INTERIM REPORT

FUEL CONSERVATION IN TEXAS: TRANSPORTATION

AN EVALUATION OF VARIOUS MEASURES

PREPARED FOR
THE GOVERNOR OF TEXAS

BY
TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS

DECEMBER 1, 1973

FOREWORD

This interim progress report is presented in response to a request by Governor Briscoe to evaluate immediate energy conservation measures concerning highway travel.

Research in the area of transportation energy conservation is inadequate for conclusive analysis of specific conservation measures; therefore, the material in this report is preliminary.

The information used as a basis for the various analyses is referenced in the report to provide an opportunity for the various agencies who are working on this problem to evaluate and expand the data base as the study proceeds.

Hopefully, the Interagency Transportation Council and other groups will find this and subsequent reports valuable in conducting deliberate evaluations of the effectiveness of energy conservation strategies and policies.

The Texas Transportation Institute will continue to search out meaningful data on which to base the evaluation of the probable consequences of various alternative measures for fuel conservation.

EXECUTIVE SUMMARY

Transportation And The Fuel Shortage

- According to many projections, the United States is facing an energy shortage in the immediate future. Projections of resulting shortages in transportation fuels range from 10 to 30 percent for the next year.
- Crude petroleum, which is used to produce over 95 percent of all transportation fuels, represents about 40 percent of all mineral fuel resources consumed in the United States.
- Transportation activities account for about 25 percent of total U.S. energy consumption; hence, transportation uses about 60 percent of all crude oil consumed in the United States.
- The relative productivity and fuel consumption of the various transportation modes nationwide are as follows:

Mode of Travel	Percent of Passenger-Miles Served	Percent of Ton-Miles of Freight Served	Percent of Total Transportation Fuel Consumed
Passenger Car	86.4	0.0	60
Truck	0.0	18.2	23
Bus	2.4	0.0	1
Railroad	0.9	34.7	4
Water	0.3	27.8	4
Aviation	10.0	0.2	8
Pipeline	0.0	19.1	N/A
	100.0	100.0	100

Note: Nationwide data.

- In view of the impending energy shortage and transportation's relative share of total energy consumption, it appears imperative that some measures be taken to reduce the rate of consumption of transportation fuel.
- Current transportation practices by both individuals and businesses in Texas have been founded on a past history and future expectancy of a plentiful supply of inexpensive fuel. Certainly, there is some waste associated with many of these practices. Some can be eliminated with beneficial rather than negative results, and others can be modified so as to produce fuel savings without severely affecting the economy.

Strategies For Fuel Conservation Measures

- Geographic conditions, urban development, and associated travel needs in Texas are sufficiently different from those in other parts of the nation that fuel conservation measures should be tailored to meet the needs of Texas.
- Strategies for fuel conservation programs might differ depending on whether they are designed for long-run or short-run effects. Long-run strategies might stress higher utilization of the more energy-efficient modes, while short-run strategies should be designed to achieve immediate fuel savings with minimum economic and social impacts.
- Mandatory fuel control measures can be applied to force a reduction in fuel consumptions; however, those mandatory control measures evaluated in this report tend to generate significant economic and social impacts.

- Voluntary fuel conservation measures can be adopted by individual households, business firms, and cities with less severe economic and social impacts. However, the effectiveness of these measures depends upon a public awareness program that will generate public support and participation.
- Indeed, the effectiveness of both mandatory and voluntary measures depends upon public awareness and support. Unless the public is thoroughly convinced that the selected control measures are necessary, they will not meet their full potential. A concerted and continuing public information program will probably be necessary.

Relative Effectiveness and Impact of Control Measures

- Estimated fuel savings cited for each control measure evaluated in this report are based on an assumption that each control measure is implemented in isolation. The estimated fuel savings are not additive for all measures because of overlapping effects.
- The relative effects of combined fuel conservation measures or programs evaluated in this report are presented in the following table. Again it should be stressed that the cumulative effects of these programs are not additive.

Strategies	Maximum Potential Fuel Savings	Economic/Social Impact
Mandatory Control Measures		
Speed Limit Reductions	6%	Moderate
Fuel Allocation	10%	Moderately Severe
Rationing	25%	Severe
Cumulative Effect of all Mandatory Measures	30%	Extremely Severe
Voluntary Control Measures		
Urban Travel	10%	Minor
Individual Vehicles	5%	Minor
Business Firms	5%	Minor
Cumulative Effect of all Voluntary Measures	15%	Moderate

- A combination of mandatory and voluntary measures (perhaps including speed limit reductions, some fuel allocation, and most of the voluntary measures) can yield a net fuel savings of about 20 percent with only moderate social and economic impacts.
- If the required fuel savings are as high as 30 percent, rationing will probably be necessary, and the social and economic impacts will be severe.

TABLE OF CONTENTS

	Page
SECTION I - INTRODUCTION AND BACKGROUND INFORMATION	
Introduction	I-1
General Transportation Data	I-3
Energy Consumed by the Transportation Sector	I-3
Fuel Consumption and Efficiency of the Various Modes of Transport	I-3
Characteristics and Trends in Highway Transportation	I-4
SECTION II - MANDATORY FUEL CONTROL MEASURES	
Effects of Alternative Speed Limit Reductions	II-1
Reducing Speed Limits on Rural Roads	II-1
Reducing Speed Limits on Urban Freeways and Arterials	II-10
Motor Fuel Allocation	II-12
General Public	II-13
Buses	II-14
Trucking	II-15
Railroads	II-17
Aviation	II-19
Fuel Rationing Measures	II-22
Rationing An Individual's Fuel Supply	II-22
Sunday Closing of Service Stations	II-31
SECTION III - VOLUNTARY FUEL CONTROL MEASURES	
Urban Programs	III-1

Page

SECTION III, Continued

Reduction in Urban Travel III-4
Car Pooling III-7
Urban Public Transit. III-9
Staggered Hours III-12
Bicycling and Walking III-13
Traffic Engineering Improvements. III-15
Four-Day Work Week. III-18
Fuel Economy For Individual Vehicles III-21
Tune-Ups. III-21
Tires III-23
Air Conditioners. III-25
Reduced Vehicle Weight. III-26
Driving Habits. III-29
Other III-30
Fuel Conservation in Business Firms. III-32
Reduced Business Travel. III-32
Improved Efficiency of Diesel Vehicles. III-33
Reduced Empty Backhauls III-35
Increased Truck Weight Limits III-36

SECTION IV - ECONOMIC IMPACT OF TRANSPORTATION FUEL SHORTAGE

General Effects. IV-1
Effects Upon National Economy IV-1
Effects Upon Texas Economy. IV-3
Household Consumption Patterns. IV-4

Page

SECTION IV, Continued

Transportation Industry. IV-7

Truck and Bus Operators IV-8

Air Transportation (Includes General Aviation and Scheduled Carrier) IV-10

Other Industries IV-13

Agriculture, Forestry, and Fishing. IV-13

Mining. IV-17

Construction. IV-17

Government and Education. IV-18

Manufacturing IV-20

Wholesale Trade IV-21

Communications. IV-22

Utilities IV-22

Retail Trade and Services IV-23

Finance, Insurance, Real Estate IV-26

SECTION I

INTRODUCTION AND BACKGROUND INFORMATION

INTRODUCTION

The United States will, if existing habits and lifestyles continue, be confronted by an energy shortage. Although the actual magnitude of this shortage is dependent on considerations such as foreign policy and the severity of winter weather, current estimates of the magnitude of the energy shortage indicate that transportation-related fuel consumption will need to be reduced by between 10 to 30 percent. Texans will be called upon to pursue programs that will help bring the demand for energy 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 can be encouraged to voluntarily reduce their energy consumption.

Each of these alternative approaches has associated with it certain advantages and disadvantages. In pursuing any of the above approaches, it must be realized that transportation is absolutely essential to all economic activity.

Mandatory governmental controls provide a means of closely controlling the absolute amount of fuel consumed. However, no such system can be equitably applied to all parties affected. In addition, fuel consumption can be reasonably curtailed by only a certain amount, and ill-founded mandatory controls might well have a severe impact on the economy of Texas and the nation.

Economic pricing, consisting of allowing the price of fuel to increase, can be used to decrease demand for fuel and thus equate fuel demand with fuel supply. Such an approach will adversely affect low income persons while not necessarily inconveniencing upper income households.

Individuals can be encouraged to voluntarily reduce their transportation related fuel consumption. Current transportation practices by both individuals and businesses in Texas have been founded on a past history and a future expectancy of a plentiful supply of inexpensive fuel. There is considerable waste associated with many of these practices. Some can be eliminated with beneficial rather than negative results, and others can be modified so as to produce fuel savings without severely affecting the economy. If the population can be convinced of the existence and severity of an energy shortage, considerable fuel savings can be achieved by this voluntary approach.

Considerable energy is used for transportation purposes. In the face of an energy shortage, it is only appropriate that prudent means of reducing this consumption be pursued.

This report presents the results of preliminary evaluations of numerous measures that might be instituted in an effort to conserve energy in transportation activities. The potential fuel savings are estimated, and significant social and economic impact are identified for each potential action program included. This information should prove useful to those persons formulating fuel conservation measures for the State of Texas.

GENERAL TRANSPORTATION DATA

Data related to transportation activities are presented in this chapter. This information provides the basis for many of the evaluations included in subsequent sections of this report.

Energy Consumed by the Transportation Sector

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

Fuel Consumption and Efficiency of the Various Modes of Transport

- Highway-oriented transportation consumes the majority of transportation fuel (Table I-1). Passenger automobiles consume the greatest percentage of total transportation fuel consumption.
- The magnitude of passenger and freight transport served by the different modes of travel is summarized in Table I-2. Highway travel serves the great majority of passenger movement, whereas freight transport is served primarily by rail and water.

- Certain modes of travel use fuel more efficiently than others (Table I-3). Bus and train transportation are most efficient for passenger movement, whereas water, pipelines, and rail are most efficient for freight transport.

Characteristics and Trends In Highway Transportation

- Texas has developed as an auto-oriented state. Indicators of travel in Texas are reflective of the dependence Texans place on the private automobile. Virtually all of these indicators suggest that Texans travel more than other Americans. Per capita of both vehicle miles traveled and vehicle ownership in Texas exceed the national average by 9 and 11 percent, respectively (Table I-4).
- The historical rate of increase in per capita travel has been substantial. Between 1960 and 1970, the population of Texas increased at a rate of less than two percent per year; during this period, indicators of travel such as vehicle miles of travel per person and gallons of gasoline consumed per vehicle have increased at annual rates of 3-4 percent (Figure II-1).
- 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 and vehicles per capita should exist in Texas by 1980. Consequently, the future demand for auto fuel in Texas should not increase as rapidly as historical trends might suggest.

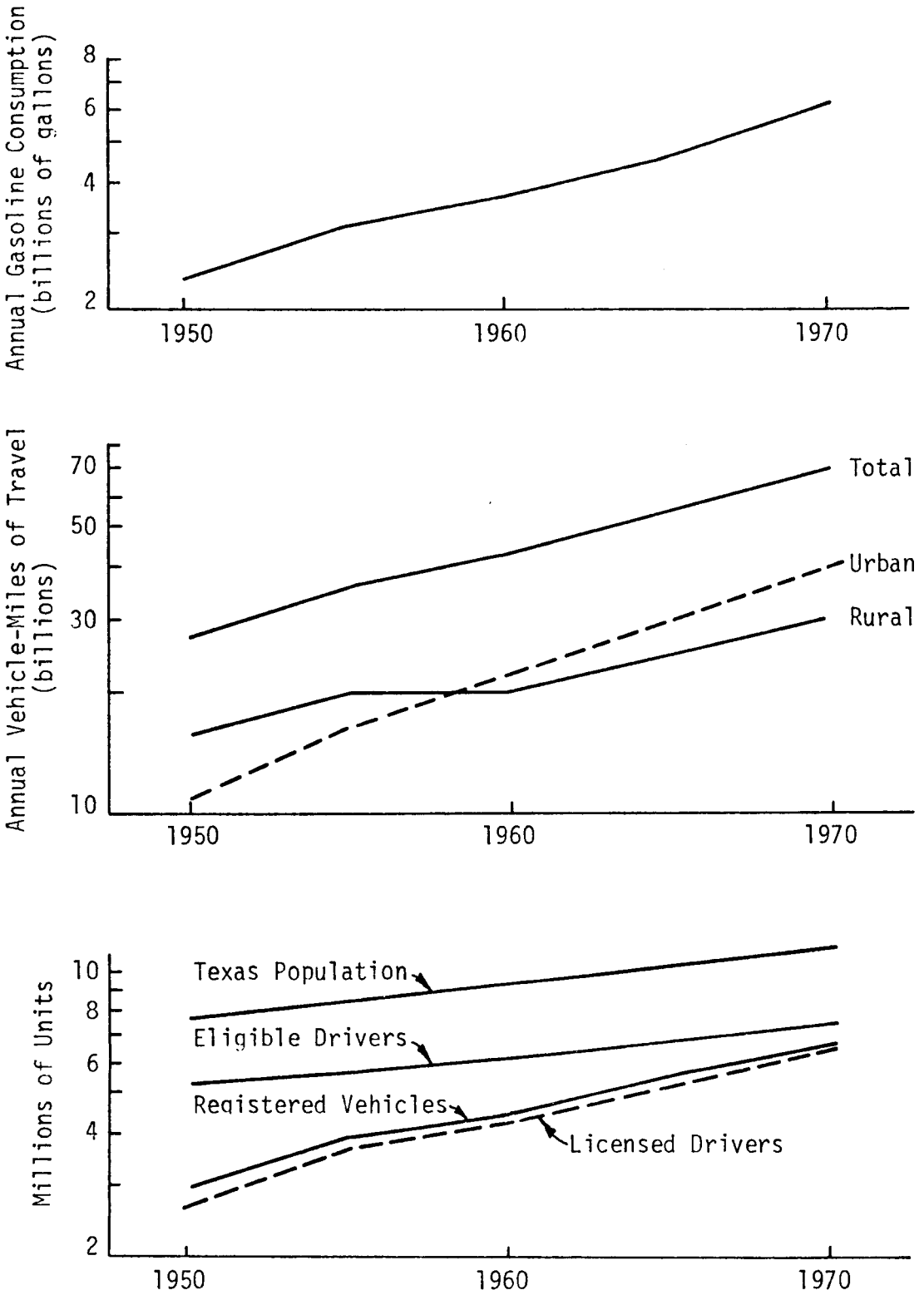

FIGURE I-1. HISTORICAL TRENDS, INDICATORS OF TRAVEL IN TEXAS

TABLE I-1. CONSUMPTION OF TRANSPORTATION FUEL
BY ALTERNATIVE MODES OF TRANSPORT, UNITED STATES DATA

Mode of Travel	Percent of Total Transportation Fuel Consumed
Highway Use	84
Passenger Cars	60
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

TABLE I-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	0.9	34.7
Water, Inland and Coastal	0.3	27.8
Aviation	10.0	0.2
Pipeline	0.0	19.1
TOTAL	100	100

TABLE I-3. FUEL EFFICIENCY OF ALTERNATIVE MODES OF TRANSPORTATION

Passenger		Freight	
Transport type	Passenger miles per gallon	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.

Source: Lincoln, G. A. , Energy Conservation: Science, Volume 180, No. 4082, April 13, 1973

TABLE I-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 Motor Fuel Consumed Per Year (billions)	3.7	6.3	57.9	92.3
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

Resources

1. Wilbur Smith and Associates. State of Texas Public Transportation Development Manual. Prepared for the Texas Mass Transportation Commission, 1971.

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

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

4. U.S. Department of Transportation, Federal Highway Administration. Highway Statistics (for years 1966-1971).

5. Texas Highway Department, Planning Survey Division. "Daily Vehicle-Miles, All Texas Road Systems, 1950-1970." Unpublished Data, 1972.

6. U.S. Bureau of the Census, U.S. Department of Commerce. "General Population Characteristics, Texas, 1960."

7. U.S. Bureau of the Census, U.S. Department of Commerce. "General Population Characteristics, United States, 1960."

8. U.S. Bureau of the Census, U.S. Department of Commerce. "General Population Characteristics, Texas, 1970."

9. U.S. Bureau of the Census, U.S. Department of Commerce. "General Population Characteristics, United States, 1970."

10. 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.

11. Lincoln, D. A. "Energy Conservation." Science, Volume 180, No. 4082, April 13, 1973.

SECTION II

MANDATORY FUEL CONTROL MEASURES

EFFECTS OF ALTERNATIVE SPEED LIMIT REDUCTIONS

- Motor vehicles require additional fuel to travel at higher speeds to overcome wind resistance that becomes significant at speeds above approximately 45 mph. Fuel savings can accrue if highway trips are made at speeds lower than 70 mph.
- Experience in World War II with a 35 mph speed limit indicates that average speeds were reduced even though the actual compliance with the speed limit was relatively low.
- No good information is available from which to estimate the degree of motorist compliance with reduced speed limits. The level of compliance will depend upon public attitude and degree of enforcement.
- A strong public information program is the most essential portion of a speed reduction program as compared to enforcement that has little effect unless the motorist perceives the need for posted speed limits.

Reducing Speed Limits on Rural Roads

Program Description

Four alternative maximum speed limits for rural roads were analyzed in comparison with the present 70 mph speed limit:

(1) 60 mph

(2) 55 mph

(3) 50 mph for automobiles, 55 mph for buses and large trucks

(4) 50 mph

Estimated Fuel Savings

- An estimate of fuel reductions that may be achieved from various proposed speed reductions is as follows:

Speed Reduction (Rural Highways)	Percent Reduction in Total Statewide Fuel Consumption for Highway Transportation
70 to 60	3% to 4%
70 to 55	5% to 5.5%
70 to 55-50	5.5% to 6%
70 to 50	6% to 6.5%

Economic/Social Impact

- Rural gasoline stations and truck stops may have a greater reduction in sales as compared to urban stations.
- Increased travel time will affect the desire to travel to resort and recreation areas especially those that are located at distances more than, for example, 80 miles from the populations they serve.
- Truck and bus operations will be significantly affected. The magnitude of the impact on their operations, as well as subsequent economic impacts, is discussed in Section IV of this report.
- Percentage increases in the time required to make intercity trips vary with the speed reductions as follows:

Speed Reduction	Additional Time Required
70 mph to 60 mph	17%
70 mph to 55 mph	27%
70 mph to 50 mph	40%

- Each individual and business firm will perceive some costs and inconveniences associated with increased time required to travel.

Pertinent Information and Assumptions on Calculated Fuel Savings

- Characteristics of the fuel consumption of passenger cars on rural roads as related to speed were obtained from the Cope study. The Cope study's reported savings resulting from speed reduction are, as expected, somewhat less than earlier studies because of anti-pollution equipment and varying rear axle ratios.
- Truck and bus fuel consumption tables in Claffey and Winfrey were used with Texas weight data from the study by Buffington, et al. to derive fuel consumption for rural Texas trucks.
- Fuel consumption tables in gallons per mile at 5 mph intervals were prepared using vehicle weight data for Texas vehicles for the primary vehicle types classified at speed survey and vehicle count stations. Figure II-1 is a plot of the data in the more familiar miles-per-gallon units.
- Studies demonstrate that gasoline vehicles burn 50 percent more fuel than the equivalent diesel rig; however, this is not fully reflected in the fuel consumption figure because economics makes it attractive to use diesel for heavily loaded trucks.
- Speed distribution tables were prepared with the proportion of each type of vehicle by highway classification for existing and proposed speed limits. Observed 1973 speed survey data provided the basis for the speed distribution tables. Example speed distribution curves are shown in Figure II-2.

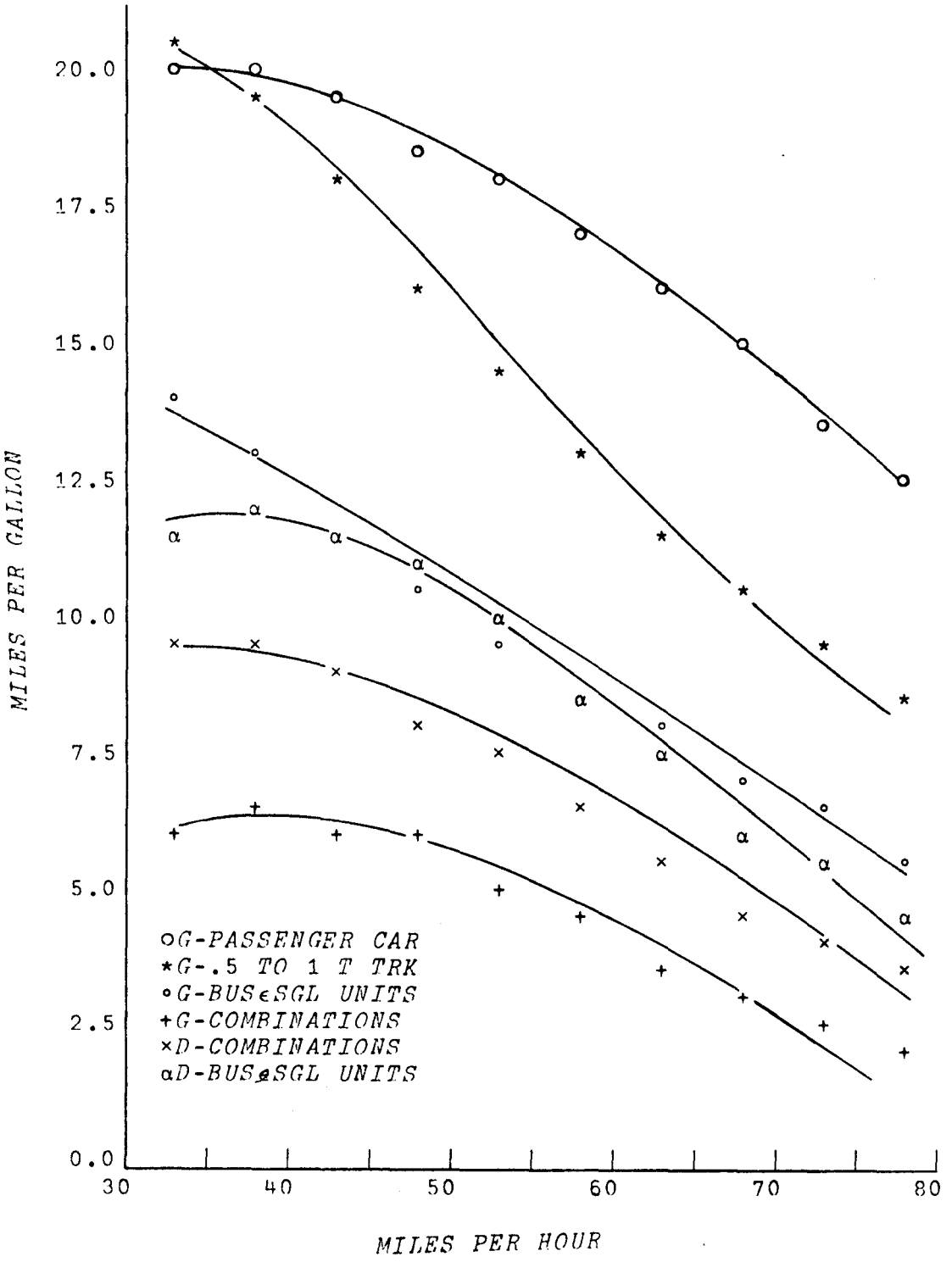

FIGURE II-1. FUEL CONSUMPTION OF SELECTED VEHICLES

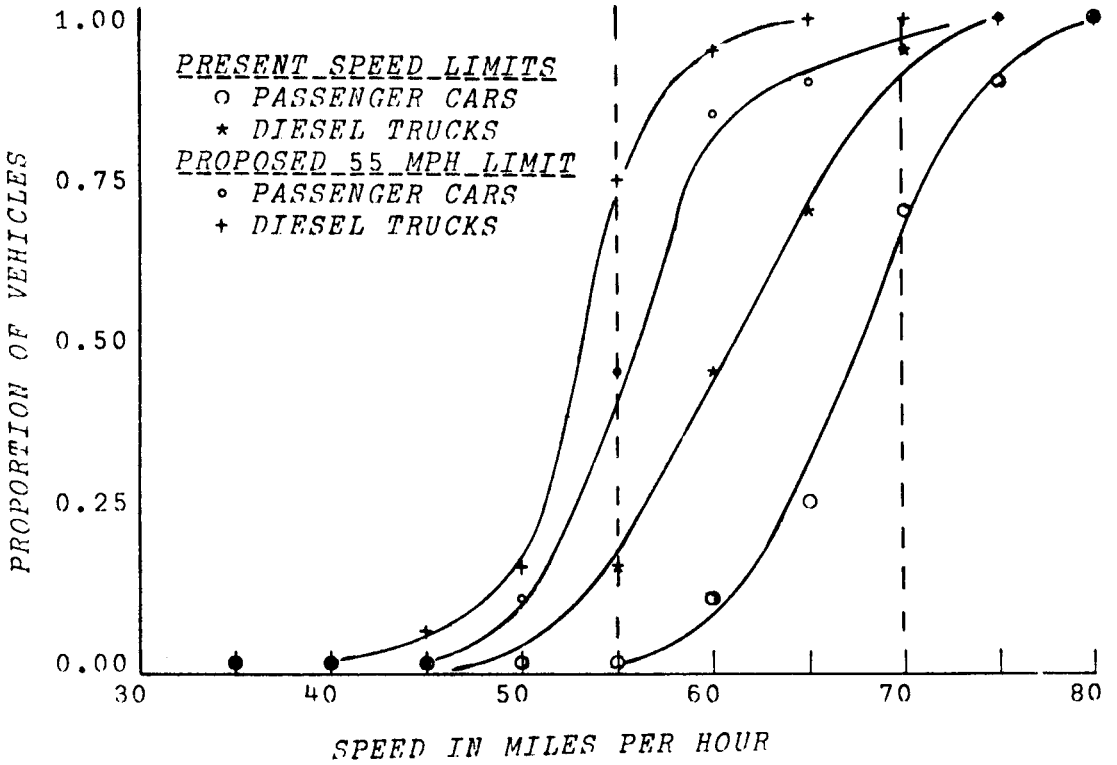

FIGURE II-2. SELECTED EXAMPLE CUMULATIVE SPEED DISTRIBUTIONS INTERSTATE HIGHWAYS

- The percentages of various types of vehicles on Texas main rural roads, as interpreted from manual count station data to the nearest percent, are as follows:

	Interstate Highways	Other State Highways	Farm-to-Market
	---------- percent----------		
Gasoline			
Passenger cars	71	67	60
Pickup to one-ton truck	15	21	31
Bus and other single unit	2	4	5
Combination tractor-trailer	3	2	3
Diesel			
Combination tractor-trailer	8	5	1
Bus and other single unit	1	0	0
	100	100	100

- The proportion of vehicle miles traveled on main rural roads is as follows:

Interstate	25%
Other state highways	56%
Farm-to-market	19%

- Effects of speed limit changes on county roads are not included in this evaluation.
- Speed distribution curves were assumed for use in calculating fuel consumptions by passenger cars and diesel trucks on various types of rural roadways.

- Approximately 38 percent of daily vehicle miles are driven on rural roads. Because rural fuel consumption is less than that for urban driving, rural travel accounts for only 30 percent of the total statewide gasoline consumption.
- The proportion of 67 percent diesel fuel consumed on rural main roads was derived by considering the trucks in the total traffic stream, the available highway mileages, the total vehicle miles by truck, and the truck-use studies from the Census of Transportation.
- These estimates do not include any assumption of a change in travel habits as a result of increased travel time.

Evaluation/Comments

- The effects of speed limit changes on the number of accidents are difficult to evaluate; however, the available data indicate that fatalities and injuries will be reduced as travel speed is reduced.
- Figure II-3, from a study by Cleveland, shows the relationship of accident severity to travel speeds. It is also evident from Figure II-3 that because of the greater impact at higher travel speeds, high-speed accidents tend to produce more serious injuries and greater property damage.
- The degree of motorist compliance with reduced speed limits can be expected to have a large effect on the number of accidents.
- Motorists who travel at speeds that have greater than a 10 percent difference from the average speed--whether faster or slower--will experience a much higher accident rate, as shown in Figure II-4.

- A reduction in speed can be expected to reduce the number and severity of accidents; however, if compliance is not high, the slower drivers who are complying with the reduced speed rate could contribute to an increased accident rate.

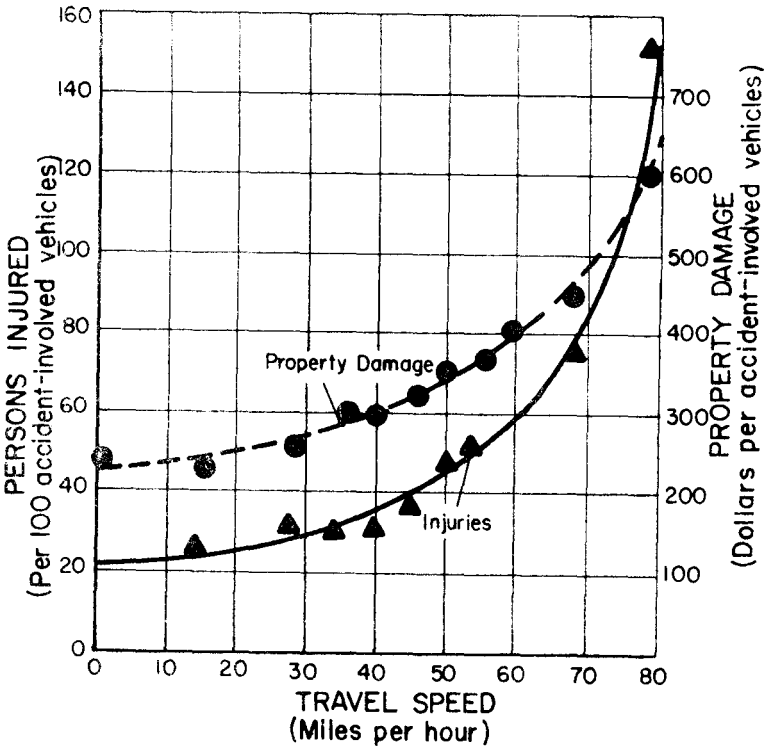

Figure II-3. SPEED VS. INJURIES AND PROPERTY DAMAGE

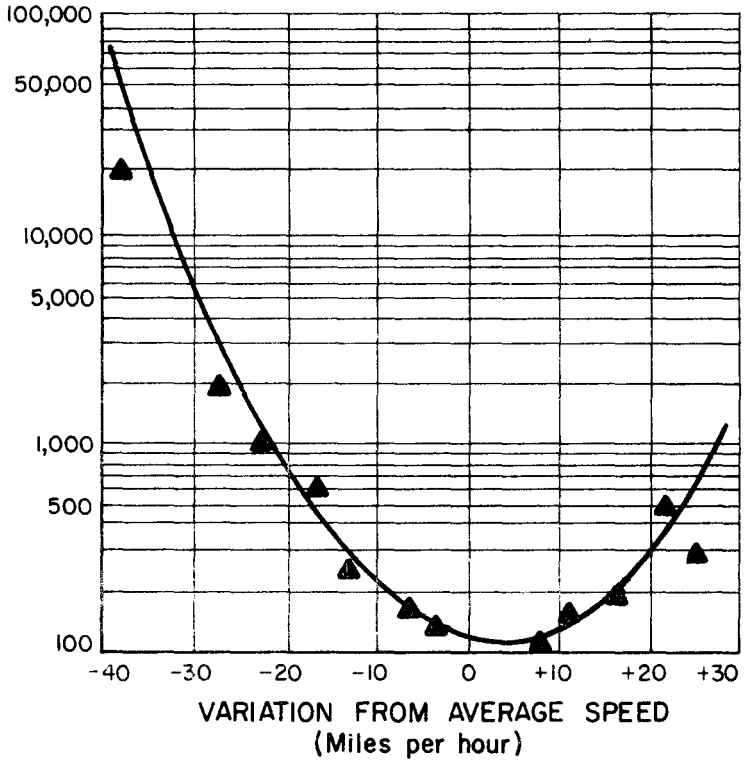

Figure II-4. VARIATION OF INVOLVEMENT RATE FROM AVERAGE SPEED (Daytime)

Reducing Speed Limits on Urban Freeways and Arterials

Program Description

Reduction of speed on urban freeways and arterials to a maximum of 50 mph

Estimated Fuel Savings

Maximum of 0.5 to 0.7 percent of total gasoline consumption

Economic Impact

Negligible

Pertinent Information/Assumptions

- Approximately 13 percent of total state vehicle miles are driven on urban Interstate roadways, and another 17 percent of total state vehicle miles are driven on other urban U.S. and state highways. Slightly more than half of these two classes of roadways (15 to 20 percent of total) currently have speed limits in excess of the proposed 50 mph urban maximum. The remaining streets and roadways have speeds of 50 mph or less.
- Assuming a high degree of compliance with the recommended 50 mph speed, 3.5 percent of the fuel consumed on urban freeways and arterials could be saved. This saving applies to 15 to 20 percent of all vehicle miles, and a savings of 0.5 to 0.7 percent of statewide gasoline consumption could be expected.

Evaluation/Comments

- A reduction in speeds would slightly decrease accident severity.
- The additional time required to make most urban trips would be negligible.

Resources

1. Cope, E. M. The Effect of Speed on Gasoline Fuel Consumption. U. S. Department of Transportation, October 1973.

2. Claffey, Paul J. and Associates. Running Costs of Motor Vehicles as Affected by Road Design and Traffic. NCHRP Program Report 111, 1971.

3. Winfrey, Robley. Economic Analysis for Highways. International Textbook Company, Scranton, Pennsylvania, 1969.

4. Buffington, Jesse, W. G. Adkins, Dale L. Schafer. Fuel Tax Differentials of Texas Cargo Vehicles. Texas Transportation Institute Research Report 131-1, May 1968.

5. Texas Highway Department. Planning Survey Division 1973 Speed Survey.

6. Texas Highway Department. Planning Survey Division Percentage of Various Types of Vehicles on Rural State Highways and Farm-to-Market Roads.

7. Cleveland, Donald E., "Speed and Speed Control," Traffic Control and Roadway Elements - Their Relation to Highway Safety/Revised, Ch. 6, Highway Users Federation for Safety and Mobility, 1970.

MOTOR FUEL ALLOCATION

- The distribution of motor fuel can be controlled through a mandatory allocation program. Such a program would allocate delivery of fuel from bulk distributors to various large volume users.
- Allocation of bulk deliveries has maximum impact on large volume users of motor fuel, such as the transportation industry and business firms that utilize motor vehicles in their daily operations.
- An allocation program that limits the deliveries of gasoline to service stations will have some impact on fuel consumption by small volume users of motor fuel.
- A national fuel allocation program has recently been implemented and is based on the 1972 levels of consumption. Current fuel consumption rates are about 5 percent greater than in 1972.
- In order to provide a reserve fuel supply for assignment to essential services, many bulk users are being restricted to 90 percent of their 1972 consumption. This results in a net 15 percent shortage from current demand.
- The current national fuel allocation program can produce a net reduction of 5 to 10 percent in transportation fuel consumption.
- The impact and effectiveness of the fuel allocation program on various components of transportation activity are evaluated in this chapter.

General Public

Program Description

Restrict deliveries to service stations to 90 percent of 1972 levels.

Estimated Fuel Savings

Approximately 8 percent reduction in statewide transportation fuel consumption

Social/Economic Impact

- Gasoline prices will tend to increase drastically.
- People will have to reduce their travel.
- Recreational and tourist establishments will be impacted.

Pertinent Information/Assumptions

- Passenger cars account for about 60 percent of total transportation fuel consumption.
- Total fuel supply to service stations will be about 15 percent less than current supply (5 percent growth since 1972 plus 10 percent reduction in 1972 levels).
- Assuming that about 10 percent of the fuel consumed by passenger cars is purchased in bulk quantities rather than at service stations, this program can influence about 54 percent of the fuel consumed.
- The net reduction in statewide consumption of transportation fuel will be approximately 8 percent (15 percent X 54 percent).

Evaluation/Comments

- Most individuals can probably achieve a 15 percent reduction in motor fuel consumption without major inconveniences.

- Allocation programs do not, however, force each individual to curtail his own consumption. The net reduction in supply will be 15 percent, but some people will be willing to pay higher prices to minimize the inconvenience. Hence, other individuals will be forced to curtail consumption to a greater extent.

Buses

Program Description

Restrict deliveries to bus firms to 90 percent of their 1972 consumption.

Estimated Fuel Savings

Less than 0.1 percent of statewide consumption of transportation fuel.

Social/Economic Impact

- Several urban public transportation systems will be severely impacted.
- Intercity bus service may have to be curtailed by 10 percent.
- Curtailments in bus service will penalize lower income families most severely.

Pertinent Information/Comments

- Bus operations consume only 1 percent of total transportation fuel.
- Consumption of fuel by buses has remained reasonably stable since 1972. Thus, the program will result in a net 10 percent decrease in fuel consumption by buses.
- The net potential reduction in statewide consumption of transportation fuel is only 0.1 percent (1 percent X 10 percent).

Evaluation/Comments

- Bus transportation is the most fuel efficient form of passenger transport available to most Texans.
- During the fuel shortage, bus ridership will probably increase as people seek alternative ways to serve their travel needs. Thus, bus systems should be increasing their operations rather than decreasing them.
- At least three Texas cities (Austin, Waco, and Ft. Worth) have recently purchased new city buses and extended schedules in an effort to rejuvenate transit usage. These transit systems will be severely impacted because their current fuel consumption is significantly higher than 1972 levels.
- At least three Texas cities (Waco, Ft. Worth, and Amarillo) recently replaced old gasoline-and LPG-powered buses with new diesel-powered vehicles. This change resulted in a net decrease in total fuel consumption; however, the allocation program is established based on the 1972 consumption of diesel fuel. Thus, they are facing severe fuel shortages unless special action is taken.

Trucking

Program Description

Restrict fuel deliveries to trucking firms to 90 percent of 1972 levels.

Estimated Fuel Savings

Approximately 4 percent reduction in statewide consumption of transportation fuel.

Social/Economic Impact

- The trucking industry will be severely impacted by the magnitude of this fuel restriction.
- Some trucking firms may be forced out of business which will increase unemployment.
- Some shippers will have severe difficulty in obtaining truck service.

Pertinent Information/Assumptions

- Trucking accounts for 23 percent of all transportation fuel consumption.
- Large trucks that use diesel fuel account for about 10 percent of total statewide consumption of transportation fuel.
- Sales of diesel for highway use in Texas for the first eight months of 1973 are running almost 18 percent above the same 1972 period.
- Gasoline-powered trucks consume about 13 percent of all transportation fuel, and the consumption of gasoline by trucks has increased slightly since 1972.
- Overall, the trucking industry has increased its fuel consumption by about 8 percent since 1972. If the fuel supply is restricted to 90 percent of the 1972 level, the trucking industry will be facing an 18 percent shortage of fuel.
- The total reduction in statewide consumption of transportation fuel will be approximately 4 percent (18 percent X 23 percent).

Evaluation/Comments

- Reduced speed limits will result in some reduction in the fuel consumed by over-the-road tucks. Fuel economy measures (discussed in Section III of this report) for individual trucks can help the

trucker cope with the shortage. However, the combined effect of these measures will not contribute 18 percent savings.

- Many Texas fleet operators have been switching from gasoline-power to diesel-powered vehicles to gain a 60 percent reduction in fuel consumption per ton-mile. Hence, sales of diesel fuel have increased 18 percent in one year. The total shortage in diesel fuel under this program approaches 30 percent.
- Under such a program, truckers will be forced to curtail their operations significantly.

Railroads

Program Description

Restrict deliveries of fuel to railroads 90 percent of 1972 levels.

Estimated Fuels Savings

Approximately 0.7 percent of statewide consumption of transportation fuel

Social/Economic Impact

- Stronger pressure will develop to abandon rail lines serving smaller communities as a way to reduce total fuel consumption.
- Some unemployment may result in those firms that can no longer obtain rail service.
- The lower Rio Grande Valley may be most severely affected.

Pertinent Information/Assumptions

- Railroads account for 4 percent of the total statewide consumption of transportation fuel.

- Tonnage transported by railroads has been increasing at an annual rate of about 4 percent. A comparison of pertinent rail operating data between 1963 and 1972 is as follows:

	Year		Percent Change
	1963	1972	
Tons Transported	158,751,000	222,304,000	40%
Revenue (Freight)	$445,048,000	$784,816,000	76%
Locomotive Mile	*109,781,000	113,543,000	3.4%
Fuel Consumption, Gallons (Diesel Fuel)	189,297,000	266,031,000	40%
Cost of Fuel	17,577,000	26,471,000	50%
Fuel Cost Per Locomotive Unit Mile	*0.16	0.23	44%

*For the year 1964

Source: Annual Reports, Texas Railroad Commission

- It is estimated that, in the absence of fuel restrictions, the consumption of diesel fuel by Texas railroads will exceed 275 million gallons in 1973 and approach 290 million gallons in 1974.
- The railroads will face a total 17 percent shortage of fuel under this program.
- A net reduction of 0.7 percent (4 percent X 17 percent) in statewide consumption of transportation fuel would result from this program.

Evaluation/Comments

- Railroads are the most energy-efficient mode for transporting

freight. Railroads consume about one-fifth as much fuel as trucks per ton-mile carried. If a prolonged energy shortage is imminent, it would seem appropriate to encourage an increase in the proportion of freight carried by rail. Fuel restrictions will not accomplish that objective.

Aviation

Program Description

Reduce current fuel consumption in the various sectors of aviation activities as follows:

Scheduled Air Carriers	15 percent reduction
Non-scheduled Air Taxis	20 percent reduction
Industrial Flying	20 percent reduction
Corporate and Business	40 percent reduction
Instructional and Pleasure	50 percent reduction

Estimated Fuel Savings

Approximately 1.5 percent of statewide consumption of transportation fuel

Social/Economic Impact

- Immediate curtailment of flight schedules on routes with low load factors will occur. In general, these routes are serving cities that already have limited scheduled air service.
- The loss of jobs in the airline industry will be significant.
- The impact on the general aviation sector will be most severe. Many private airports will cease operation, the small aircraft manufacturing

business will drastically reduce production and lay off employees, and some cities will lose existing air taxi or commuter air service.

Pertinent Information/Assumptions

- The aviation industry accounts for the following portions of the total statewide consumption of transportation fuel:

Scheduled Air Carriers	7 percent
All General Aviation	1 percent

- The estimated statewide fuel savings are as follows:

Scheduled Air Carrier	(7 percent X 15 percent) =	1.05 percent
General Aviation	(1 percent X 40 percent) =	0.40 percent
Total for Aviation		1.45 percent

Evaluation/Comments

- Under this allocation program, general aviation is being restricted more severely than any other sector of activity; yet, this total sector just accounts for 1 percent of statewide fuel consumption.
- Light aircraft, such as those used in general aviation, are not as inefficient a user of fuel as one might think. A four-place plane (a Cessna 172, for instance) will use fewer gallons of fuel flying between cities than an average car will use in driving between the same cities.
- The geographic size of Texas makes the time savings available from flying highly attractive for many trips. Thus, it seems that the impact of this program may be greater in Texas than in many other states.

Resources

1. Lincoln, G. A. "Energy Conservation." Science Magazine, Vol. 180, No. 4082, April 13, 1973.

2. Bureau of the Census, U.S. Department of Commerce. Statistical Abstract of the United States 1972. 93rd Annual Edition.

3. Association of American Railroads. Yearbook of Railroad Facts. 1972 Edition.

4. Air Transport Association of America. Air Transport 1971.

5. Wilbur Smith and Associates. State of Texas Public Transportation Developmnet Manual. Prepared for the Texas Mass Transportation Commission, 1971.

6. Holder et al. The Role of the Texas Mass Transportation Commission. Texas A&M University, August 1971.

7. "The Greyhound Corporation 1970 Annual Report." Greyhound Corporation, Chicago, Illinois.

8. Bureau of Census. 1967 Census of Transportation: Commodity Transportation Survey. Volume III, Part 2 Production Areas and Selected States, U.S. Government Printing Office, Washington, D.C., 1970.

9. Corps of Engineers. Waterborne Commerce of the United States. Part 2. Waterways and Harbors Gulf Coast, Mississippi River System and Antilles, U.S. Government Printing Office, Washington, D.C., 1955, 1960, 1967-1970.

10. U.S. Department of Transportation, Federal Highway Administration, Highway Statistics. 1950-1971.

FUEL RATIONING MEASURES

- Private vehicles account for more than half of the fuel consumed by all forms of transportation. Rationing of gasoline is the most direct and positive method of forcing a reduction in the consumption of fuel.
- Fuel rationing is the ultimate mandatory control available to force reduced consumption of transportation energy. If the required reduction in transportation fuels exceeds that which can be achieved through speed limit reductions and fuel allocation, and if only mandatory controls are used, then some level of fuel rationing will be required.
- Fuel can be rationed by direct apportionment of supply to individuals (as done in W. W. II) or by limiting time availability (closing of service stations on Sundays). Both methods are evaluated in this chapter.

Rationing an Individual's Fuel Supply

Impact on Fuel Consumption

- The impact of a rationing program on the total amount of fuel consumed would depend upon the allotment scheme used. Recent discussions have indicated that allotments of less than 10 gallons per week per vehicle are being considered.
- The average motor vehicle in Texas consumes 18.9 gallons per week. This figure includes some vehicles that are used for business travel; therefore, the typical fuel consumption by private auto-

mobiles is probably slightly less.

- A rationing plan which allocates only 10 gallons per week per vehicle would force Texans to reduce personal vehicle travel by more than 40 percent.
- This would result in an estimated 25 percent reduction in statewide consumption of transportation fuel.

Characteristics of Rural Travel

- Approximately 20 percent of Texans reside in rural areas.
- Travel per vehicle in rural areas does not appear to be much different from that in urban areas; at present, on the average, a vehicle travels about 200 miles per week, or 10,400 miles per year.
- An average rural dwelling unit consists of 3.2 persons and has 1.4 vehicles. Thus, the average household travels about 280 miles per week.
- It is reasonable to assume that the average trip length (miles) in rural areas is substantially longer than in urban areas. It can also be assumed that, because trips are longer, the travel patterns of rural households are more organized than those of urban households. Considerably fewer "unnecessary" trips are made by rural residents.

Impact of Rationing on Rural Travel

- Rationing of 10 to 15 gallons per week per vehicle would allow the average household to travel (assuming 14 mpg) 200 to 300 miles per week. It should be noted that the travel of one-car families will be restricted to about 150 to 200 miles per week.
- Thus, the average family, being able to travel at least 200 miles per week, will not be unduly inconvenienced. However, the term "average"

infers that about 50 percent of the rural families travel more than 200 miles per week. These families may very well be unable to continue their present travel pattern.

- It should 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 makes fewer trips but longer and better planned trips, reducing travel may be extremely difficult. A rationing scheme that forces these families to significantly curtail existing travel could have serious economic implications.

Characteristics of Urban Travel

- The average urban residence in Texas is estimated to own approximately 1.4 private vehicles.
- The current gasoline consumption in Texas is estimated at 18.9 gallons per vehicle per week.
- The estimated current average weekday travel by purpose for urban residents (estimates based on information from Texas urban transportation studies and updated to reflect 1973-1974 travel characteristics using information from research conducted by the Texas Transportation Institute) may be summarized as follows:

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	139	100	71

- The average distance from home to work is 7.2 miles in large urban areas and 2.9 miles in small urban areas. Vehicles can average 10 mpg in urban travel; the average worker in a large urban area would need 7.2 gallons of gasoline per week to drive to and from work for five days, and the average worker in a small urban area would need 2.9 gallons of gasoline per week.

Impact of Rationing on Urban Travel

- Assuming that automobiles can average 10 mpg in urban travel and assuming that an employee goes to work five times per week, the gasoline requirements for urban workers may be estimated. Using trip length frequency information for home-based work trips from Texas urban transportation studies, the following estimates were made for workers who drive to work:

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 suggest, for example, that if fuel were rationed to 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. Such families would obviously suffer severe economic hardships since they would be forced to either quit their jobs or relocate in closer proximity to their work. These figures also suggest that gasoline rationing would have the least impact on small 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.

- Approximately 1.4 employed persons per dwelling unit are in urban areas in Texas. In addition, approximately 1.4 vehicles per dwelling unit are in urban areas in Texas. This suggests that, on the average,

approximately one vehicle per employee is in urban areas in Texas. Therefore, if gasoline were rationed to 10 gallons per vehicle per week, approximately 22 percent of the employees in large urban areas would not have enough gasoline to drive to work for a week (See table in preceding paragraph). Again, these people would have to seek alternative means of travel to work.

- Using 10 gallons per vehicle per week rationing, it can be seen from the preceding table 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. Indeed, 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.
- With a 10 gallons per vehicle per week rationing scheme, it can also be seen from the preceding table that 11.9 percent of the employees in small urban areas would need more than half this amount (i.e., more than 5 gallons) to drive their car to work, and 0.7 percent would need more than 10 gallons per week to drive their car to work. Thus, it can be seen that such rationing would have substantial impact in small urban areas but obviously not as severe as in large urban areas.

- When considering gasoline rationing, it is useful to review the estimated minimum requirements for the average urban family in Texas. Several assumptions will be necessary to obtain such an estimate. These assumptions are as follows:
    - 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 could, under austerity conditions, 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 which is about 38 percent of their 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. Under 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

urban areas would provide the average family with only 3.2 gallons more than that required under austerity conditions. If the average family in urban areas were limited to 10 gallons per week and they wanted (or needed) to make a 200-mile intercity (i.e., a 400 mile round trip), they would have to limit their activities to austerity conditions for approximately 10 weeks in order to save enough gasoline for such a trip (assuming 12 mpg for intercity travel).

Economic and Social Impacts

- The economic and social impacts of gasoline rationing are, at best, severe. The level of severity of these impacts, of course, depends upon the size of the allocation. Indeed, the severity of these impacts will increase almost exponentially as the size of the allocation is reduced.
- Some employees (especially in large urban areas) will be forced to either quit their current jobs or relocate. This suggests some increase in unemployment. This also suggests a decrease in property values in fringe and rural areas and an increase in value for property which is located in close proximity to shopping and employment opportunities.
- Resort communities will probably be severely impacted. Property values in these communities may generally be expected to decline substantially. The intensity of the impact on these communities will probably be a function of the size of the gasoline allocation and the location of the community (i.e., the distance from major metropolitan areas).

- The automotive industry will be severely affected. The demand for intermediate-size and full-size automobiles will obviously decline under rationing, whereas the demand for compact and subcompact size automobiles will increase. The resale value of intermediate- and full-size automobiles may be expected to decline sharply. Other portions of the automotive industry will also be affected. Reductions in automobile usage will, of course, reduce the demand for automotive equipment such as tires, batteries, etc.
- Almost the entire recreational industry will be severely affected. This includes:
    - Motels and hotels
    - Tourist attractions such as Six Flags Over Texas, Aquarena, Astroworld, Sea-A-Rama, etc.
    - Manufacturers and retail dealers for boats, boat motors, and other water sports equipment
    - Manufacturers and retail dealers for camping equipment, travel trailers, and mobile homes
    - Manufacturers and retail dealers for hunting and fishing equipment
    - Manufacturers and retail dealers for other sporting and recreational equipment which relies on any substantial travel in order to utilize the equipment

  The slow-down of this industry will, of course, have an impact on the entire economy.
- If there is long-term gasoline rationing, it may be expected to affect trends in urban development and urban form. There may be

a trend toward higher density development as portions of urban areas are developed and redeveloped.

- Large regional shopping centers will be adversely affected by gasoline rationing. These centers generally depend on attracting a significant portion of their customers from rather substantial distances. Indeed, if there is long-term rationing, a new emphasis will be placed on smaller community and neighborhood shopping facilities, as opposed to the larger regional facilities at greater distances. Since there are certain economics-of-scale associated with the regional center concept, some diseconomics will be encountered as the trend reverses to the smaller shopping facilities, thereby increasing the prices for goods and services. Rationing will also have severe effects on highly specialized retail establishments since they normally depend on attracting customers from substantial distances.
- Long-term gasoline rationing may be expected to influence many industry location decisions. Smaller cities and communities will become more attractive since they would offer definite advantages to their employees (i.e., residents of smaller cities and communities will not be as adversely affected by rationing as will residents of large urban areas).

Sunday Closing of Service Stations

Estimated Fuel Savings

Less than 2 percent of total gasoline consumption

Pertinent Information/Assumptions

- In conjunction with each urban transportation study in Texas, the Texas Highway Department has conducted a survey of highway trips entering, leaving, and passing through urban areas. In these surveys, the drivers were asked the origin and destination of their trips. Based on the results of these studies, the following trip length frequency was estimated for vehicles traveling over the rural highways of Texas:

Trip Distance (Distance Between Origin and Destination)	Estimated Percentage of Trips	Estimated Percentage of Daily Vehicle Miles on Rural Highways
under 50 miles	64.2%	21.3
50 - 99 miles	19.6%	19.5
100 - 199 miles	9.0%	17.9
200 - 499 miles	5.7%	26.4
500 miles and over	1.5%	14.9

- From highway traffic count data collected by the Texas Highway Department using permanent automatic traffic recorders, it is estimated that the average volume of Sunday traffic on Texas highways is approximately 20 percent higher than the average daily traffic on Texas highways.
- The average automobile will be assumed to be able to travel roughly 200 miles on a tank of gas.
- It would seem reasonable to assume that the closing of service stations on any given day would have little effect on trips less than 100 miles.

- It would seem reasonable to estimate that the closing of service stations for one day would affect those 100-199 mile trips on which the tripmaker would plan a return trip on the same day. It is estimated, therefore, that the closing of service stations for one day would eliminate approximately half of the 100-199 mile trips. Of those trips being eliminated, it would seem reasonable to assume that a substantial portion would simply be shifted to a different day. Also, a substantial portion are probably for social-recreational purposes. In such instances, it is likely that the tripmaker would simply seek social-recreational activities that require less travel; thus, a substantial portion of these trips would simply be replaced by shorter trips. It is estimated, therefore, that 50 percent of these trips would continue to be made, 25 percent would be replaced with shorter trips, and 25 percent would be eliminated.
- It would also seem reasonable to assume that trips greater than 200 miles could not be made on a day when service stations are closed. However, not all these trips would be eliminated because many would simply be shifted to a different day. It would be assumed, therefore, that only 75 percent of these trips would be eliminated and the remainder shifted to a different day. It is also likely that most of those trips being eliminated are for social-recreational purposes. It is likely, therefore, that many of these tripmakers would simply seek social-recreational activities that require less travel. In essence, it would seem reasonable to assume that a large portion of those trips being eliminated will be

replaced with shorter trips. It will be assumed, therefore, that 40 percent of those trips that are greater than 200 miles would be replaced by trips less than 200 miles and that 25 percent of those trips that are greater than 200 miles would be shifted to a different day.

- If it is assumed that the above trip length frequency is representative of Sunday travel, the closing of service stations on Sunday would eliminate approximately 33 percent of the vehicle miles currently being traveled on Sunday on rural highways. It should be recalled that the vehicle miles on rural highways account for approximately 40 percent of the vehicle miles within the state. It should also be noted that vehicles generally get substantially better mileage in rural driving than in urban driving; thus, this traffic probably accounts for only 30 percent of the gasoline consumption. Because Sunday traffic on rural highways is about 20 percent higher than the average daily traffic, Sunday traffic on rural highways accounts for approximately 5.1 percent of total weekly gasoline consumption in the state. Since the closing of service stations on Sunday would reduce the Sunday vehicle miles on rural highways by approximately 33 percent, the net effect of Sunday service station closings on the total weekly gasoline consumption in the state would be a reduction of approximately 1.7 percent (i.e., 0.33 times 5.1 percent).

Economic and Social Impacts

- This program is obviously directed toward the reduction of weekend

social-recreational travel. Such a reduction would, of course, have an impact upon the recreation industry which includes:

- Hotels and motels
- Restaurants
- Resort communities
- Manufacturers of boats and other water sports equipment
- Manufacturers of camping equipment, travel trailers, and mobile homes
- Manufacturers of hunting equipment

The decline in the sales of these goods and services will have substantial impact on the recreation industry and, therefore, will have an impact on the economy in general.

- It would seem reasonable to expect that at least some of the longer trips on weekends are necessary. These travelers would, of course, have to seek other means of transportation. It is reasonable to expect, therefore, that this program would tend to increase the use of intercity commercial passenger carriers (i.e., buses, airlines, and trains).
- There is a substantial amount of goods movement by trucks on Sunday. The closing of service stations on Sunday will obviously have an impact on this activity. Some goods may be shifted to rail for movement; but generally it will simply mean a reduction in the movement of goods by truck.

Resources

1. Texas Highway Department. "Urban Transportation Studies and Origin-Destination Surveys for Various Texas Cities." 1963-1970.

2. Chapin, Jr., F. Stuart. Urban Land Use Planning. University of Illinois Press, 1965.

3. Netzer, Dick. Economics and Urban Problems. Basic Books, Inc., 1970.

4. Hoover, Edgar M. An Introduction to Regional Economics. Alfred A. Knopk, Inc., 1971.

5. Texas Highway Department. 1972 Annual Report. U. S. Department of Transportation, Federal Highway Administration.

6. ----. Texas Almanac, 1972-1973.

7. Christiansen, Dennis L. "A Preliminary Evaluation of the Temporal Stability of Trip Generation Rates." (Research Report 167-6), Texas Transportation Institute, April 1973.

SECTION III

VOLUNTARY FUEL CONTROL MEASURES

URBAN PROGRAMS

- Since 1950, Texas has experienced a 45 percent increase in population and an 85 percent increase in urban population.
- Approximately 80 percent of all Texans reside in urban areas. Virtually all of the state's population growth is taking place in these areas.
- The type of urban development in Texas is typical of a "Western City." Most urban growth has occurred since the era of the automobile; correspondingly, population densities are relatively low.
- It is a recognized fact that transportation and land use are integrally related. Low densities of development are closely associated with the transportation service provided by the private automobile. The individual urban resident, due to the nature of urban development in Texas, must depend heavily on the transportation afforded by his automobile.

Urban Travel Characteristics

- At present, urban vehicle-miles of travel constitute about 60 percent of statewide vehicle-miles of travel. The percentage of total statewide travel that occurs in urban areas has been increasing and can be expected to increase continually.
- Because urban driving, as opposed to rural travel, results in lower miles per gallon, motor fuel consumed in urban travel probably exceeds the 60 percent value and may be as much as 70 percent of all motor fuel used in Texas.
- Trends in 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 (based on urban transportation study data collected by the Texas Highway Department and updated to reflect 1973-1974 travel based on research conducted by the Texas Transportation Institute) may be summarized as follows:

	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 Distance from Home to Work	7.2 miles	2.9 miles
Average Daily Auto Trips/Auto	5.4 trips	6.1 trips
Average Daily Auto-miles/Auto	26.9 miles	14.1 miles
Average Weekly Auto-miles/Auto	139.0 miles	71.0 miles

- Travel of urban residents can be further related to the purpose of the travel. The current average weekly urban travel by trip purpose for urban residents (estimates based on information from Texas urban transportation studies) may be summarized as follows:

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	139	100	71

- The average trip length (miles) is not the same for all trip purposes; the work trip is about 50 percent longer than the average urban trip. Thus, any program directed toward reducing the number of vehicle trips to work will have a more than proportional impact on reducing urban vehicle-miles of travel.

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 directed at reducing urban travel.
- Several programs can be pursued that will reduce urban gasoline consumption and these programs are discussed in this chapter. It should be realized that all these programs are not necessarily compatible. 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 gasoline savings that would result from implementing all the urban programs is not the summation of the savings associated with each of the individual programs.

- A concerted effort by urban citizens to comply with the voluntary portions of the program discussed in this chapter can yield a net savings of 10 percent in statewide fuel consumption without undue hardship or severe economic impact.

Reduction in Urban Travel

Program Description

Elimination of unnecessary travel by urban residents in Texas.

Estimated Fuel Savings

Maximum of 8 percent of total gasoline consumption.

Economic and Social Impacts

- A program such as this will have its greatest impact on shopping habits. The tendency of shoppers to shop for "specials" at numerous stores (i.e., comparative shopping) might be reduced; therefore, the cost of groceries and other shopping goods might increase by a modest amount. The tendency toward impulse buying might increase, thereby increasing the amount of money spent on shopping goods.
- Some adjustment in our current lifestyle will be necessary and will result in some inconvenience until habits are changed.
- This program should not reduce the amount of money spent for goods

and services (other than those associated with the automobile) and may well result in a modest increase in the amount of money spent on goods and services.

Pertinent Information/Assumptions

- Present urban travel patterns consist of many disjointed, unorganized trips. If the urban households can be convinced that careful planning of their trip-making is desirable, vehicle miles of urban travel can be reduced.
- Potential reductions in trip making must be related to the purpose of the trip. Work travel can hardly be considered unnecessary travel; thus, no reduction in travel for work purposes is assumed. This, of course, does not preclude possible fuel savings in such travel by car pooling or increased transit usage. Such potential savings will be discussed in subsequent sections of this chapter. Travel for school and medical-dental purposes could, likewise, hardly be considered unnecessary travel. Probably very little personal business travel could be considered unnecessary travel. Personal business travel includes trips to visit the lawyer, to the bank, etc. Shopping, social-recreational, and eat-meal travel are probably the most likely areas for the reduction of unnecessary travel.
- The average urban household generates eight one-way, non-stop trips per day. The total number of miles driven could be reduced by linking trips in an efficient manner so that the total number of trips is reduced. For example, an individual might travel to work

and back home (accounting for two trips) and then drive to the grocery store for milk, bread, eggs, etc, and then return home (two more trips). If he had planned ahead, he could have stopped by a convenient grocery store on the way home. His total trips for the day would have then been three instead of four, and the vehicle-miles of travel would have been reduced.

- It would seem reasonable that, on the average, each urban household could reduce current travel by 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, the elimination of one auto trip per day 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 on the average of one unnecessary trip per day per household may be expected to reduce the fuel consumption of urban residents for urban travel 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 6 and 10 percent.

Evaluation/Comment

- This analysis assumes a successful program for a voluntary reduction of unnecessary urban travel. It is doubtful that a voluntary program of this nature will be fully successful. Indeed, unless the public is thoroughly convinced that this is a necessary program, it will not meet its full potential. Its success, therefore, depends upon the success of the public awareness campaign

that will be necessary to implement the program.

Car Pooling

Program Description

Increased use of car pools

Estimated Fuel Savings

Two percent of statewide gasoline consumption, assuming fuel availability is not severely curtailed

Economic Impact

- The demand for parking at the place of employment will be reduced.
- Peak period urban congestion can be reduced which will also decrease travel time, improve safety, and reduce vehicle emissions.

Pertinent Information/Assumptions

- 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 the trips of a non-personal nature that originate at home and terminate in an area of concentrated activity. Thus, car pooling serves a limited number of trip purposes, being primarily applicable to serving the work trip and offering 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 the home. 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.

- Assume that voluntary car pooling will primarily affect those work trips which originate at home, or 20 percent of urban trips, and that the average occupancy for those trips is 1.1 persons per auto. If this could be increased to 2.0 persons per auto, thus eliminating 45 percent of those vehicle trips which can be car pooled, urban trips could be reduced by 9 percent. Because the trip to work is longer, increased vehicle occupancy might decrease urban miles of travel by as much as 13 percent, thereby reducing statewide travel by 7 percent. A corresponding reduction in gasoline consumption can be assumed. This estimate represents the maximum potential gain from car pooling that would occur under austerity conditions because it assumes that the average occupancy of those vehicles "eligible" for car pooling will be nearly doubled.
- A secondary means of estimating the potential of car pooling involves analyzing those trips that originate at home and terminate in an area of concentrated activity. The central business district (CBD) generally is the area of most concentrated employment. A means of estimating the effect of car pooling would be to assume that all auto trips originating at home and terminating in the CBD might be car pooled. About 10 to 20 percent of total auto trips have a destination in the CBD; about 50 percent of these trips are work trips.

Between 50 to 75 percent of these work trips have an origin (home) that is conducive to car pooling. Thus, when car pooling is considered in relation to areas of concentrated employment, about 6 percent (15% x .5 x .75) of total daily urban trips appear to be conducive to possible car pooling. If the occupancy in these trips were doubled (to 2.2 persons per auto), 3 percent of total urban trips might be eliminated. This 3 percent of trips would represent 4.5 percent of urban vehicle miles, and a corresponding percentage of urban gasoline consumption can be assumed. A 3 percent reduction in urban gasoline consumption will represent about a 2 to 3 percent reduction in statewide gasoline consumption. This appears to represent a reduction in gasoline consumption that can be achieved by an extensive voluntary car pooling program.

Evaluation/Comment

- The awareness of an energy shortage may cause some individuals to form car pools, and some encouragement by industry could stimulate this trend. If gasoline rationing becomes a reality or if the threat of possible rationing is so severe as to make residents believe rationing is imminent, car pooling could become much more extensive.

Urban Public Transit

Program Description

Increase usage of urban public transit.

Estimated Fuel Savings

Approximately 1 percent of total statewide gasoline consumption

Economic Impact

- An increase in transit ridership will improve the economic condition of the transit industry in Texas.
- Peak period congestion can be reduced, resulting in fewer vehicle emissions, reduced travel time, and safer urban roadways.
- Parking demand at the place of employment will be reduced.

Pertinent Information/Assumptions

- In the short run, the capability of transit to serve additional trips is limited. In those cities where transit operates, the transit system presently serves only 4 to 5 percent of total urban trips. Fifty percent of these trips are served during the peak period, and 60 percent of transit trips are work trips.
- Because transit vehicles serve the majority of their trips during peak periods and because these vehicles operate at on near capacity during these periods, it is assumed that, in the short run, daily transit ridership cannot be increased by more than 15 to 20 percent.
- A 20 percent increase in transit trips would decrease urban auto trips by one percent (transit would serve 5 to 6 percent of urban trips). Since most of the trips served will be work trips, urban vehicle miles of travel could be reduced by 1.5 percent, reducing statewide mileage by about 1 percent. A similar reduction in gasoline consumption can be assumed. This may be a high estimate because only 20 cities in Texas have transit service.
- In the long run, additional transit equipment can be purchased, and transit capacity can be increased. It is assumed that transit will never be able to serve more than about 15 percent of total

urban trips. This is comparable to tripling existing usage.

- This will result in a 10 percent decrease in urban auto trips. Since transit will be serving many trips other than work trips, urban vehicle-miles of travel should also be decreased by about 10 percent, resulting in a reduction of 6 percent in statewide travel. A corresponding reduction in gasoline consumption can be assumed.

Evaluation/Comment

- If the price of gasoline increases significantly, or if fuel availability becomes limited, urban residents may demand that public transportation be made available to serve their trip desires. Only 20 Texas cities are currently served by transit. Those cities without transit service may find it necessary to make major capital expenditures to install a transit system, and those cities with a transit system may find it necessary to greatly expand that system.
- Transit is primarily designed to serve corridors of concentrated person movement; it can never be expected to realistically serve the numerous dispersed trips that are presently a major part of our urban lifestyle. If transit is utilized to serve these diverse trips, it is entirely conceivable that more fuel will be consumed than is now being consumed by the private auto in serving these trips.

Staggered Hours

Program Description

Encourage implementation of staggered work hours

Estimated Fuel Savings

Approximately 1 percent of total statewide gasoline consumption

Economic Impact

- Provides a means for serving more riders with existing transit equipment. This transit ridership increase will improve the the economic condition of transit in Texas.
- Staggered hours will spread traffic demand over a greater time period, thereby decreasing travel time, reducing congestion, improving safety, and reducing vehicle emissions.

Pertinent Information/Assumptions

- Staggered hours will tend to smooth traffic flow. However, the potential fuel savings associated with this improved traffic flow will be negligible.
- Persons arriving at work at staggered time intervals will make formation of car pools somewhat more difficult.
- Staggering hours will cause the peak period to be longer in duration. This will permit transit operators to serve more riders without increasing fleet size. Transit presently carries about 50 percent of the daily ridership during peak periods. Assuming that staggering of hours might increase peak period ridership by as much as 50 percent, total daily ridership will be increased by 25 percent. Since transit presently serves about 4 to 5 percent of urban trips in

20 Texas cities, the increased ridership will mean that transit will be serving an additional 1 percent of urban trips in those cities served by transit.

- The additional 1 percent of trips is primarily the longer work trip; thus, urban vehicle-miles of travel might be reduced by 1.5 percent. Since urban miles of travel constitute 60 percent of statewide travel, statewide travel will be reduced about 1 percent, with a corresponding reduction in gasoline consumption.

Evaluation/Comment

- Staggering hours will reduce traffic congestion. This could encourage some existing transit riders to discontinue using the transit service and begin driving their private autos. Therefore, unless some restrictions (fuel availability, parking limitations, etc.) are imposed, the staggering of hours could decrease transit ridership. Under this condition, statewide fuel consumption would be increased.

Bicycling and Walking

Program Description

Discontinue using the private automobile to make those trips that are conducive to walking and/or bicycling.

Estimated Fuel Savings

Less than 3 percent of total statewide gasoline consumption

Economic Impact

- Bicycle sales will be increased.
- The auto parking demand at the place of employment will be reduced.

- Some capital expenditure might be desirable to expedite the flow of bicycles and to provide parking for these vehicles.

Pertinent Information/Assumptions

- 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).
- Restrictions other than distance reduce the potential for using walking and/or bicycling. Based on age, physical condition, and attitude, only about 45 percent of the population will utilize these alternative modes of transportation. 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 will further reduce the potential for walking/bicycling by about 30 percent. Bicycling/walking can adequately serve about 75 to 80 percent of all trip desires (based on trip purpose). In addition, urban gasoline consumption represents only about 60 to 70 percent of statewide consumption.

- Based on these constraints and limitations, it appears as if bicycling/walking will have the potential to reduce urban gasoline consumption by about 4 percent (15.4% x .45 x .7 x .8). A 4 percent reduction in urban vehicle-miles results in a net 2 to 3 percent reduction in statewide gasoline consumption.

Traffic Engineering Improvements

Program Description

Implement traffic engineering improvements that will reduce unnecessary speed changes in the traffic stream. Fuel savings that can result from improvements in individual driver habits are discussed separately in a subsequent section of this report.

Estimated Fuel Savings

Less than 2 percent of statewide gasoline consumption.

Economic Impact

- A substantial capital investment will be required to implement street and traffic improvements.
- Improving traffic flow will assist in maintaining the integrity of the existing street system thereby reducing the need for constructing new street and highway facilities in the future.
- Smoothing traffic flow will reduce congestion, decrease travel time, increase safety, and reduce vehicle emissions.

Pertinent Information/Assumptions/Calculations

- Vehicle acceleration and deceleration within the traffic stream have an adverse effect on fuel consumption. Traffic engineering techniques such as progressive signalization, access control,

turn restrictions, and freeway surveillance can be implemented to smooth the flow within the traffic stream.

- These techniques are primarily applicable to the freeway and arterial street system. Although this system comprises only about 20 percent of urban street mileage, some 60 percent of urban vehicle miles of travel occur on these facilities.
- Freeway control represents a means of improving traffic flow, but this control will have a significant effect only during peak operation. In Texas, about 28 million vehicle-miles are driven daily on urban Interstate highways. Fifteen percent, or 4.2 million, of these miles occur during peak conditions, and 50 percent, or 2.1 million vehicle-miles, of this travel could noticeably benefit from freeway control.
- Based on Gulf Freeway data during the peak period, average speed is 15 mph without freeway control and 30 mph with freeway control. At a constant 30 mph speed a vehicle will consume 0.044 gallons per mile; at a constant 15 mph speed a vehicle will consume 0.061 gallons per mile.
- Thus, during the peaks, a daily savings of 36,000 gallons would result in an annual savings (250 workdays) of 9 million gallons. Freeway control has two additional benefits. The above analysis is based on average speeds; with freeway control, acceleration noise should be reduced and fuel consumption will also be reduced. In addition, fewer lane blocking incidents will occur with control. These two factors might double annual savings. Thus, total annual gasoline savings is 18 million gallons. At present gasoline

consumption rates, total statewide gasoline consumption could be reduced by 0.3 percent with extensive implementation of freeway control.

- Arterial street operation could also be improved to reduce gasoline consumption. Arterial operation consists of running time and delay time. Gasoline consumption can be reduced by increasing average running speed and reducing delay time. On the average, running time is 85 percent of total travel time, and delay time is 15 percent of travel time.
- Traffic flow could be improved to reduce delay time by 20 percent, and total travel time would be reduced by 3 percent. A 3 percent reduction in travel time would result in a 5 percent reduction in gasoline consumption since a reduction in delays will also reduce considerable acceleration and deceleration.
- At present, about 27 million vehicle-miles per day are driven on arterial streets. Assuming the average vehicle operates at 10 mpg, about 2.7 million gallons of gasoline are consumed daily on arterial streets. The savings resulting from improving traffic operations on arterials could apply to all vehicles operating at all times of the day. Thus, about 135,000 gallons of gasoline might be saved per day, or 50 million gallons per year. Of the total 6.3 billion gallons consumed, this represents a savings of 0.8 percent.
- Average running speed can also be increased. Assuming it will increase from 20 to 30 mph, at 20 mph a vehicle will consume 0.05 gallons per mile, and at 30 mph, a vehicle will consume 0.044 gallons per mile. A daily savings of 162,000 gallons would result, for an annual

savings of 59 million gallons. This is a 0.9 percent reduction in statewide gasoline consumption.

- Total savings in statewide gasoline consumption resulting from improved traffic flow on arterial streets could be 1.7 percent.

Evaluation/Comments

- A significant cost and some lead time are required before these traffic improvements can be implemented. Consequently, traffic engineering improvements constitute a long-range approach toward reducing gasoline consumption.

Four-Day Work Week

Program Description

The work week consists of four, rather than five, days

Estimated Fuel Savings

Negligible to negative

Economic Impact

- Business catering to the employee at his place of work will be adversely affected (restaurants, etc.).
- If fuel is available, a positive impact will be realized by recreation and travel-oriented businesses.
- Peak period urban congestion can be reduced at least one day per week, resulting in fewer vehicle emissions and safer urban roadways.
- Accidents and travel on rural roadways may increase due to increased recreational travel.

Pertinent Information/Assumptions

- Twenty percent of work trips would be eliminated. Work trips constitute about 35 percent of urban trips; thus, urban trips would be reduced by 7 percent due to the elimination of those work trips. The 7 percent trip reduction (due to the longer length of the work trip) corresponds to about a 10 percent reduction in urban vehicle miles of travel, or a 6 percent reduction in statewide travel. If no additional trips are substituted for those work trips, statewide gasoline consumption could be decreased by 6 percent.
- However, it is unrealistic to assume that no other tirps will be made on the day the individual no longer goes to work. One other trip (to the store, doctor, etc.) on these days will nearly offset any gains made due to elimination of the work trip. If several other trips are made, an increase in statewide fuel consumption may actually result.
- If the worker is off on either Friday or Monday, he will always have a three-day weekend, and these long weekends tend to encourage intercity travel. If fuel is available, it is reasonable to assume that many families will take advantage of the long weekend and travel more extensively. An increase in this type of travel could greatly increase statewide gasoline consumption.

Resources

1. Everall, Paul. Urban Freeway Surveillance and Control, The State of the Art. U.S. Department of Transportation, Federal Highway Administration, 1972.

2. Pignataro, Louis J. Traffic Engineering Theory and Practice. Prentice-Hall, Inc., 1973.

3. Drew, Donald. Traffic Flow Theory and Control. McGraw-Hill Book Company, 1968.

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

5. Holder, R. W. Unpublished Technical Memorandum submitted to the Commissioners of the Texas Mass Transportation Commission, August, 1972.

6. Christiansen, Dennis. "Time Trend Analysis, Literature Review and Interpretation." Unpublished Technical Memorandum, submitted to the Texas Highway Department, 1972.

7. Texas Highway Department, Planning Survey Division. "Daily Vehicle-Miles, All Texas Road Systems, 1950-1970." Unpublished Data, 1972.

FUEL ECONOMY FOR INDIVIDUAL VEHICLES

- The following measures are available for improving individual vehicle fuel economy: (1) maintaining a properly tuned engine; (2) switching to radial tires, (3) maintaining tire pressures at or above manufacturer recommendations, (4) reducing use of air conditioners, (5) buying and using smaller vehicles, (6) practicing good driving habits, especially reducing sudden starts and number of speed changes.
- To be effective, individual fuel economy measures must be practiced continuously and by a large percentage of the population. This will require a comprehensive information campaign accompanied by specific instructions for fuel economy.
- It might be feasible to require certain tune-up adjustments in motor vehicle inspection procedures. Further study and evaluation should be performed before serious consideration is given to implementing any mandatory tune-up regulations.

Tune-Ups

Program Description

Maintenance of properly tuned engines

Estimated Fuel Savings

Maximum would probably exceed 2 percent of total gasoline consumption

Economic/Social Impact

- Expenditures on auto servicing would increase by as much as $20-$30 for a complete tune-up.
- Inconvenience associated with leaving a car at a garage tends to

discourage frequent tune-ups.

- This program element would tend to partially offset possible adverse effects of the fuel shortage on automobile dealers and service stations.

Pertinent Information/Assumptions

- Fuel consumption in many vehicles, especially those that are relatively old, can be reduced by tune-ups. For example, adjusting the spark timing can save 5 to 10 percent on fuel consumption and would probably be effective on 10 to 30 percent of all vehicles. Changing spark plugs that have been used for more than 15,000 miles can save 5 to 10 percent of fuel. Other standard tune-up procedures, such as changing the air cleaner and points, cleaning the pollution control valve, and adjusting the carburetor also can save fuel.
- It is estimated that four out of five of all automobiles that are more than three years old would benefit from tune-ups; it would be reasonable to expect an average fuel savings of greater than 5 percent for each of these vehicles.
- A recent Department of Transportation study shows a comparison of "before-and-after" tune-ups, with a savings of about 10 percent for a test passenger car; however, no generalization can be made from this limited information.
- Based on the above information, it appears reasonable to assume that a fuel savings of greater than 2 percent could be realized if all motorists and appropriate motor vehicle maintenance personnel made a concerted effort to maintain properly tuned engines.

- In the absence of a comprehensive publicity campaign, or some type of enforcement, the maximum savings from this program probably would be less than 1 percent.
- Some fuel savings can be accomplished by simply adjusting the timing device and carburetor. It would appear that a study should be made of the feasibility of incorporating some of these adjustments into the annual motor vehicle inspection system.

Evaluation/Comments

- This is an area in which automobile dealers, garages, and service stations can make a contribution by providing economical tune-up services to the public.
- An increase in car pooling and use of mass transit might decrease the inconvenience of persons doing without their car for a day while it is being tuned.

Tires

Program Description

Switch to radial tires and maintain proper tire pressures.

Estimated Fuel Savings

Maximum of 1 percent of total gasoline consumption.

Economic/Social Impact

- A switch by some motorists to radial tires might be expected to increase overall expenditures on tires by a small percentage.
- Overall economic and social impact would be small.

Pertinent Information/Assumptions

- A recent sample made by the Texas Highway Department showed that

about 80 percent of all tires have less than 30 pounds of tire pressure, about 50 percent have less than 26 pounds, and about 10 percent have less than 20 pounds.

- Although it is not possible from the above percentages to indicate the number of cars having less than recommended pressures, it nevertheless is safe to offer the generalization that many of the sample vehicles probably could save fuel by increasing tire pressures.
- Savings of up to 5 percent in fuel consumption have been mentioned in the popular press. No comprehensive, scientific study has been identified that deals with the effects of tire pressure on fuel consumption.
- Radial tires can save up to 3 percent of passenger car fuel consumption.
- Based on the above information, it is assumed that up to 1 percent of total gasoline consumption could be saved by maintaining recommended tire pressures or pressures even slightly higher than those recommended.

Evaluation/Comments

- This is an area in which service stations can contribute greatly by checking tire pressures.
- Limited information suggests that maintaining adequate tire pressure also reduces traffic accidents by a small amount.
- To obtain the best gas mileage, or when pulling a load on long trips, some manufacturers recommend that tires be inflated four pounds over normal pressure.
- Improper front wheel alignment also causes fuel economy loss in addition to excessive tire wear.

Air Conditioners

Program Description

Reduction in use of air conditioners in motor vehicles

Estimated Fuel Savings

Maximum of 1 percent of gasoline consumption

Economic/Social Impact

- Doing without air conditioners for long trips (more than 30 minutes) on hot days would be a severe inconvenience.
- The economic impact of this program element would be negligible except as it would affect fuel sales.

Pertinent Information/Assumptions

- A recent U.S. Department of Transportation study indicates that fuel consumption in automobiles can be reduced by about 10 percent (in a range of 5 percent to 14 percent, depending on speed) by turning off air conditioners.
- No information is available on the proportion of all vehicle miles traveled in Texas with air conditioners operating. In the absence of this information, it is assumed that one-third of all vehicle miles are operated with air conditioners "on."
- Using the above assumption, the absolute maximum savings from Texans discontinuing all use of automobile air conditioners would be about 3 percent of total state gasoline consumption. Expected savings probably are a maximum of 1 percent, even if a widespread publicity campaign is enacted.

Evaluation/Comments

- Since winter is approaching, there would be a several month lag before this program element would have maximum effect; however, many vehicles are now operated with both air conditioner and heater in concert during cool, humid weather.

Reduced Vehicle Weight

Program Description

By using smaller cars, motorists can decrease fuel consumption per mile of travel

Estimated Fuel Savings

Small savings in next few months. Maximum of 1 percent of statewide consumption in next year. Over 5 percent savings in statewide fuel consumption within 3-4 years.

Economic/Social Impact

- The switch from larger to smaller cars decreases the dollars-per-vehicle sold by car dealers. In the short-run, this may be somewhat offset by increased sales of small cars (over those that would otherwise have been sold).
- The demand for small cars has created a slack in demand for larger cars, both new and old. It appears that this trend may have a substantial short-term effect on new and used car dealers through a reduction in value of their inventories and through a reduction in sales. It appears that sales prices for large, used cars will decline several hundred dollars.

Pertinent Information/Assumptions

- As shown in Figure III-1, which is based on information developed by the U.S. Environmental Protection Agency, the weight of a vehicle substantially affects fuel economy. A 2500-lb. vehicle gets approximately twice as much fuel per gallon as does a 5,000-lb. vehicle.
- Recent information indicates that sales of small cars represented about a 40 percent share in the 1973 model year and are expected to climb to about 50 percent in the 1974 model year. This 10 percent shift from larger to smaller cars probably will save about 1 percent in total gasoline consumption in 1974, compared to the situation had there been no shift.
- In addition to consumers shifting to smaller cars, automobile manufacturers are beginning to increase their emphasis on ways to reduce automobile weight. The combination of these two trends should increase average miles per gallon by greater than 5 percent over a period of three to four years.
- In the next two or three months, the savings in statewide gasolin consumption due to consumers' shifting to smaller cars will only be a small fraction of 1 percent.

Evaluation/Comments

- The estimate of 1 percent savings in 1974 might likely be as much as 2 percent if fuel allocations are cut by more than 15 percent and if enough smaller cars are available to meet consumer demand.

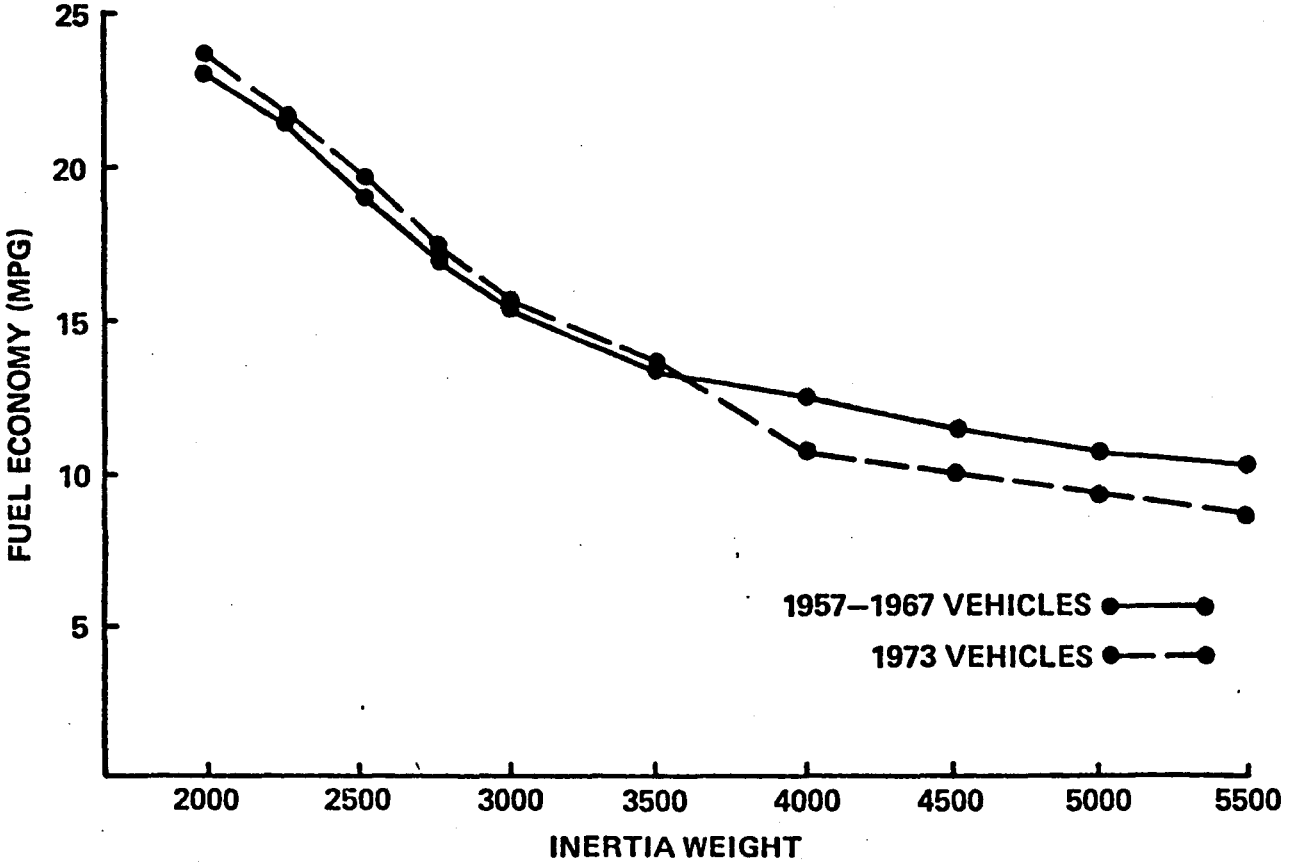

FIGURE III-1. FUEL ECONOMY VS. INERTIA WEIGHT

Driving Habits

Program Description

Use fuel-saving driving habits, with special emphasis on avoiding rapid acceleration and unnecessary speed changes and passing

Estimated Fuel Savings

Maximum of 1 percent of statewide gasoline

Economic/Social Impact

- The economic/social impact of this element would be negligible except as it affects fuel consumption.

Pertinent Information/Assumptions

- A study by automotive engineers has revealed that the difference in a "hot rod" and "Sunday" driver can be about two miles per gallon in city driving.
- Other writers contend that owners of pickups with campers, motor homes, and car-trailer combinations can increase gas mileage by 20 percent if tips gleaned from tests with a direct-reading miles-per-gallon fuel meter are practiced.
- It would be unrealistic to expect the average driver to generate savings of the above magnitudes by avoiding speed changes and sudden starts and stops, but it appears reasonable to assume a maximum statewide savings of 1 percent of all gasoline if a comprehensive effort is made in this direction.

Evaluation/Comments

- Reducing speed changes probably would reduce accidents.
- Better overall economy and longer engine life can be obtained with more conservative driving habits.

Other

Program Description

Other possible actions

Estimated Fuel Savings

Maximum of 1 percent of total gasoline consumption

Pertinent Information/Assumptions

Listed below are some other voluntary measures that the people of Texas could take to further increase the amount of fuel saved in operating their motor vehicles.

- Make maximum use of most fuel-efficient vehicles in multi-car families.
- Use recommended fuels.
- Avoid "pumping" the accelerator.
- Avoid "riding" the brake pedal.
- Be sure parking brake is fully released.
- Turn engine off if idling more than a minute or so.
- On colder mornings, avoid idling engine for purpose of heating the passenger compartments.

Evaluation/Comments

- No estimates have yet been made concerning the amount of fuel savings the individual items listed above would generate.
- It is not unreasonable to assume that, in the aggregate, gasoline savings of a maximum of 1 percent could be realized.

Resources

1. Paul J. Claffey. Running Costs of Motor Vehicles As Affected by Road Design and Traffic, NCHRP Report No. 111, Highway Research Board, Washington, D. C., 1971.

2. Kenneth D. Hankins, et. al. "Influence of Vehicle and Pavement Factors on Wet-Pavement Accidents," Highway Research Record No. 376, Highway Research Board, Washington, D. C., 1971.

3. U.S. Environmental Protection Agency. A Report on Automotive Fuel Economy. Washington, D. C., October 1973.

4. C. E. Schiffler and G. W. Niepoth. "Customer Fuel Economy Estimated From Engineering Tests." SAE Paper 650861, November 1965.

5. G. J. Huebner, Jr. "General Factors Affecting Vehicle Fuel Consumption." SAE Paper, May 1973.

6. T. C. Austin and K. H. Hellman. "Passenger Car Fuel Economy-Trends and Influencing Factors." SAE Paper 730790, September 1973.

7. E. M. Cope. "The Effect of Speed on Automobile Gasoline Consumption Rates." U.S. Department of Transportation, October 1973.

8. Other information, including news releases, of Automobile Manufacturers Association, Automobile Association of America, and others.

FUEL CONSERVATION IN BUSINESS FIRMS

- Most large business firms generate some transportation-related fuel consumption in their daily operation whether by business travel, delivery service, or work vehicles.
- Procedures and practices that have developed over the years when fuel was plentiful and inexpensive must certainly have some inefficiencies relative to fuel consumption. An intensive evaluation of current practices should reveal some opportunities for significant fuel savings.
- Several voluntary action programs are identified in this chapter. Some pertain to businesses in general, whereas others are specifically aimed at the transportation industry. If all of these programs were adopted, the business sector could account for more than 5 percent reduction in statewide fuel consumption.

Reduced Business Travel

Program Description

Reduction of unnecessary or marginal business travel

Estimated Fuel Savings

Approximately 2 percent reduction in statewide fuel consumption.

Economic/Social Impacts

Negligible

Pertinent Information/Assumptions

- Approximately 15 percent of the passenger cars are registered to various business firms. These vehicles are typically driven more than privately-owned automobiles.

- Approximately half of the passengers carried on scheduled airlines are traveling on business.
- Probably more than 10 percent of these trips could be totally eliminated, and another 5 percent reduction in travel could be achieved through better planning of business trips.
- The net fuel savings from such reductions in business travel would be approximately 2 percent.

Evaluation Comment

- In addition to reducing travel, businesses can conserve fuel by eliminating inefficiencies in everyday operations involving motor vehicles. For example, a departmental director in one Texas city recently instituted a program in his department that resulted in fuel savings in excess of 25 percent without adversely affecting his operations. There were, of course, some additional costs involved.

Improved Efficiency of Diesel Vehicles

Program Description

Maximize the operating efficiency of trucks and buses using diesel fuel.

Estimated Fuel Savings

- More efficient operations of trucks and buses may result in a maximum diesel savings of 2 percent.

Economic/Social Impacts

Maintenance costs will increase significantly, at least temporarily.

Pertinent Information/Assumptions

- Derating diesel engines to lower horsepower in line with actual payloads may save 2 to 5 percent.
- Reducing available engine speed to conform with lower speed limits may save 4 to 5 percent.
- Installing a temperature-modulated fan may save 3 to 5 percent.
- Installing wind deflectors and vortex stabilizers to reduce wind drag may save 5 to 6 percent.
- Radial tires reduce rolling friction and may save as much as 8 to 9 percent fuel on a truck.
- Turning off engines when vehicles are stopped will save less than 1 percent on most vehicles. A three-minute idle for gasoline engines and a five-minute idle for diesel engines is the maximum recommended level.
- The six items listed above are not all additive. If all items are accomplished, the cumulative improvement in operating efficiency for that vehicle might total 20 percent.
- Diesel-powered trucks and buses account for about 10 percent of the State's total fuel consumption. Thus, if all diesel-powered vehicles achieved maximum improvement, the net impact on statewide fuel consumption would be a net 2 percent reduction.

Evaluation/Comment

- Many fleet operators have already made many of the above adjustments to their equipment.
- The cost and supply of some items are questionable for many truckers.

- Greater attention to fuel economy can be made in purchasing new equipment with regard to engine size, gear ratios, transmission selection, tractor and trailer size.

Reduced Empty Backhauls

Program Description

Alter current trucking practices to reduce empty backhauls.

Estimated Fuel Savings

A maximum of 1 percent reduction in statewide fuel consumption.

Economic/Social Impacts

- Increased traffic availability would improve the viability of the common carrier industry.

Pertinent Information/Assumptions

- It is estimated that 35 percent of total truck miles are empty miles. The loaded/empty miles ratio will vary for certain carrier groups, equipment configuration, and 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 that were regulated by the I.C.C.
- If private carriers who do not have available backhauls would convert their shipments to for-hire carriers, the availability of backhauls would increase. The total percentage of empty trucks on the road might be reduced from 36 percent to less than 25 percent.

- Trucks consume about 10 percent of the fuel; therefore, the total fuel savings would be about 1 percent.

Evaluation/Comments

- Specialized vehicles have less opportunity to obtain backhauls. Thus, all empty backhauls can probably never be eliminated.
- This program would result in a significant transfer of equipment and personnel from private carriage to common carriage.

Increased Truck Weight Limits

Program Description

Increase the limit on Gross Vehicle Weight (GVW) from the present 72,000 pounds to 90,000 pounds for five axle combination vehicles.

Estimated Fuel Savings

Estimated savings will be between 1.0 and 1.5 percent of the total statewide fuel consumption.

Economic/Social Impact

- The actual fuel savings realized is dependent upon cargo mix being transported. Trucks transporting high density cargoes will benefit most from this action.
- Increased weights of trucks will increase maintenance requirements on streets and highways during a period when the State's revenue from fuel taxes is reduced. These disbenefits must be carefully evaluated. Any action that would accelerate the deterioration of the road system would not be of benefit to the general public or to the freight haulers.

- Because of the decreased funding available for rebuilding and maintaining the road system, consideration should be given to reducing allowable weight limits on certain routes and curtailing the hauling of overweight loads.
- Probably a few major routes should be considered in terms of the ability of the road system to accommodate the increased weight. Careful attention must be paid to axle weight, weight distributions, and total routes traveled.
- An increase in GVW will provide a mechanism whereby the loss in truck productivity caused by reductions in speed limits can be partially overcome. This becomes particularly important in the event that allocations to common carriers is made on the basis on ton-mile productivity. If Federal fuel allocation to transportation modes is made on the basis of "energy effectiveness", Texas' relative low weight limits would cause trucking to suffer from this approach.

Pertinent Information/Assumptions

- In a recent nationwide study, A. D. Little Company estimated a 17 percent fuel savings (to truckers) by increasing GVW to 105,000 pounds.
- The California Department of Transportation has taken action to issue overweight permits where such action will increase fuel efficiency of truck hauling.
- The Director of the Transportation Division of the Cost of Living Council has asked for an evaluation of the effects of a 10,000 pound weight increase for trucks on the Interstate system.

- The Office of Oil and Gas has estimated that there will not be sufficient supply of fuel to meet the projected 10 percent gain in intercity truck traffic, and advocates heavier loads and twin trailers.
- Combination tractor-trailer vehicles are estimated to consume approximately 9 percent of the motor vehicle fuel used in Texas.
- If it is optimistically assumed that current average gross operating weight for vehicles transporting high density cargo increases 24 percent under relaxed regulation, this would increase the average gross operating weight for all five-axle trucks by approximately 17 percent. It is further assumed that this increase would result in a 17 percent decrease in vehicle-miles traveled by trucks. Realizing that the increased weight would increase the average fuel consumption per mile, it is optimistically estimated that this would result in a 15 percent reduction in the fuel consumed by these vehicles.
- Since these vehicles account for approximately 9 percent of the total fuel consumption, the increase in the limit on gross vehicle weight would result in up to 1.5 percent reduction in statewide highway fuel consumption.
- Among the carrier groups which could conceivably transport these increased weights are those participating in moving most agricultural products. For example, livestock carriers

recently interviewed stated that, with no detrimental effects on the animals, they could easily transport 8,000 pounds of additional live animal weight. Since transportation of livestock by rail is no longer an option, the shipper weight increase may be the only alternative for fuel savings to be realized in this industry.

Evaluation/Comment

- Railroads can transport high-density products for less fuel than trucks; therefore, a transfer of these commodities to rail shipment would result in an energy savings. On the other hand many communities in Texas (agri-business oriented) are served by railroad branch line operation that are uneconomical to the railroad and inefficient in the light of the fuel shortage. The trade off to trucks here may produce fuel savings in the aggregate.
- Safety and other highway impacts of increased truck weights have not been considered in this evaluation. A careful evaluation of all disbenefits in these areas should be performed before current regulations are relaxed.

Resources

1. Keller, J. J. and Associates, Inc. Exempt Guide Bulletins, Volume 59, p. 4, Nenah, Wisconsin, October 1973.

2. Private Truck Council of America, Inc. Private Line, p. 2. Washington, D. C., November 16, 1973.

3. Transportation Association of America. What's Happening in Transportation, p. 2, November 20, 1973.

4. A. D. Little and Company.

SECTION IV

ECONOMIC IMPACT OF TRANSPORTATION FUEL SHORTAGE

GENERAL EFFECTS

The purpose of this chapter is to identify and to evaluate some of the effects of the energy shortage upon economic variables and activities. The primary emphasis is upon the direct short-run economic effects of the fuel shortage in transportation. An attempt has been made, however, to place these effects within the context of the overall impact of the energy shortage upon the U.S. and Texas economies, as well as selected industries and industry groups.

Effects Upon National Economy

While there are no adequate models that might forecast how the U.S. economy will react to the energy shortage, existing analytical techniques have been used to generate tentative estimates for 1974. There is widespread agreement that the energy shortage will lead to: (1) slower rates of growth of real GNP; (2) some increase in unemployment; and (3) an increase in the rate of inflation.

- GNP - Current estimates of the effects on GNP range from an absolute reduction in GNP of 2 percent from the 1973 levels to an increase of 3 percent over 1973. The preponderance of estimates is that GNP will be slowed to an increase of 1 to 2 percent over the 1973 level.
- Unemployment - Increases in unemployment up to 8 percent (from a current level of 4.5 percent) have been forecast. Most estimates, however, call for increases of up to no more than 6 percent.
- Inflation - Prior to the energy shortage, a 5 percent increase in 1974 prices was expected. This estimate has been revised upward to about 7 percent.

There are at least two very critical factors that will determine the realized magnitudes of the impact upon output and employment: (1) the extent to which energy cutbacks can be confined to nonessential users; and (2) the duration and magnitude of the Mideast embargo.

- The unwelcome effects might be appreciably reduced by the extent of voluntary cooperation and by increasing efficiency in relatively nonessential areas.
- One estimate states that a cut of 5 to 10 percent in United States consumption of energy could be absorbed without deleterious effects on the overall level of economic activity.
- The determination of those activities that are nonessential is a value-judgment. Reduction/elimination of <u>any</u> activity, e.g., night baseball games, represents a departure from current market relationships and will produce impacts.
- Energy savings resulting from more efficient utilization need not be confined to the consumer. The savings are also possible in the industrial sector. For example, Union Carbide reports that it has reduced its energy inputs per pound of output on the order of 20 percent by instituting 228 energy-saving measures. Also, since 1967, Du Pont has increased output by 50 percent while increasing energy usage by only 10 percent. In the building industry, more efficient design and construction methods could achieve energy savings of 35 to 50 percent of the amounts that would have been used.
- As discussed in previous chapters, there are efficiency measures that can be applied to generate fuel savings in the transportation sector. At this time, no information exists to indicate the extent to which these measures are being utilized.

The Mideast oil embargo, if of relatively short duration, will cause a slowdown but not one of pronounced or prolonged impact. Instead, the effect will be more like that of a strike in a basic industry.

- The major impact of the embargo will be upon the rates of growth.
- There is a close (almost perfect) correlation between available energy per capita, industrial production, and the standard of living.
- The impacts will be made more serious by a prolonged embargo.

With regard to the effects upon prices, a critical determinant will be governmental price control policies. Petroleum prices significantly affect the Consumer Price Index and probably will not be allowed to rise to levels (maybe an increase of 20¢ per gallon of gasoline) that would be obtained in the absence of price controls. If prices are held down in the presence of continued shortages, the need for some allocation mechanism will persist.

Effects Upon Texas Economy

Although there is no precise relationship between the changes in national economic variables and comparable measures for the Texas economy, the two are not independent of each other. In previous periods of national economic slowdown, economic activity in Texas has also slowed. There is no reason to expect the Texas economy to be insulated from nationwide tendencies due to the present energy problems. However, Texas will experience differential effects, which are not fully reflected in the changes in national economic aggregates, due to its unique relationship

to both the supply and demand forces of the energy shortage. Thus, it is not unreasonable to expect that reductions in Texas output and employment will be of lesser magnitudes than those reflected in the measures for the U.S. Of particular importance is the extent to which Texas-produced crude oil can be expanded to mitigate the effects of reduced oil imports.

The nature of the economic impact on Texas of the fuel shortage will depend upon the amount of shortage relative to demand and upon the duration of the shortage. The distribution of the economic impact among individuals and firms will depend primarily upon the allocation, rationing and other control procedures that are used. In general, it is known that the allocation of the shortage will be divided among transportation and other sectors of the economy.

The direct economic impact of fuel shortages in transportation will be divided among households, the transportation industry, and government transportation. Initial allocation procedures call for the largest fuel usage reductions to occur in household travel and air travel.

The extent of the economic impact also will depend on what mandatory and voluntary programs are devised by governments, firms and individuals to cope with reduced allocations and with rationing, if it occurs.

Household Consumption Patterns

The economic impact on households and those impacts indirectly caused by households will be of two types: (1) changes in consumption patterns to adjust to fuel shortages, and (2) reductions in overall demand because of reduced incomes resulting from reduced employment. Some of the changes in consumption patterns suggested by the mandatory and

voluntary programs outlined in previous parts of this report are:

- Reduced purchases of gasoline, having an impact on service stations. The nature and extent of this impact will depend on the amount that gasoline prices are increased.
- Purchases of a higher percentage of smaller cars, bicycles, and motorcycles and reduced purchases of large automobiles, new and used. Reduced sales and usage of recreational vehicles.
- Increased use of mass transit. Possible increased use of scheduled air carriers or auto, shifting from general aviation. Decreased use of parking lots.
- Additional purchases of tune-up services and radial tires.
- Reduced purchases of the services of restaurants, recreation, and services associated with reduced travel in both rural and urban areas. This impact probably would not be large if fuel shortages were around 10%, but could become substantial with shortages of 20-30%, since fuel savings of those percentages probably cannot be achieved without substantial decreases in amount of travel.
- Consumers also may change their consumption patterns because of the adverse psychological impact of the fuel shortage. In the short term, it appears that consumers are not curtailing expenditures, but are rather increasing expenditures of certain items such as small cars and gasoline cans. If the fuel shortage persists, however, the psychological impact may cause a decrease in consumption relative to total income. One important factor that may work in the other direction is increasing prices. It

appears that relatively high rates of inflation will continue and even increase, and this will tend to keep consumers from postponing consumption.

- Some unemployment and reduced incomes will result from fuel shortages in air transportation and reduced sales of service stations, lodging, recreation, etc. These reductions will have secondary effects on final demand for products and services. The immediate impact will be somewhat ameliorated by unemployment compensation and people living off their savings.

TRANSPORTATION INDUSTRY

- The economic impact of the fuel shortage on transportation industries could be substantial. It appears that federal allocation procedures will tend to favor sectors of the transportation industry in relation to the part they play in production, as opposed to serving final demand. Thus, pipeline, water, and rail transportation probably will have relatively small reductions as compared to air and passenger cars. Trucks and buses are in a somewhat intermediate category and probably will receive percentage allocations similar to those for rail, unless shortages increase more than is now predicted.
- One very important factor, mentioned in an earlier chapter, is that truck fuel allocations are being cut to 1972 consumption. Given the large increases in 1973 diesel used by trucks in Texas and the increases that were anticipated for 1974, there could be a somewhat severe shortage of diesel for trucks in 1974.
- Given the integral part that the transportation industry performs in the distribution of raw materials to manufacturers, between manufacturers, and finally to wholesale and retail outlets, it is essential to the United States and Texas economy that adequate fuel be provided to transportation. The expected economic impact of the fuel shortage on truck, bus, and air transportation is discussed in more detail on the following pages.

Truck and Bus Operators

The following discussion points out some direct and indirect economic effects of the fuel shortage on truck and bus fleet operators.

Economic Effects

- Reduced highway speeds reduce truck and bus productivity.
- Reduced speeds increase driver and other costs per ton-mile.
- Increased costs result in increased costs to distribute both raw materials and finished goods.
- In some cases fleet operators will attempt to offset reduced productivity by operating more trucks--increasing both fuel used and distribution costs.
- Slower speeds require rescheduling of people and equipment.
- Many drivers will be faced with relocating their homes or seeking other employment.
- Rescheduling intercity bus operations could run upward of a million dollars per firm--not considering driver relocation.
- Some products now moving will not be able to move at higher costs.
- Consumers and business firms are likely to be faced with longer delivery times.
- Perishables will not move to the most distant markets.
- A failure by truckers or bus operators to secure fuel will mean that passengers and products will not move.
- Some truckers may attempt to solve their fuel problems by greater road purchases; however, not all will be able to do so.
- Goods that cannot reach markets will no longer be produced, adding to unemployment.

- Shippers will attempt to ship their goods by less energy consuming modes.
- Certain forms of trucking will go out of business. This trend will be most evident in private trucking.
- As schedules become longer in time, businesses will carry larger inventories, requiring less frequent shipments.
- Shortages of equipment in other modes may slow down the shifting of shipments between modes.

Overall Evaluation

- Many obvious fuel conserving programs increase transportation costs.
- Several government regulations imposed on trucks and buses are fuel consuming. These regulations will need to be considered.
- Regulations affect not only fuel economy but competitive advantages.
- Gross vehicle weight regulations affect the competitive differences between truck and rail.
- Highway specific route regulations affect competitive differences between trucking firms. For example, a carrier that is restricted to operating on older highways may now be better able to attract business from a carrier operating over the direct route.
- Easing of leasing regulations may allow some carriers to offer lower rates or more prompt service, shifting business away from other firms.
- Buses currently move more passenger miles per gallon of fuel than any other mode, but fuel allocations based on fixed percentages of a base year fuel consumption may force passengers to higher fuel consuming modes.

- Many communities in Texas are completely dependent on truck transportation for their goods. Modal shifts that weaken the trucking industry may result in complete loss of service to these cities and towns.

Air Transportation (Includes General Aviation and Scheduled Carrier)

- Fuel cutbacks in aviation mean reduced service to the people of Texas
- Some unemployment will result, particularly in general aviation.
- Some small airports will close.

General Aviation

- General aviation includes industrial, pipeline and powerline patrol, instructional, and pleasure flying as well as scheduled and non-scheduled air taxi operations.
- The proposed fuel cutbacks in general aviation will likely result in a significant reduction of the industry in Texas.
- Some airports serving smaller Texas towns will likely cease operations.
- Employment in the associated industries for sales, maintenance, flight instruction, etc. will be reduced.
- Reductions in scheduled commuter service can be expected.

Industrial Aviation

- Reductions in crop-dusting activities due to fuel cutbacks might be as high as 20 percent.
- Attempts to substitute ground application of herbicides/insecticides due to reduced crop dusting will reduce the total fuel saved and may result in larger amounts of fuel consumed.

- Curtailment of the patrolling of energy transmission pipelines might increase losses of energy.
- Some unemployment in crop dusting businesses is likely to occur.

Corporate and Business Aviation

- Fuel cutbacks will result in reduction of business travel and some increase in usage of scheduled air carrier service by businessmen.
- Some unemployment of corporation pilots is likely to occur.
- To the extent that businessmen have to resort to other means of travel for completing necessary trips, the time cost of travel will increase. Also, increased utilization of business automobiles will reduce the amount of total fuel saved.

Pleasure and Instructional Flying

- The major impact is likely to be on fixed base operators who provide services for pleasure and instructional flying such as instruction, aircraft rentals or sales, maintenance, aircraft storage, etc.
- Extended fuel cutbacks of 50 percent will eliminate the marginal fixed base operator, thereby reducing the number of airports available to general aviation in Texas.
- Employment reductions in aircraft sales, maintenance, repair parts sales, etc., may be substantial to the industry.

Commuter Airlines

- Reductions in service can be expected throughout the state, although the magnitude of the reduction cannot be determined at this time.
- Davis Airlines expects to cut its Dallas-College Station commuter service by 33 percent if its fuel usage has to remain at 1972 levels.

- Metroflight Airlines is expected to curtail its commuter flights to Victoria, Galveston, and (possibly) Beaumont.

Scheduled Air Carriers and Commuter Airlines

- Fuel reductions are expected to lead to:
  - (1) A reduction in number of flights
  - (2) An increase in fares
  - (3) An increase in load factors
- Profits may tend to increase, although this is far from certain.
- Industry-wide employment will decrease, but the relative magnitude is uncertain.
- Some cutbacks in international service to Texas are expected.
- Texas International is expected to cut 7 percent of its 2,500 scheduled weekly flights, primarily weekend flights. Braniff is expected to cut its service by 3.5 percent.

OTHER INDUSTRIES

The impact of the fuel shortages in transportation (as opposed to other fuel shortages) on sectors of the economy other than transportation will be somewhat diverse, depending on how each uses transportation in production and on the extent to which they sell to final demand. A discussion is given below for each of the sectors of the economy.

Agriculture, Forestry, and Fishing

This sector, of course, is very vital to the Texas economy, and includes farm production of field crops, food grains, cotton, vegetable, citrus, livestock, dairy poultry, forestry and the dollar value of fish landed at Texas ports. In addition, agricultural services such as harvesting, ginning, and spraying on a custom basis are important parts of this sector. Of critical importance to the sector is the availability of fuel for farm implements, gins, crop drying, etc., in addition to fuel for transporting products. In the following discussion, primary emphasis is placed on the movement of fresh fruits and vegetables from the Lower Valley of Texas and of livestock throughout the state, even though analagous transportation problems probably exist for other parts of this sector.

- As shown in Table IV-1, the fruit and vegetable industry of the Lower Valley is highly dependent on motor trucks for moving their products. Rail is seldom used for transporting citrus and the rail share of vegetables has declined substantially over the past few years. A rapid shift to rail service is hampered by a shortage of rail equipment and unacceptable delivery schedules.

Table IV-1. Shipments From the Lower Rio Grande Valley

Season	Citrus				Vegetable			
	Truck	%	Rail	%	Truck	%	Rail	%
1965-66	5,895	92.1	503	7.9	11,017	54.8	9,092	45.2
66-67	8,703	94.8	481	5.2	12,945	49.9	12,972	50.1
67-68	5,181	92.2	436	7.8	6,779	50.9	6,549	49.1
68-69	10,425	92.6	837	7.4	12,349	51.0	11,852	49.0
69-70	12,162	95.8	536	4.2	16,655	57.6	12,261	42.4
70-71	15,605	97.4	414	2.6	14,680	59.9	9,831	40.1
71-72	14,394	98.8	169	1.2	16,356	68.7	7,467	31.3
72-73	16,372	99.2	135	0.8	18,665	71.6	7,387	28.4

- The ICC, in its Car Service Order No. 1160 - Substitution of Refrigerated Car for Boxcars, is encouraging the use of very specialized and needed equipment to move lumber. If this equipment is diverted, it will be difficult to increase rail shipments, and,at the same time,the demand for refrigerated truck equipment will increase.
- A shortage of rail cars is reported by California shippers resulting in economic losses directly attributable to a lack of transportation.
- Reduced speed limits will increase transit time to market points. Since shelf life of perishable commodities is directly related to transit time certain distant markets may be lost.
- Long distance shipments of livestock may incur an additional delay of 24 hours into feedlots throughout the state.
- Truck transportation charges for transporting agricultural products will increase due to rising fuel costs and reduced speed.

- Additional costs incurred in transporting agricultural products will be passed to the consumer. This will, in turn, impact the on-farm demand for these products.
- Smaller size carriers participating in the movement of Texas agricultural commodities--especially in interstate commerce may be unable to secure enough fuel to remain in business, thereby reducing the supply of equipment even further.
- Carriers of agricultural commodities who normally purchase most of their fuel on the road will find it increasingly difficult to meet their delivery requirement.
- Carriers will attempt to minimize their empty miles and may shift their equipment to serving shipping points in which they incur the least amount of unproductive miles. Most agricultural carriers serving the Valley are "deadheaded" from Houston or San Antonio.
- Agricultural production and subsequent transportation to markets is currently a seven-day-a-week operation. Many carriers loaded on Friday and Saturday must travel over Sunday in order to meet market requirements. A typical week's shipment of oranges and grapefruit has the following distribution:

Day of Week	Percent of Total Weekly Shipment Leaving Shipping Point
Monday	13,95%
Tuesday	17.50%
Wednesday	14.00%
Thursday	12.50%
Friday	16.30%
Saturday	23.90%
Sunday	1.90%
Total	100.00%

A ban on the Sunday sale of diesel fuel would severely disrupt shipping schedules and will result in additional marketing costs.

- In telephone conversations with truck brokers and the executive vice president of the fruit and vegetable shippers association and recent visits with livestock carriers, it was found that:
  (1) No truck shortage has yet developed in the Texas Valley; however, the season is just now starting, and a critical problem is expected as the season progresses.
  (2) Interstate truck rates on both produce and livestock have increased. Produce rates are currently 20 percent higher than a year ago.
  (3) Adequate and suitable rail car equipment is not available to produce shippers in the Lower Valley.
- Actions which might help reduce the adverse economic impact of this fuel shortage include removal of radial operating restrictions from certificates of specialized irregular route carriers regulated by the Railroad Commission, especially those with agricultural products or livestock authority and allowance of overweight intrastate shipment of perishables, livestock, and other agricultural products.
- Also, the Interagency Transportation Council and the State Department of Agriculture could work with shippers and shipper groups in an attempt to divert truck shipments to rail. Grains can be economically diverted to rail if equipment is available. There is the possibility of shifting the movement of livestock to rail; however, some diversion of produce to rail might be made. According to the Vice President and General Manager of the Pacific Fruit Express Co., refrigerated car supplies "are still very short." Any significant

shift of fruit and vegetables will require increased investment in equipment and improved delivery service from the Valley. This is a long term operation.

- Also, the feasibility and impact of an embargo on motor carriers transporting grain to port elevators might be further evaluated. The embargo should apply to carriers transporting grain which originated more than 250 miles from port.

Mining

In Texas, mining includes crude petroleum production, natural gas and natural gas liquids production, oil and gas exploration, drilling and well servicing, sand and gravel. stone, clay, gypsum, sulphur, and a small amount of metal ore production. Much of the basic raw material from this sector is transported by pipeline and rail and probably will be less adversely affected than some other sectors by the fuel shortage in transportation. Like agriculture, mining is critical to the economy of Texas and also is especially important in times of a fuel shortage. Overall, the energy shortage probably will have a large, positive economic impact on Texas mining, the precise amount depending upon the price increases that are allowed.

Construction

This sector represents residential, commercial and institutional, industrial, facility construction, and maintenance and repair work.

- Much of the economic impact on this sector of a transportation fuel shortage will be indirect and will depend on the extent to which materials for construction services such as foundation work, masonry, carpentry, electrical, heating, etc., are not delivered because of rail and truck shortages.
- Also, fuel allocation procedures based on the previous year's usage does not work well in construction because of the wide variability of use by specific firms from year to year.
- Some construction workers travel long distances to work because job sites are transitory. Reduced speed limits and fuel rationing may affect them considerably.
- Reductions in gallons of highway fuels sold will cause a proportionate reduction in funds available to the Texas Highway Department, unless fuel taxes are increased. Given that highway maintenance probably will remain relatively constant, a more than proportionate reduction in highway facility construction probably will occur. This could have a somewhat severe impact on some segments of the construction sector.

Government and Education

The decrease in motor fuel sales will decrease motor fuel tax receipts by a proportionate amount. This will have a substantial effect on highway construction and maintenance and also on the Texas public schools, that receive one-fourth of these tax revenues.

- The Director of the Texas Research League says that there may be a possibility of increased oil and gas production taxes making up for the

loss to schools from gasoline taxes, but there is no way the loss can be made up to the Highway Department.

- The state crude oil tax, which provides about 5.6 percent of all state tax money, is 4.5 percent of the market value as it comes out of the ground. The state also gets three to 16 cents per barrel in pipeline tax. Crude oil taxes furnished about $210 million of state revenue in the last fiscal year ending August 31.
- Natural gas production taxes, which furnish more than 3 percent of state revenue, are 7.5 percent of the wellhead value and produced about $125 million the last fiscal year.

o The revenue loss to the Texas Highway Department could be as high as $7 million, according to Mr. Marcus Yancey, Jr., Assistant State Highway Engineer, if a reduction of 180 million gallons is realized. Federal fuel tax revenue used to match state funds would also be reduced.

o The revenue from the crude oil and natural gas production taxes goes 25 percent to the operation of public schools and 75 percent to the state's general fund.

o The state gasoline tax, five cents per gallon, goes 25 percent to the Available School Fund and 75 percent to the Texas Highway Department's construction funds.

Manufacturing

The manufacturing sectors include production of food and kindred products, textile and apparel products, lumber and wood products, furniture and fixtures, paper, printing, publishing chemicals, petroleum, rubber and plastics, leather, stone, clay, glass, concrete, primary and fabricated metals, machinery, equipment, instruments, photographic and optical goods, watches, clocks, and miscellaneous manufactured goods. Manufacturing establishments such as food processors and petroleum refineries receive raw materials, transform these materials into more highly usable states, and sell the resulting outputs either to other manufacturers, in the case of partially finished goods, or to consumers (final demand) in the case of finished goods.

The producer of intermediate products usually does not deal directly with final demand sectors of the economy since his output is not in a form usable by final consumers. Thus, these manufacturing sectors must anticipate and forecast demands for their products through the analyses of product demands of their customers' customers several times removed.

- Manufacturers are dependent on truck, rail, air, water, and pipeline to move raw materials and intermediate products from other manufacturers to their plants and then move their output to other manufacturers or to wholesale and retail market outlets.
- With some shortages of materials and intermediate products already occurring, additional disruption could cause delays and inefficiencies in production and even unemployment. Thus,

a reduction of transportation fuel beyond what can be saved by increased efficiency could have substantial effects.

- Because of changes in consumption patterns of consumers resulting from changed travel patterns, there probably will be some changes in the amount and mix of goods produced by manufacturing. In the short-run, it does not appear that these will be severe in Texas.
- As discussed previously, decreasing speed limits on trucks to conserve fuel will increase delivery times and cause some problems in production and distribution schedules. Greater efficiency in handling raw materials and products may reduce this impact.

Wholesale Trade

The wholesale and warehouse industry serves a very vital role in our distribution system. Businesses of this type act as middlemen between the producer and the retailer by coordinating and consolidating orders for finished products which make for an efficient distribution system. They and the manufacturers can use the various modes of transportation to transport products to regional and local warehouses or directly to the retailers.

- In recent years, retailers, wholesalers, and manufacturers have used computers to keep a close eye on inventories. The idea is to have no more products in stock than are absolutely necessary to prevent delays in purchases by the final consumer. The advantage is to keep the amount of capital invested into inventories as low as possible and thus free it for other endeavors.

- Motor vehicles carry most of the tonnage of manufactured products to wholesale and retail warehouses. A 15 percent reduction in motor vehicle fuel, together with a reduced speed limit, may disrupt delicate inventory balances existing at the present time.

Communications

The communications sector includes telephone and telegraph, radio and television, and other communication services. Mass media communications are significant in the sale of goods and services through communications of advertising services that inform consumers about products and services. In addition, mass media communications services are used widely in entertainment and recreation associated with advertising.

- Use of telephones and telegraph may be substituted on a limited scale for air and passenger car travel. To the extent that this happens, it will offset possible adverse effects of a general slowdown in economic activity.

Utilities

This sector includes the production of electricity, the distribution of natural gas, and the providing of water and sanitary services. Although this sector will be affected considerably by the energy shortage, it does not appear that there will be many transportation-related effects.

Retail Trade and Services

The retail trade and services industry is very sensitive to the amount of travel by motor vehicles. This is because our society uses the automobile almost exclusively to make all types of trips, some no more than a few blocks in length. The more distant a particular business is from its customers or its product supply sources, the more dependent it is upon the motor vehicle. Retail and service businesses along rural highways and in remote places are more dependent upon the motor vehicle than those in urban areas where pedestrian travel can be substituted.

- Businesses of the traffic-serving type are more dependent on the amount of travel by motor vehicles than those of the nontraffic-serving type. There is a direct relationship between amount of travel (ADT) and the amount of gross dollar sales for the three major types of traffic-serving businesses, e.g., service stations, food service, and motels. If the amount of travel (ADT) drops, there probably will be a drop in the gross dollar sales of these three types of business. Under normal circumstances, service stations are the most affected by a drop in traffic volume of the three types because these businesses derive most of their revenues from fuel and oil products used by motor vehicles.
- Assuming gasoline prices did not change, a 15 percent reduction in the gallons of motor fuel sold by service stations would amount to a decrease of about $400 million in gross sales in Texas. This calculation uses a reduction of 1.18 billion gallons of motor fuel sold in 1973. About one-seventh of this

is state motor fuel tax receipts (about one-fourth of which goes to schools and three-fourths to highways).

- Closing of service stations on Sundays and increases in fuel prices probably will substantially reduce the adverse impact of the fuel shortage on service stations as a whole.
- Nevertheless, some stations, especially independents, probably will be more adversely affected than the average. Also, Sunday closings probably will reduce the income of service station employees if their hourly wages are not increased.
- Studies of recreational travel indicate that weekend users of recreation will generally drive for as long as two hours in one direction. If the travel time increases much beyond two hours, users tend not to make repeat trips to recreation oriented facilities.
- The amount of money spent annually to make hunting and fishing trips in Texas runs into millions of dollars. A 1964 study of outdoor recreation in Texas revealed that the total trip expenditures of hunters and fishermen were nearly 95 million dollars in 1955 and 156 million dollars in 1960, showing a 65 percent increase over a five-year period. If that trend continued to the present, the 1973 trip expenditures would be 312 million dollars or double that of 1960. In 1960, over 47 million trips were made, totalling over 2.7 billion automobile miles, to yield an average trip length of 56 miles. The amount spent per

trip was over three dollars and has likely doubled by 1973. Reductions in fuel consumption and increases in travel times probably will reduce hunting and fishing trips and reduce the net incomes, tax revenues, and employment of businesses catering to this type of activity.

- Nontraffic-serving businesses probably would not experience a significant impact from a 15 percent reduction in fuel consumption. Also, the impact would not take effect as suddenly as it would for the traffic serving types.
- The sales of specialized recreational vehicles (campers, camper trailers, motor homes, etc.) might be substantially decreased. To the extent that retailers reduce the prices on these vehicles, the total reduction in number of vehicles sold will be lessened.
- Retailers of automobiles (new and used) will tend to reduce prices on larger automobiles as a result of the shift in demand in favor of smaller, more fuel-efficient vehicles.
- Retailers that rely upon regular, daily deliveries (such as food handlers) are more vulnerable to a reduction in transportation than retailers (such as clothing stores) who require less frequent transportation.

Finance, Insurance, Real Estate

This sector includes banking and credit agencies; insurance establishments, including insurance agents and carriers; and commodity brokers, dealers, exchanges and services, real estate, and holding and investment companies. In general, this sector will be affected as is the overall economy, although there will be some situations where this is not the case.

- The principal transportation-associated effect on this sector will be the short-term increase in profits of automobile insurers because of reduced travel and lower speeds resulting in fewer and less expensive accidents.
- There may be a rather severe depression in stock brokerage.
- A reduction in available fuel coupled with a lower speed may cloud the future of the rural land market and the rural real estate industry. During the last 25 years, many urban individuals and syndicates have been purchasing rural lands as far away as 150 miles for purposes of investment, hobby farming, and recreational activities. The price of rural land has increased 189 percent between 1947 and 1965, or about 10.5 percent per year. A study also showed that land ownership is shifting more and more from rural ownership to urban and absentee ownership. A higher percentage of rural lands selling in recent years are now mortgaged to a greater degree than was the case ten years ago. If the absentee owners are unable to travel to these places as often as they had planned, they may place their tracts on the market and depress land prices.

Resources

1. Grubb, Herbert W. The Structure of the Texas Economy. Vols. I and II, Office of the Governor, Austin, Texas, March, 1973.

2. Andrews, F. B. and Wooten, A. B. What's Happening in the Texas Farm and Ranch Land Market Texas A&M University, Texas Agricultural Experiment Station, Bulletin 1042, September 1965.

3. Andrews, F. B. and Wooten, A. B., This Land is Your Land-It's Worth More Every Day Texas Agricultural Progress, Vol. 13, No. 4, Fall 1967. pp. 8-9.

4. Buffington, Jesse L. "The Economic Impact of Interstate Highway Bypasses," Texas Transportation Researcher, Vol. 4, No. 1, January 1968, pp. 2-6.

5. Schmedemann, Ivan W., Wooten, A. B., Franklin, W. D. "Outdoor Recreation... Potential in East Texas," Texas A&M University, Texas Agricultural Experiment Station, Bulletin 1013, July 1964.

6. Cone, Connie. "Texas Construction Energy Conservation Texas Business Review, November 1973.