled through a mandatory program that allocates deliveries from refineries to various large volume users. Because it deals with fewer entities, such a program can be implemented with a much smaller bureaucratic work force than would be required for a full-fledged rationing program.

A program to allocate bulk deliveries has a direct impact on large volume users of motor fuels, such as members of the transportation industry. It has an indirect impact on individual consumers through allocations to service stations.

A national fuel allocation program was announced in November 1973. The stated objective of this program was to hold the 1974 level of consumption of motor fuels to the level experienced in 1972. Historically, total motor fuel consumption in Texas had been increasing at an annual rate of 6 to 8 percent. Hence, the target values for Texas were some 12 to 16 percent less than the projected unrestricted demand for motor fuels in 1974.

The fuel allocation program met with mixed success in meeting its goal in Texas as is indicated in Figure III-8. The impact and effectiveness of this program on individual consumers as well as bulk users are evaluated in this section.

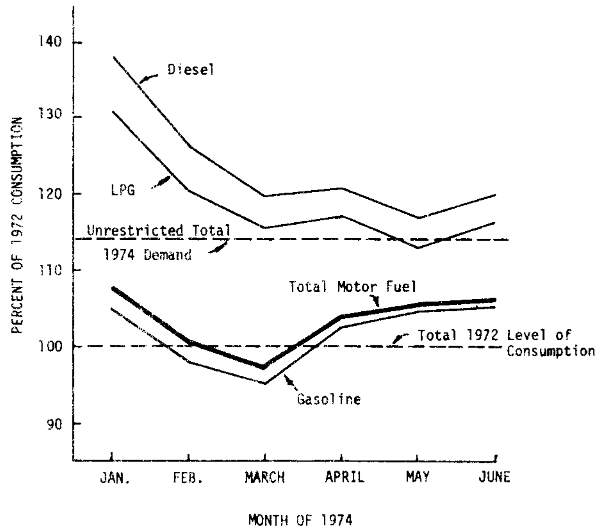


Figure III-8: 1974 Consumption of Motor Fuels In Texas As A Percent of 1972 Levels

Individual Consumers (Gasoline)

The vast majority of the gasoline consumed in Texas is purchased by individual consumers from retail service stations. Hence, the most effective way to control gasoline consumption through an allocation program is to allocate the deliveries to service stations.

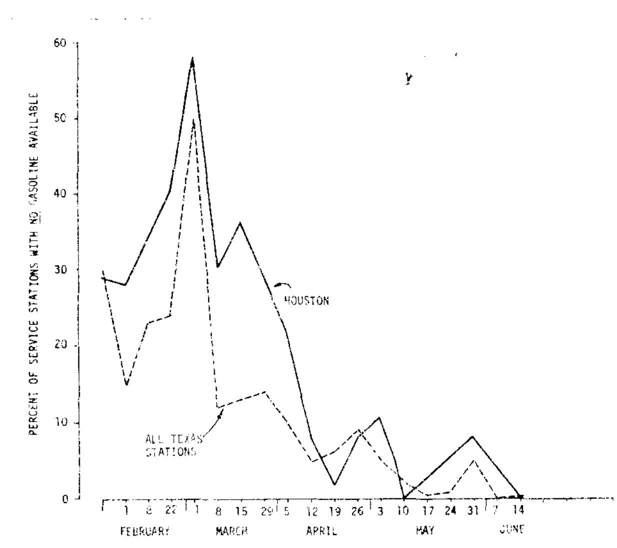
Gasoline consumption in Texas has historically been increasing at an annual rate of 5 to 6 percent. Consequently, the unrestricted demand for gasoline in 1974 would have been at least 110 percent of the 1972 level of consumption, or 10 percent above the level the allocation scheme was designed to accomplish.

Several problems arose in developing procedures for allocating fuel supplies to specific service stations. Numerous stations had ceased operations between 1972 and 1974 and many had been replaced by new stations in different locations. Also, a net increase in the number of service stations had occurred between 1972 and 1974. Hence, the allotments to established service stations were often less than their actual 1972 deliveries.

The most severe curtailment of supply occurred in February and March of 1974 when the average allotment to existing stations was only 83 percent of 1972 sales. As can be seen from Figure III-8, the total gasoline consumption in Texas fell below the 1972 level for these two months. The gasoline consumption during February 1974 was 98 percent of the 1972 level, and it dropped to 95 percent in March 1974.

Various station operators adopted different strategies in selling their limited supplies of gasoline. Most of them reduced their hours of operations, some closed their pumps each day after selling a daily quota, some closed several days each week, and others sold their total monthly allotment and then closed for the remainder of the month. The net result was a random and unpredictable pattern of stations without gasoline.

The American Automobile Association donducted a weekly survey of the number of stations with no gasoline available during the Spring of 1974 (12). Some results of this survey are presented in Figure III-9. As indicated in this figure, gasoline was more scarce in major urban areas, such as Houston, than in the rest of the State. As might be expected, more



Source: American Automobile Association

Figure III-9: Effect of Fuel Allocation on Gasoline Availability stations ran out of gasoline during the months of February and March, when the curtailment of supply was most severe, than in other months. At one point, half of the service stations in Texas reported that they had no gasoline.

It is difficult to fully evaluate the effectiveness of the fuel allocation program in reducing statewide consumption of gasoline. Actual consumption levels remained well below the projected unrestricted demand. Indeed, consumption during the months of February and March was 12 percent and 15 percent, respectively, below the projected unrestricted demand for gasoline. Certainly, during these two months, the allocation program forced a severe reduction in fuel consumption. Even so, some gasoline was still available that was not consumed.

During April and May, average gasoline allotments were increased and very few service stations were running out of gasoline. During the month of June, most stations could obtain all of the gasoline that they could sell, and yet, the statewide consumption of gasoline was still running at least 6 percent below the projected unrestricted demand. Perhaps the increased price of gasoline was a factor in reducing the consumption of gasoline.

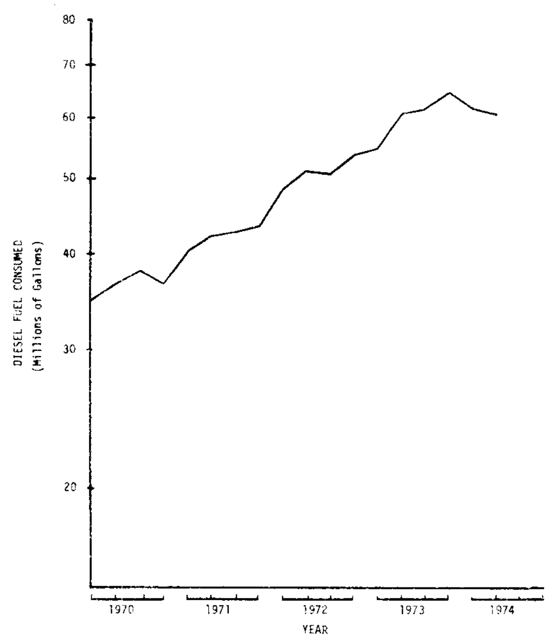
The allocation program probably did have some indirect impact on gasoline consumption levels because of uncertainties concerning the availability of gasoline. However, all of the actual savings resulted from the actions of individuals (reduced travel, reduced speed, etc.). The magnitude of these savings was probably greater because of the allocation program and the publicity associated therewith.

Bulk Users (Diesel and LPG)

The majority of the diesel and LPG fuels consumed in Texas are delivered in bulk quantities to large users. Hence, a fuel allocation program for these fuels can directly control the amount of fuel allotted to specific users.

A national allocation program for diesel fuel was announced in November 1973. The original guidelines established monthly allotments for all users based on 90 percent of their 1972 consumption. The other 10 percent was held in reserve to be allocated to special hardship cases. This program never really went into effect. Its date of implementation was postponed twice, and before it actually went into effect a category of top priority users had been established which included most large volume consumers of diesel fuel. Users in this priority category were to be supplied all the fuel they needed.

Historically, the consumption of diesel fuel in Texas had been increasing at an annual rate of 15 percent (Figure III-10). Hence, the projected unrestricted demand for diesel fuel in 1974 was some 130 percent of the 1972 consumption level. However, as can be seen on Figure III-8, the actual consumption of diesel fuel in 1974 fell significantly below the 130 percent level during all months except January.



Source: Texas Highway Department

FIGURE III-10: Trends In Diesel Fuel Consumption, 1970-1974
(Monthly Average Per Quarter)

Monthly consumption rates during the second quarter of 1974 averaged only 60 million gallons per month. If the historical growth trend had continued unabated, these rates would have averaged 70 million gallons per month. Obviously, something has depressed the rate of consumption of diesel fuel.

As mentioned previously, the diesel fuel allocation program did not really deter consumption because most of the large volume users were in the top priority category and could obtain all the fuel they needed. However, the price of diesel fuel increased rapidly so that many firms took positive steps to improve their fuel efficiencies. Also, the reduced speed limit probably resulted in some savings of diesel fuel. Even so, these two factors together would not have produced the total savings of more than 35 million gallons of diesel fuel that accrued during the first half of 1974.

Probably the most significant factor contributing to the reduced levels of consumption of diesel fuel was the slackening off in freight traffic. Due to the sagging economy, the quantity of freight carried by both trucks and railroads declined during the first two quarters of 1974. Indeed, truck tonnage handled during the second quarter of 1974 was down more than 3 percent from the same quarter in 1973. The decline in rail traffic was not so severe, but it was significant.

Apparently, factors other than the announced fuel allocation program tended to curtail the consumption of diesel and LPG fuels by large volume users. The fuel allocation program itself had little or no effect.

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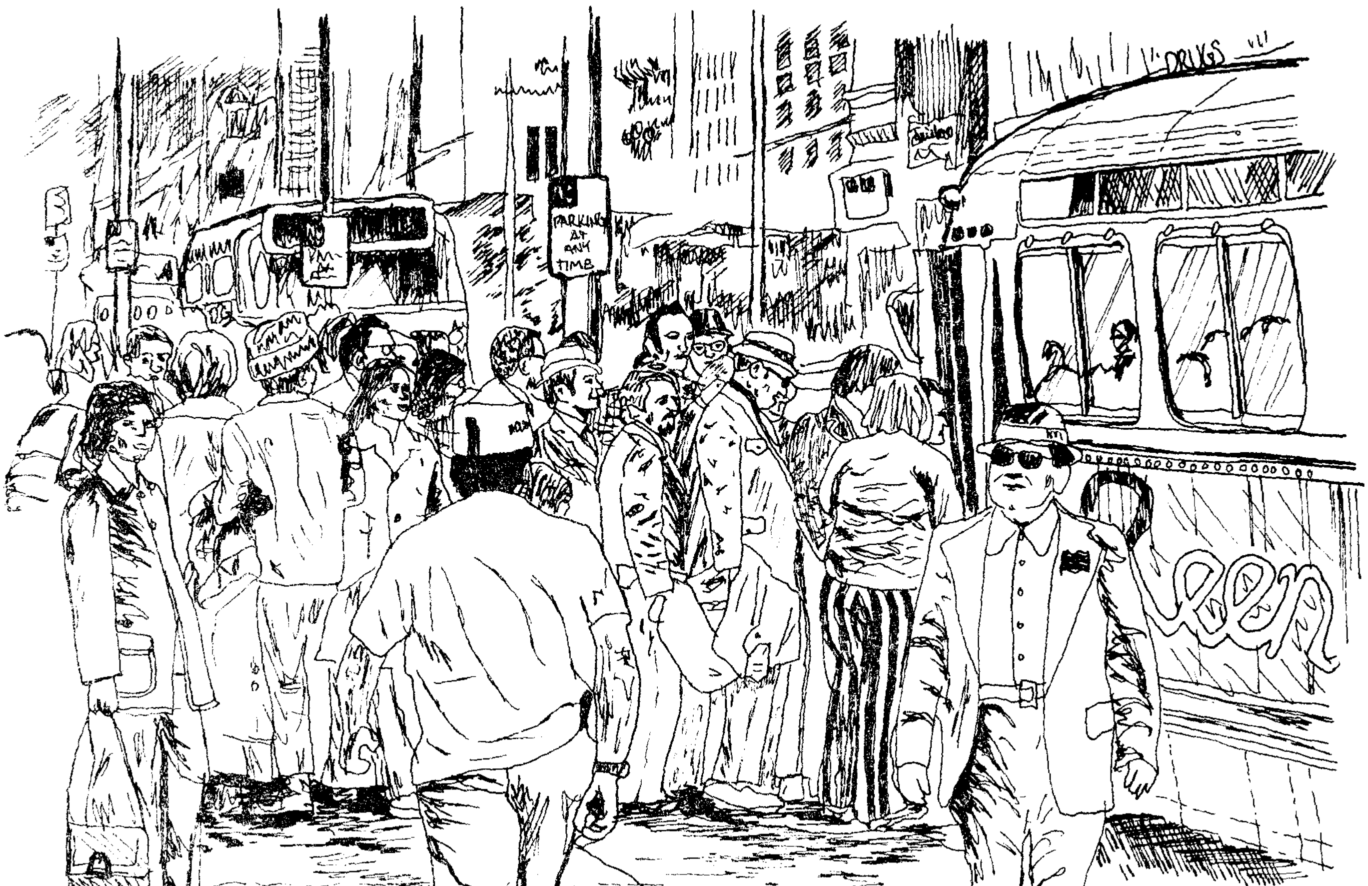
IV. VOLUNTARY CONSERVATION MEASURES



IV. VOLUNTARY CONSERVATION MEASURES

Fuel consumption can be reduced significantly by voluntary actions on the part of the public. This section of the report presents a description of alternative voluntary fuel savings measures and an evaluation of the potential fuel reduction associated with each measure.

Urban Development and Travel Characteristics

While Texas population increased by 45 percent between 1950 and 1970 (1,2)*, virtually all the growth occurred in urban areas. Approximately 80 percent of all Texans presently reside in urban areas. As a result, benefits from voluntary programs will be most evident in urban areas. This section primarily considers methods of reducing urban fuel consumption.

The form of urban development in Texas is typical of a "Western City"--a city that has developed at a low population density. Land development and transportation are integrally related. The type of transportation afforded by the automobile is ideally suited for low densities of development and, consequently, is a basic component of the lifestyle in Texas.

The percentage of total statewide travel that occurs in urban areas has been increasing and can be expected to continue to increase (3). Presently, urban vehicle miles of travel constitute about 60 percent of statewide vehicle miles of travel. Due to the lower fuel efficiency associated with urban driving, it is estimated that 70 percent of statewide fuel consumption occurs in urban areas.

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* Denotes number of reference listed at end of section.

Characteristics of urban travel are perhaps better understood if they are related to the activities of the individual household. Current estimates of average weekday (Monday-Friday) travel by urban residents in Texas are summarized in Table IV-1 (4,5).

Table IV-1: Weekday Travel Characteristics in Texas Urban Areas

Characteristic	Large Urban Areas (Population > 175,000)	Small Urban Areas (Population < 175,000)
Average Daily Auto Trips/Dwelling Unit (one-way)	7.2 trips	8.7 trips
Average Trip Length	5.0 miles	2.3 miles
Average Daily Auto Miles/Dwelling Unit	36.0 miles	20.0 miles
Average Daily Auto Trips/Auto (one-way)	5.4 trips	6.1 trips
Average Daily Auto Miles/Auto	26.9 miles	14.1 miles
Average Weekly Auto Miles/Auto	134.3 miles	71.0 miles

Travel of urban residents can also be related to the trip purpose. The current average weekly urban travel by trip purpose for urban residents is shown in Table IV-2. The average trip length is not the same for all trip purposes; the work trip is about 50 percent longer than the average urban trip (4).

Table IV-2: Average Weekly Travel By Trip Purpose

Purpose for Travel	Average Weekly Travel (Monday-Friday)			
	Large Urban Areas		Small Urban Areas	
	Auto-Miles/ Dwelling Unit	Auto-Miles/ Auto	Auto-Miles/ Dwelling Unit	Auto-Miles/ Auto
Work	82.1	61.2	37.0	26.0
Personal Business	23.7	17.7	14.5	10.3
Shopping	36.5	27.3	22.5	15.8
School	4.9	3.6	3.3	2.3
Medical-Dental	2.7	2.0	1.1	0.8
Social-Recreational	20.2	15.1	13.3	9.4
Eat-Meal	9.9	7.4	8.3	5.9
All Purposes	180	134.3	100	71

Alternative Urban Programs

Due to the high percentage of statewide travel and gasoline consumption that occurs in urban areas, the greatest potential for reducing statewide gasoline consumption lies in programs designed to reduce urban travel. Several such programs have been proposed. It should be pointed out, however, that potential results of all the programs are not necessarily additive. For example, a substantial increase in car pooling will reduce the potential ridership that might be served by transit, and vice versa. Thus, the total fuel savings that would result from implementing all the urban programs are not the summation of the savings associated with each of the individual programs.

A concerted effort on the part of the public to comply with the voluntary portions of the program discussed in this chapter can yield a net savings of approximately 10 percent in statewide highway motor fuel consumption without undue hardship or severe economic impact. A discussion of the individual programs that can contribute to this savings is presented in the remainder of this section.

Reduction in Urban Travel

Program Description

Elimination of unnecessary travel by urban residents in Texas.

Estimated Fuel Savings

Maximum of 8.5 percent of statewide highway motor fuel consumption.

Maximum of 7.1 percent of total statewide transportation fuel consumption.

Analytical Procedure

- Present urban travel patterns consist of many disjointed, unorganized trips. The average urban household in Texas generates eight one-way, non-stop trips per day (5). For example, an individual might travel to work and back home (two trips), drive to the grocery store for necessary food items, and then return home (two more trips). If he had planned ahead, he could have stopped by a store on the way home from work. His total trips for the day would have been three, instead of four, and the vehicle miles of travel would have been reduced.

- If members of the urban household could be convinced that careful planning of trips is desirable and economical, vehicle miles of urban travel could be reduced, by linking or combining trips in an efficient manner so as to reduce total trips.

- Potential reductions in trip making must be related to the purpose of the trip. Work travel logically cannot be considered unnecessary travel; thus, no reduction in work trips, unless accomplished by car pooling or increased usage of the available transit system, can be expected.

  Travel for school and medical-dental purposes could, likewise, hardly be considered unnecessary travel. Shopping, social-recreational, and eat-meal travel are probably the most likely areas for the reduction of unnecessary travel.

- It would seem reasonable that, on the average, each urban household could reduce current travel by at least one trip per day without causing any real inconvenience. Since the average trip length is 5 miles in large urban areas and 2.3 miles in small urban areas (Table IV-1), the elimination of one auto trip per weekday per household would amount to a weekly savings of about 25 auto-miles per household in large urban areas and 12 auto-miles per household in small urban areas. In other words, the elimination of one unnecessary trip per day per household may be expected to reduce the fuel consumption of urban residents by 14 percent in large urban areas and 12 percent in small urban areas. This reduction will result in a reduced statewide gasoline consumption of between 8 and 10 percent. Similarly, this represents a 7.7 to 9.2 percent reduction in the statewide consumption of highway motor fuel and a 6.5 to 7.7 percent reduction in total statewide fuel consumption.

Pertinent Information

This analysis is based on the assumption that a voluntary program for reducing unnecessary urban travel will be a successful endeavor. However, the success of a volunteer program such as this depends, in turn, upon the success of the public awareness campaign that will accompany the program. Unless the public is thoroughly convinced that the action is worth the effort required, the full potential of the program will not be realized.

Car Pooling

Program Description

Increased use of car pools.

Estimated Fuel Savings

2.7 percent of statewide consumption of highway motor fuel.

2.3 percent reduction of total statewide fuel consumption.

Analytical Procedure

- Car pooling has long been encouraged as a means of reducing peak period urban congestion; however, urban residents have not extensively participated in car pools.

- Only a limited number of urban trips are conducive to car pooling. Car pooling is primarily designed to serve trips of a nonpersonal nature that originate at home and terminate in an area of concentrated activity. Thus, car pooling serves a limited number of trip purposes. It is primarily applicable to serving the work trip and offers some potential for serving shopping and school trips.

- Work trips constitute 30 to 35 percent of urban trips, and about 50 percent of these originate at home (4). Shopping represents 15 to 20 percent of urban trips, whereas school trips are less than 5 percent of urban trips. Assuming that car pooling is primarily applicable to those work trips that originate at home and that it can acceptably serve approximately 10 to 20 percent of the shopping and school trips, it appears that only 20 to 30 percent of total urban trips are conducive to car pooling.

- It is generally agreed that voluntary car pooling will primarily affect work trips that originate at home. These trips account for 20 percent of urban travel. The average occupancy for work trips is 1.1 persons per auto. If this average could be increased to 2.0 persons per auto, thus eliminating 45 percent of those vehicular trips that can be car pooled, urban trips could be reduced by 9 percent (45% x 20%). Theoretically, because the average length of the work trip is 50 percent greater than that of the average urban trip, increasing the number of persons per vehicle could decrease urban miles of travel by as much as 13 percent. A 13 percent reduction in urban miles of travel would reduce statewide vehicle travel by 7.8 percent. Because urban travel in general is less fuel efficient, statewide gasoline consumption could be expected to decrease by 9.1 percent (13% x 70%) and would reduce the overall consumption of highway fuels by approximately 8.4 percent. It should be pointed out that these estimates represent the maximum potential gain from car pooling that could be expected to occur under austerity conditions because they are based on the assumption that the occupancy of all vehicles "eligible" for car pooling would be nearly doubled.

- Another method of estimating the potential fuel savings from car pooling involves the analysis of vehicle trips that originate at home and terminate in an area of concentrated activity, such as the central business district (CBD). Accordingly, it is initially assumed that all automobile trips originating at the home and terminating in the CBD would be potential car pool vehicles. These trips can be described as follows:

    1. about 10 to 20 percent of total auto trips have a destination in the CBD;
    2. approximately half (50%) of these trips are for work purposes; and

3. between 50 and 75 percent of these work trips have an origin (home) that is conducive to car pooling.

Therefore, when car pooling is considered in relation to the areas of concentrated employment, about 5.6 percent (15% x .5 x .75) of total daily trips appear to be eligible for car pooling. If the occupancy of the vehicle making these trips were doubled (an increase of 2.2 persons per auto), 2.8 percent of total urban trips would be eliminated, representing a 4.2 percent reduction in urban vehicle miles. Since 70 percent of the gasoline in Texas is consumed in urban areas, this method of car pooling could reduce statewide gasoline usage by 2.9 percent. This, in turn, would reduce statewide consumption of highway motor fuel by 2.7 percent, and statewide transportation fuel consumption would decrease by 2.3 percent.

Pertinent Information

The awareness of an energy shortage may result in the voluntary formation of car pools, and some encouragement from industry could stimulate this trend. If gasoline rationing becomes a reality, or if the threat of rationing is so severe as to make residents believe that such a drastic measure is imminent, many citizens may cooperate in the formation of car pools.

Analysis of Implemented Programs (6,7)

- During the past six months, the cities of Dallas and Fort Worth have attempted to encourage car pooling. Both cities agree that potential energy savings are a major reason for actively encouraging the formation of car pools. Dallas and Fort Worth are participating in the Federal Highway Administration Computer Matching Car Pool Program.

- These attempts to encourage car pooling have not been in effect long enough to ascertain their success; however, both cities are optimistic about the success of the car pool program. The following summarizes the pertinent data currently available:
  1. Dallas has approximately 25,000 data entries (individual responses). City officials hope to receive 100,000 data entries as part of the first year operation. Forty percent of the City of Dallas employees have been willing to at least fill out the data cards.
  2. Fort Worth has distributed 43,400 data entries and has received 2,500 completed applications. The FHWA program has successfully matched 80 percent of the applications received.
  3. Both cities agree that the ultimate success of their respective programs is highly dependent upon a public information effort that will be initiated in the near future.

Urban Public Transit

Program Description

Increased usage of urban public transit.

Estimated Fuel Savings

Approximately one percent of total statewide highway motor fuel consumption. Less than one percent of total statewide transportation fuel consumption.

Analytical Procedure

- For the immediate future, the public transit systems have a very limited capability for serving additional trips and, thereby, reducing automobile travel. In those cities that provide public transit, the operation serves only 4 to 5 percent of the total urban trips (8). Fifty percent of the trips served by the system occur during the peak period, and 60 percent of the transit trips are for work purposes.

- Since transit vehicles operate primarily during the peak periods and because their loads are at or near capacity during these times, it is estimated that transit ridership cannot presently be increased by more than 15 to 20 percent.

- If the maximum 20 percent increase in transit ridership were to occur, urban auto trips would decrease by one percent (transit would serve 5 to 6 percent of urban trips). Since most of the trips would be for work, urban vehicle miles of travel could be reduced by 1.5 percent. This would produce a one percent decrease in statewide gasoline consumption.

- The fuel savings estimates assumed for increased transit usage may be somewhat high because only 18 cities in Texas have a significant transit system. It would be feasible in the future to purchase additional transit equipment so that the service could be expanded. Although it is assumed that public transit will never serve more than 15 percent of total urban trips, this increased service is comparable to tripling current transit usage.

- In the long run, transit might serve as many as 15 percent of urban trips. The auto presently serves these trips at about 18 passenger-miles per gallon and transit at about 30 passenger-miles per gallon. Transit is 67 percent more fuel efficient. Thus, transit could serve the 15 percent of trips at a 6 percent reduction in urban fuel. Since transit would only serve about 60 percent of urban residents, this would reduce to a 3.6 percent reduction in urban fuel. This represents about a 1.8 percent reduction in total transportation fuel.

Pertinent Information

If the price of gasoline continues to rise significantly, or if fuel availability becomes limited, urban residents may demand that public transportation be made available to serve their trip desires. Since only 18 cities in Texas are currently served by a transit system, those cities that do not have a transit operation may find it necessary to undertake major capital expenditures to install such a system. The cities where transit is now provided may be pressured to expand the service.

It is important to note that public transit is designed for travel to and from concentrated activity areas--for example, the CBD. Realistically, transit could not be expected to serve the variety of disjointed, dispersed trips that occur daily in accordance with the lifestyle to which the urban dweller has become accustomed--trips that require a heavy dependence on the private automobile. If public transit were proposed as a means of providing transportation for these many trip purposes, it is entirely conceivable that more fuel will be consumed than is now being consumed by the private auto in serving these trips.

Analysis of Implemented Programs (9)

For a variety of reasons, it is difficult to determine the precise effect that the fuel shortage has had on transit operations in Texas. It appears that, during the first six months of 1974, the downward trend characteristic of statewide transit ridership prior to that time has been arrested, and it is reasonable to assume that the energy shortage has had at least a partial influence on that reversal. However, since transit ridership has not greatly increased, transit apparently has not had a substantial impact on fuel consumption.

Staggered Hours

Program Description

Encourage implementation of staggered work hours.

Estimated Fuel Savings

0.9 percent of statewide highway motor fuel consumption. 0.8 percent of total statewide transportation fuel consumption.

Analytical Procedure

- The staggering of work hours would bring about a smoother traffic flow, but the improvement would be more of a convenience than a means of conserving fuel.
- If voluntary car pooling is to be encouraged, the staggering of work hours will only serve to make car pool formation more difficult.
- If hours are staggered, the peak traffic periods will last longer than is now the case. This would permit the public transit system available in some 18 Texas cities to carry additional riders without increasing fleet size. For example, transit presently carries about

50 percent of its daily ridership during the current peak periods. Assuming that the staggering of hours might increase the number of persons who ride during the peak period by as much as 50 percent, total daily ridership would be increased by 25 percent. The increased ridership would mean that, in the 18 cities where a public transit system is in operation, an additional 1 percent of urban trips would be served by public transit.

- The additional 1 percent would primarily involve the longer work trip; consequently, urban vehicle-miles of travel might be reduced by 1.5 percent. As has been noted earlier in the report, urban miles of travel are responsible for 60 percent of statewide travel; therefore, a 1.5 percent reduction in urban travel could conceivably produce a 1 percent decrease in statewide travel. Gasoline consumption would also drop by approximately 1 percent, and consumption of highway motor fuel would be reduced by about 0.9 percent. Consequently, the consumption of total statewide transportation fuel would decrease by approximately 0.8 percent.

Pertinent Information

The staggering of work hours will bring about a reduction in traffic congestion during the morning and afternoon peak periods. However, this situation could cause some individuals who now use the available public transit to abandon the system and, for convenience, use their automobiles. This would be a definite disadvantage in any effort to encourage transit ridership. Therefore, unless some restrictions are imposed (fuel availability, parking limitations, etc.), the staggering of hours could, in fact, decrease transit ridership, resulting in an increase of statewide fuel consumption.

Four-Day Work Week

Program Description

The work week consists of four rather than five days.

Estimated Fuel Savings

Negligible to negative.

Analytical Procedure

- As previously stated, work trips constitute about 35 percent of all urban trips (4). Thus, initiating a four-day work week would reduce work trips by 20 percent and total urban trips by 7 percent. The 7 percent reduction would, in turn, result in 10 percent decrease in urban vehicle miles of travel, or a 6 percent reduction in statewide travel. If no additional trips are made instead of the work trips, statewide gasoline consumption could decline by 6 percent.

Pertinent Information

It is unrealistic to assume that, if an individual is not required to go to work, he would not make other trips during the day. Any traveling that he might do, even if for a short errand, could conceivably offset any gains from elimination of the work trip. In effect, statewide fuel consumption could increase.

If the individual's day off was Friday or Monday, this would provide a three-day weekend and the opportunity for extra intercity travel. If fuel is readily available, many individuals or families likely would travel more extensively resulting in increased gasoline consumption.

Bicycling and Walking

Program Description

Discontinue use of the private automobile for those trips that are conducive to walking and/or bicycling.

Estimated Fuel Savings

1.9 percent of statewide highway motor fuel consumption. 1.6 percent of total statewide transportation fuel consumption.

Analytical Procedure

- It is assumed that walking could be used for trips of less than one-third mile, and either walking or bicycling could serve trips of less than one-mile. Bicycling could serve trips of less than two miles.
- Trips of less than one-third mile constitute about 0.7 percent of urban vehicle-miles; trips of between one-third and one mile constitute 3.1 percent of urban vehicle miles, and trips of between one and two miles constitute 11.6 percent of urban vehicle-miles. Thus, the total potential reduction in urban travel is 15.4 percent (0.7 + 3.1 + 11.6) (4).
- Restrictions other than distance reduce the potential for using walking and/or bicycling. Based on age, physical condition, and attitude, it is assumed that only about 45 percent of the population will utilize these alternative modes of transportation and that only 50 to 75 percent of these individuals have a bicycle available to serve their trip desires. Weather, time of day, topography, and the time value of the trip might further reduce the potential for walking/bicycling by about 30%. Bicycling/walking

can adequately serve about 75 to 80 percent of all trip desires (based on trip purpose). Urban gasoline consumption represents 70 percent of statewide consumption. Thus, for these trip of less than two miles, only about 20 percent (45% X 75% X 70% X 80%) might be made by bicycle or walking. This would reduce urban vehicle miles of travel by about 3 percent (15.4% X 20%). This would result in a 2.1 reduction in state gasoline consumption, a 1.9 percent reduction in statewide consumption of highway motor fuel, and a 1.6 percent reduction in total statewide transportation fuel consumption.

Traffic Engineering Improvements

Program Description

Implement traffic engineering improvements to allow vehicles to operate at fuel efficient speeds and to reduce unnecessary speed changes in the traffic stream.

Estimated Fuel Savings

Less than 2 percent of statewide highway motor fuel consumption.

Analytical Procedure

- Vehicle acceleration and deceleration within the traffic stream have an adverse effect on fuel consumption. Engineering principles such as progressive signalization, access control, restrictions, and freeway surveillance can be applied to improve traffic operations and provide for more efficient flow in the traffic stream.
- These traffic engineering improvements are primarily applicable to the freeway and arterial street system. Although this system represents only about 20 percent of urban street mileage, approx-

imately 60 percent of urban vehicle miles of travel occur on these facilities.

- Freeway surveillance and control provide a means of significantly improving traffic flow. However, the greatest benefit from the improved freeway operations occurs during the morning and afternoon peak periods. In Texas, approximately 28 million vehicle miles are driven daily on urban Interstate highways. Fifteen percent, or 4.2 million, of these miles are driven during peak conditions. However, it is assumed that only 2.1 million vehicle miles would be noticeably benefited from implementation of freeway control.
- Freeway control offers reduced fuel consumption by permitting a steady traffic flow. A steady flow of traffic helps eliminate the fuel consumption attributed to acceleration and deceleration in a no-control situation.
- Freeway control also influences fuel consumption by allowing vehicles to operate at more fuel efficient speeds. Speeds on the Gulf Freeway average 30 mph with control while the average speed without control is 15 mph.(10). At a constant 30 mph speed, a vehicle consumes 0.044 gallons per mile, but at 15 mph, a vehicle consumes 0.061 gallons per mile (11). Thus, during the peak periods, a daily savings of 36,000 gallons (2,100,000 X .061 - 2,100,000 X .044) would result in an annual savings (250 workdays) of 9 million gallons. Reductions in acceleration and deceleration might double this savings, resulting in an annual savings of 18 million gallons. At present gasoline consumption rates (6800 million gallons per year), gasoline consumption could be reduced by 0.3 percent by extensive implementation of freeway control.

- Arterial street operation would also be improved to reduce gasoline consumption. Consumption could be reduced by decreasing delay time and by increasing average running speed. On the average, delay time amounts to 15 percent of travel time while running time is 85 percent.

- A decrease in delay time will reduce fuel consumption simply by making the trip shorter. It will also reduce the fuel consumption associated with acceleration and deceleration. The relationship between delay time and fuel consumption is more than the proportional because of this acceleration and deceleration affect. Thus, assuming 20 percent reduction in delay time could be achieved, travel time would also decrease by 3 percent (15% X 20%) and this might decrease fuel consumption by as much as 5 percent. About 27 million vehicle miles per day occur on urban arterials, consuming 2.7 million gallons of fuel (assuming 10 mph). A 5 percent reduction would save 50 million gallons per year, representing a savings of 0.7 percent.

- Running speed might be increased from 20 to 30 mph, increasing fuel efficiency from 0.05 to 0.044 gallons per mile. An annual savings of 50 million gallons would result, representing a 0.8 percent reduction in gasoline consumption.

- Total gasoline savings from all the above measures would be 1.8 percent (0.3 + 0.7 +0.8).

Pertinent Information

The implementation of the traffic engineering measures discussed above would require considerable lead time and could be quite costly. Consequently, these improvements represent a relatively long-range approach to the reduction of gasoline consumption. Furthermore, it should be noted that many of the traffic engineering improvements have not been implemented already because the cost-benefit ratio was not considered favorable.

Individual Vehicle Fuel Economy
(12-19)

The consumption of highway motor fuels could be effectively reduced by improving the fuel efficiency of individual vehicles. The public must be convinced to take affirmative action in the following areas:

- vehicle weight
- auto maintenance
- driving habits

The improvement of individual vehicle fuel efficiency is largely dependent upon an informed public. First, the public must be convinced that it is necessary to take actions to reduce fuel consumption. Secondly, the public must be made aware of the alternative measures available that will improve vehicle fuel efficiency. If the program is successful, that is, if the recommendations are accepted and employed by a large percentage of the population, statewide consumption of highway motor fuel could be reduced by at least 5 percent.

Vehicle Weight

Greater fuel efficiency is a characteristic of lighter vehicles. By using lighter vehicles, motorists can decrease fuel consumption per mile of travel (Figure IV-1). A 5000 pound vehicle uses twice as much fuel as a 2500 pound vehicle. Whereas the benefits to be derived from increased small car use will not be realized immediately, there is a trend toward greater purchase and use of small cars (Figure IV-2).

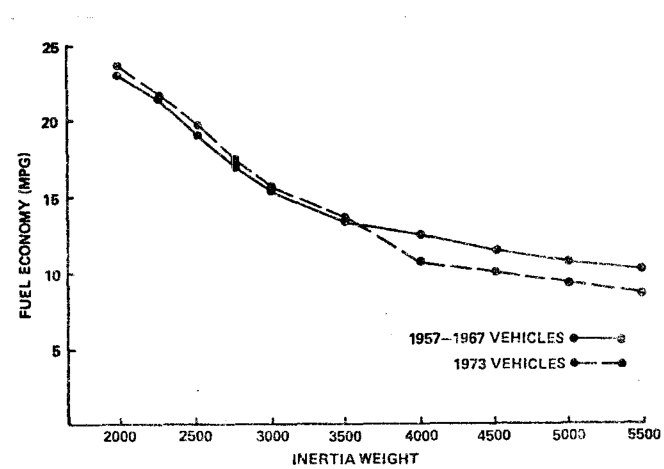
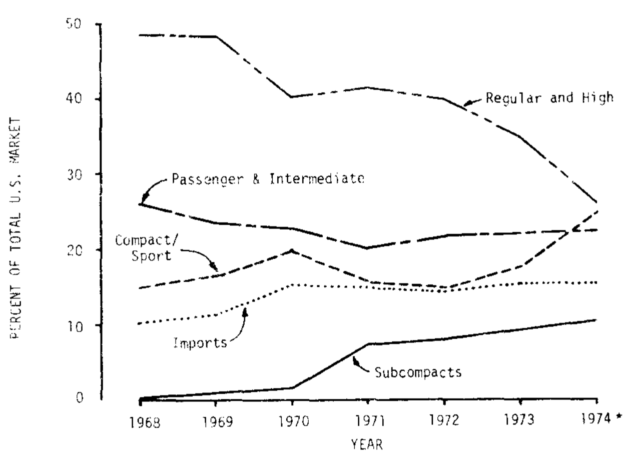


FIGURE IV-1: Fuel Economy Versus Inertia Weight

While smaller cars (subcompact, imports, compact and sport) accounted for about 41 percent of the market in 1973, they represented about 51 percent of the U.S. auto market in 1974.



* data for first five months

Source: Motor Vehicle Manufacturers Association

FIGURE IV-2 Trends In New Car Deliveries By Price-Product Groups, 1968-1974

Auto Maintenance

Tune-ups can improve fuel efficiency, especially in relatively old vehicles. It has been estimated that eighty percent of the vehicles over three years old would benefit from tune-ups. These vehicles might experience a fuel savings of approximately 5 percent.

Properly inflated tires will also improve vehicle fuel efficiency. Little effort is required on the part of the individual driver to insure that his tires are inflated to the manufacturer's recommended pressure. While fuel efficiency can be improved by maintaining proper air pressure in normal tires, radial tires can further reduce fuel consumption. Radial tires alone can reduce individual vehicle fuel consumption by as much as 3 percent.

Driving Habits

The individual driver may be required to alter his present driving habits, but there are certain actions he can take to reduce the fuel consumption of his automobile. These actions include:

- reduction in the use of air conditioning;
- reduction in the number of speed changes;
- increased use of each household's most fuel efficient vehicle;

- use of fuels recommended by the manufacturer for the specific engine in each vehicle;
- not idling the engine for longer than one minute;
- avoid idling the engine to warm the passenger compartment on cold mornings.

These actions can be taken by an individual without undue hardship.

Fuel Conservation By Business Firms
(20-23)

Transportation practices and procedures employed by most large business firms in Texas developed during the years when fuel was plentiful and inexpensive; possible fuel shortages were not a consideration. Most business firms do consume some transportation related fuel. An investigation of current business practices should reveal opportunities for significant fuel savings.

Several voluntary conservation programs that might be pursued by business are discussed in this section. Some of the suggestions pertain to businesses in general, while others are specifically aimed at the transportation industry. Total statewide fuel consumption could be reduced by more than 5 percent if all of these programs are actively pursued.

Reduced Travel

Business and travel are closely related; some of the travel associated with business could be eliminated to reduce fuel consumption. Approximately half of the passengers on scheduled airlines are on business trips. Also, businesses own about 15 percent of registered vehicles and drive these vehicles more miles per year than the average car. Probably more than 10 percent of these business trips could be eliminated and another 5 percent reduction could be achieved through better planning and scheduling.

If business firms are to reduce fuel consumption they must strive to eliminate unnecessary trips, improve trip planning and scheduling, and, most importantly, encourage fuel efficiency in all phases of operation. If firms adhere to these recommendations, an approximate 2 percent reduction in statewide highway fuel consumption and a 1.7 percent reduction in total statewide transportation fuel usage would be realized.

Improved Diesel Efficiency

Diesel-powered trucks and buses account for about 10 percent of the state's total fuel consumption. By maximizing the operating efficiency of trucks and buses, a 2 percent net reduction in statewide fuel consumption would be realized. There are several methods by which this efficiency can be attained, including the following:

- derating diesel engines to lower horsepower in line with actual payloads;
- reducing engine speed to conform with lower speed limits;
- installing a temperature-modulated fan;
- installing wind deflectors and vortex stabilizers to reduce wind drag;
- installing radial tires to reduce rolling friction; and
- turning off engines when vehicles are stopped.

The cumulative effect on an individual vehicle's fuel efficiency might be as high as 20 percent if all the above mentioned actions were taken.

While the cost and supply of some of these actions will place economic hardships on many truckers, truckers should be encouraged to give greater attention to fuel economy in purchasing new equipment, with special emphasis on engine size, gear rates, transmissions, and tractor and trailer size. The increased cost of fuel will probably stimulate business interest in fuel economy.

Trucking Industry

In addition to improving diesel engine efficiency, the trucking industry could also reduce fuel consumption in the following manner:

- reducing empty backhauls; and
- increasing weight limits.

It is estimated that 35 percent of total truck miles are accrued while the trucks are empty. Although the loaded/empty miles ratio varies for certain carrier groups, equipment configuration and type of cargo, a recent study indicates that 36.3 percent of multiple unit trucks (primarily tractor-trailer combinations) engaged in private carriage were empty. This compares to 25.9 percent of similar type, for-hire vehicles regulated by the I.C.C.

If private vehicles without backhauls converted their shipments to for-hire trucks, the percent of empty trucks might be reduced to below 25 percent. This would reduce the total number of truck miles and, thereby, reduce fuel consumption. Since trucks consume about 10 percent of the fuel, total savings would be about 1 percent. It should be noted, however, that all empty backhauls can probably never be eliminated because of specialized vehicles and other uncontrollable factors.

In a recent nationwide study, A.D. Little Company estimated that a 17 percent fuel savings (to truckers) could be attained by increasing the gross vehicle weight (GVW) to 105,000 pounds. However, many disbenefits (increased highway maintenance, etc.) would also be associated with such an action.

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