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National Energy Efficient Driving System (NEEDS) Volume I —

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Dr. John Eberhard of NHTSA served as Contract Technical Manager throughout the project.

16. Abstract

This report provides a state-of-the-art summary of the means by which individual drivers can achieve more fuel-efficient vehicle operation. It identifies fuel-efficient driving behaviors, the means of influencing behavior, appropriate audiences for attempts to foster fuel-efficient driving behavior, the types of materials needed to communicate fuel-efficient operation, and delivery systems capable of handling the communication of information. The report also describes research carried out under the project described in Volumes II and III of this report.

The authors conclude that: 1) drivers lack critical items of information concerning fuel-efficient vehicle operation, (2) efforts to encourage fuel efficiency have been generally unsuccessful and are probably unnecessary, (3) there is no good system for providing training in fuel-efficient vehicle operation to large numbers of drivers, and (4) a federally-coordinated effort is needed to assure the delivery of up-to-date information to drivers.

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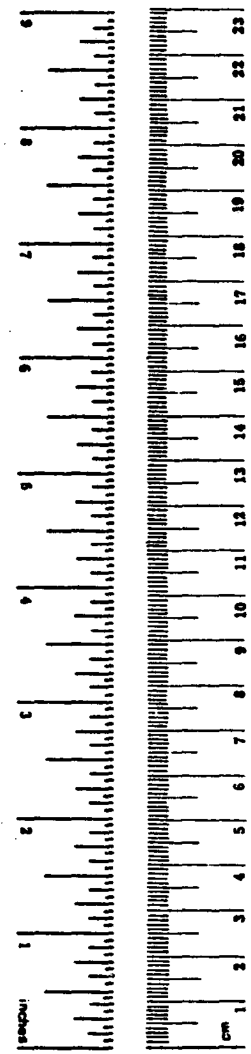
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

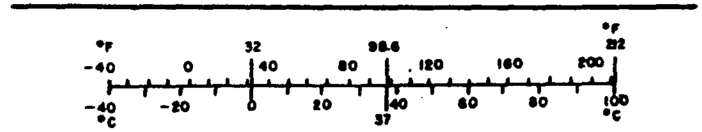
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, *Units of Weights and Measures*, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This report provides a state-of-the-art summary of means by which drivers can achieve fuel-efficient operation of vehicles. The report was prepared by the National Public Services Research Institute under contract to the National Highway Traffic Safety Administration (Contract No. DOT-HS-7-01775).

Dr. Kenard McPherson served as Principal Investigator during the early, information-gathering phases of the project. Dr. A. James McKnight served as Principal Investigator for the synthesis of data and preparation of the report. The authors were assisted by Ms. Deborah Fitzgerald, Mr. Michael Sheets, and Ms. Anne Knipper. Mrs. Ruth Freitas, Mr. Eugene Fasnacht, and Ms. Patricia Goll participated in preparation of the final manuscript.

The authors wish to express their gratitude to Dr. John Eberhard who served as Contract Technical Manager throughout the entire project. His guidance, insight, and patience were warmly appreciated. Appreciation is also expressed to Mr. Darrell A. Beschen, U.S. Department of Energy, who provided access to materials and contributed generously of his time and insight.

Additional volumes of this report are as follows:

> Volume II, Driver Education Program--describes the development and evaluation of a high school driver education program designed to communicate fuel-efficient driving information and develop fuel-efficient driving skills.
>
> Volume III, Home Vehicle Use Study--describes the nature and results of an effort to encourage more efficient use of home vehicles by better trip planning and monitoring of fuel consumption.

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CHAPTER 1

INTRODUCTION

BACKGROUND

The U.S. energy problem is one of increasing demand for a decreasing--and expensive--supply. The 1974 and 1979 international oil crises showed the average American that the problem was serious; few were truly aware of it until their pocketbooks were hit hard.

After World War II and until the 1974 crisis, the cost of energy, when corrected for inflation, steadily declined, and low prices encouraged less efficient use. At the same time, U.S. dependence upon imported oil steadily grew to nearly half of consumption. Largely owing to rising costs, the last few years have seen more and more attention focused upon energy conservation, and a consequent reduction in dependency upon foreign oil to about 36% in 1981.

Role and Purpose of Conservation

While few experts can agree on the sizes of domestic and world petroleum resources or on how many years it will take to exhaust them, all agree that the supplies are finite and that they are being depleted more and more rapidly. The role of conservation is both to effect more efficient consumption and to reduce overall consumption. Conservation cannot solve the energy problem, but it can slow the depletion of supplies to buy time for the development of alternative energy sources and new technology. Obviously, the more effective conservation is, the more time it will buy.

Targets for Conservation

The transportation sector accounts for about half of the petroleum consumed each year in the U.S. Half of this is used by automobiles. The individual drivers who operate the over 120 million privately-owned passenger cars are, therefore, ideal targets for fuel conservation efforts. Even small increases in the fuel economy of the average automobile could have a dramatic effect upon gasoline consumption: an increase of only 1 mpg would save from 100,000 to 150,000 barrels of oil per day or between 2% and 3% of daily consumption by automobiles. Reduced travel would, of course, enhance those savings.

Importance of Public Support

The effectiveness of any conservation measures in the personal transportation sector will obviously depend upon the support of a driving public that values freedom of mobility. Only twice has annual automobile travel declined--in 1974 after the Arab oil embargo and again in the 1979 temporary shortage. Each of those reductions followed a gasoline shortage at the pumps and a substantial price increase. Successful conservation efforts require that the drivers be favorably disposed to fuel-efficient driving and willing to reduce, at least to some extent, travel by automobile.

Attitudes

What are the attitudes of the public toward fuel conservation and driving? A Gallup survey conducted in February 1980 for the Highway Users Federation asked a national sample of 1,572 adult drivers whether rising gas prices had changed their driving habits a great deal and 35% said they had changed them somewhat. Only 12% said they had not changed their driving habits at all. The table below shows some of the reported ways in which habits had changed.

TABLE 1

REPORTED WAYS DRIVING HABITS CHANGED

	%
Now driving less	27.8
Drive less and with conservation in mind	42.3
Drive same but with conservation in mind	15.3
Drive more but with conservation in mind	3.0
Use the car with the best fuel mileage when possible	18.8
Purchased a car that gets better fuel mileage	14.8

The table indicates that many respondents said they had reduced travel and that even some who had not still claimed they drove with fuel conservation in mind. Survey results also indicated that among those driving less, 63% reported they had reduced social and weekend driving, while nearly half had reduced the number of shopping trips by car. Eighteen percent reported they had reduced vacation travel, a claim supported by the fact that drivers in 1979 made 13% fewer travel route requests to AAA than in 1978.

Although the trip to work was not affected for most people in the survey, 20% responded that in order to cope with higher gas prices one family member had stopped driving to work alone. Three-quarters of these family members had switched to some form of ridesharing.

The table shows that about 15% of those who reported their driving habits had changed indicated they had purchased a more fuel-efficient car. Over the last decade there has been a sharp trend toward the purchase of smaller, more economical new cars. Between 1970 and 1980, the market share of standard size cars decreased by over 50%, while sales of smaller compacts and subcompacts increased dramatically.

Vehicle purchase trends, reductions in travel, and changes in other driving habits indicate the American public is motivated to reduce personal fuel consumption and from time to time actually makes efforts to do so. For maximum impact, however, conservation efforts by the public must be directed to areas of transportation behavior where they will do the most good.

NEED FOR A COMPREHENSIVE PROGRAM

A comprehensive program of voluntary transportation energy conservation was determined to be an appropriate mechanism for directing and gaining maximum benefit from public efforts. An effort to design such a program was initiated in 1977. Called the National Energy Efficient Driving System (NEEDS), the design effort was carried out under the joint sponsorship of the Departments of Transportation and Energy.

Goal of NEEDS

The goal of the National Energy Efficient Driving System was to design a program capable of reducing individual driver demands for fuel through voluntary changes in transportation behavior involving minimum inconvenience and no appreciable loss in mobility. The program was intended to complement other fuel-saving efforts such as the 55 mph campaign, van and car pooling programs, the EPA Gas Mileage Guide, and DOT vehicle mileage requirements.

This scope of the effort was confined to measures that can be employed by individual drivers to improve upon the economy with which they operate their vehicles. It does not attempt to deal with measures that involve the activity of groups. Two areas of vehicle operation that are specifically excluded are ridesharing and the operation of commercial vehicles. Ridesharing, while a major contributor to energy conservation, requires a degree of coordination that almost necessitates the involvement of outside authorities, such as employers or van pool directors.

Operation of commercial vehicles is a potentially fruitful target of behavior change. During a period of relatively stable fuel prices, when individual drivers do not seem to feel the need to conserve, commercial operation with its many vehicles and high mileage offers the greatest hope of saving substantial amounts of fuel. However, achieving these savings requires a management system involving incentives and measurements and therefore is outside the realm of individual driver behavior.

Program Elements

Subsequent chapters describe and discuss a number of activities that were undertaken in the design of a voluntary conservation program. These actions included identification of the following:

- Fuel-Efficient Transportation Behaviors
- Behavioral Influences.
- Target Audiences

- o Presentational Materials
- o Delivery Systems

Fuel-Efficient Transportation Behaviors

NEEDS concentrates on those driver/consumer behaviors that will provide the greatest payoff in terms of reduced fuel demands and, in addition, have the best chances of achieving public acceptance. These behaviors, identified through literature review and expert consultation, were organized into four categories:

(1) Vehicle Selection

(2) Vehicle Maintenance

(3) Vehicle Use

(4) Vehicle Operation

Each of these four categories is discussed in Chapter 2.

Behavioral Influences

A variety of factors have been found to influence the behavior of drivers in each of the four categories just listed. The influencing factors include:

(1) Information

(2) Incentives

(3) Appeals

(4) Feedback

(5) Prompts

These influencing factors are discussed in Chapter 3.

Target Audiences

NEEDS is intended to encourage and enable the driving public to conserve fuel. However, the driving public is comprised of many groups of drivers with widely varying characteristics. Not all fuel-efficient behaviors and motivational methods are appropriate to all groups. Information and methods for communication must be matched to individual groups of drivers. To permit this, data were collected on the characteristics of six target audiences within the driving public:

(2) Postsecondary Students

(3) White-collar Workers

(4) Blue-collar Workers

(5) Home Managers

(6) Retired Persons

Each of these audiences is discussed in Chapter 4.

Presentational Materials

The materials that can be used for presenting required information to the public were divided into three broad categories:

(1) Printed Materials

(2) Audio-visual Materials

(3) Display Materials

The uses of presentational materials within these three categories, as well as their relative advantages and disadvantages, are discussed in Chapter 5.

Delivery Systems

Many organizations constitute "delivery systems"--the means by which information can be disseminated under the NEEDS program. Potential delivery systems were divided into the following categories:

(1) Governmental Organizations

(2) Educational Agencies

(3) Regulatory Agencies

(4) Employers

(5) Business

(6) Associations

(7) Mass Media

Organizations within these categories that are particularly appropriate for NEEDS are discussed in Chapter 6.

CHAPTER 2

FUEL-EFFICIENT TRANSPORTATION BEHAVIORS

The first task of the NEEDS project was to identify fuel-efficient transportation behaviors. This was accomplished through an extensive literature review and consultation with experts in the energy and transportation fields.* The result was a comprehensive list of behaviors that are related to fuel-efficient personal transportation. Because the aim of NEEDS is to encourage the use of behaviors that will have the most impact upon fuel economy and, at the same time, cause a minimum of inconvenience, the list was scrutinized and behaviors were eliminated from further consideration for one or more of the following three reasons:

- Their connection with fuel economy was too indirect.
- Their contribution to fuel economy was too small.
- They required a disproportionately large sacrifice of convenience or travel contrary to the objectives of a voluntary, nonrestrictive program.

This chapter describes and discusses the behaviors ultimately selected for NEEDS. The selection is still comprehensive, yet it focuses on behaviors having both the greatest fuel economy and the potential for public acceptance. To facilitate both discussion and analysis, the behaviors were divided into four categories:

- Vehicle Selection
- Vehicle Maintenance
- Vehicle Use
- Vehicle Operation

VEHICLE SELECTION

Background

The aim of fuel-efficient vehicle selection is to minimize vehicle fuel consumption without adversely affecting vehicle utility. Successful fuel-efficient vehicle selection begins with an evaluation of personal transportation requirements. Once those requirements are established, the vehicles capable of fulfilling the requirements most fuel efficiently can be identified.

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* The advisors consulted are listed in Appendix A.

The purchase of a more fuel-efficient vehicle is one of the most significant actions a driver can take to reduce fuel consumption. Vehicle miles-per-gallon may vary substantially within class sizes. Vehicle selection has long-term effects because once a vehicle is purchased, its fuel economy characteristics will continue to limit achievable miles per gallon for the duration of its use. For example, EPA estimates of MPG for 1982 vehicles in the mid-sized category vary as much as 100% (10 mpg to 20 mpg).

Vehicle Weight

Vehicle weight is the most important factor in determining how many miles per gallon a vehicle will deliver. The heavier a car, the more energy it will require to accelerate and overcome both gravity and rolling resistance.

Miles per gallon decreases automatically as weight increases. Halving weight produces approximately a two-fold increase in mpg (Austin, Michael and Service, 1975). The heavier the vehicle, the more power is required to overcome inertia, rolling resistance, and gravity (i.e., hills). The larger frontal area also means greater aerodynamic drag. Style or shape also influences drag. However, most current designs minimize drag, leaving frontal area as a much more important factor.

Except for slight reversals during the period 1976-1979, there has been an increase in the purchase of small vehicles at the sacrifice of full-sized vehicles. This change in purchase patterns, along with general vehicle downsizing, has been responsible for the increase in fleet mpg and has played a significant part in the overall reduction in transportation fuel consumption since 1979.

While the number of heavier cars still being sold testifies to the desirability of further behavior change, the chances of getting additional change without a substantial change in the price or availability of fuel seem small. Drivers appear generally knowledgeable concerning weight penalties and are prepared to act upon their knowledge when the motivation is strong enough. However, substantial numbers of drivers are prepared to meet the costs of driving heavy vehicles.

Engine

The three most fuel-sensitive aspects of an automobile engine are size, type and certain components.

Engine Size

The larger the size of the engine, the lower its fuel efficiency. Overall, a 10% increase in engine displacement produces a 6% decrease in mpg

(EPA, 1980). The relationship varies as a function of both speed and engine size. As speed increases over 55 mph, differences due to engine size decrease, becoming negligible in speeds of excess of 70 mph (Cornell, 1965). Also, as absolute engine size decrease, the percentage changes in size have a proportionatey smaller effect upon mpg.

Research shows drivers are generally aware of the effect of engine size upon mpg. There has been a tendency to select smaller engines where an option exists. Moreover, the trend toward smaller cars necessarily brings a trend toward smaller engines. A V-8 engine, once the standard engine in U.S. cars, is found in less than a quarter of the cars manufactured in 1981 (Kreher, 1982)

While engines have been getting smaller, a lot of smaller vehicles are sold with larger engines than needed. To what extent this is due to lack of knowledge, lack of interest, or a desire for high performance cannot be determined. However, it seems likely that efforts to get drivers to consider engine size in relation to their intended use of the vehicle could produce more appropriate selection of engine options.

Type of Engine

Of the two major engine types, gasoline and diesel--the diesel engine is by far the more fuel-efficient. According to the EPA (1973), diesel engines will deliver 40-70% better mileage than comparable gasoline engines. The greater efficiency derives from the diesel engine's higher compression ratio, resulting in more complete combustion, as well as the greater energy available from a gallon of diesel fuel.

Until recent years, gasoline engines had the automobile market to themselves and diesel engines were confined to large trucks and buses. However, recent engineering advances have resulted in reliable and economical diesel engines of the size appropriate to automobiles. Somewhat higher purchase costs, a relative lack of power, and certain minor annoyances (noise, vibration, occasional hard starting) limited their use. In 1981, diesels were found on 6% of the vehicles sold (Kreher, 1982). The number of diesel automobiles sold in the United States increased seven-fold during the period 1973-77. However, sales appear to have declined in recent years. Future increases in fuel costs may help to offset the higher purchase cost and make them even more attractive.

Engine Components

A number of engine components have an effect upon fuel efficiency. The most prominent are turbochargers, stratified charge engines, and preheaters.

A turbocharger is a device that uses exhaust gases to drive a turbine that compresses the air entering the engine to create a more efficient air/fuel mixture. Turbochargers are used primarily on diesel engines to improve their performance. Its primary effect on fuel economy is to overcome the diesel engine's major deficiency thereby making it more attractive.

The stratified charge engine employs a dual combustion process to improve engine performance. While it is expected to improve fuel economy, it has not been in use long enough at this writing to yield reliable data.

In extremely cold areas, the low mpg that occurs during engine warmup can be reduced with the aid of preheaters, which can be attached to an electrical outlet to supply heat to the engine block. On a nationwide basis, the fuel savings available from preheaters is minimal. Moreover, the individual savings in fuel economy are obviously offset to some degree by the cost of electrical energy. The net effect depends upon such factors as the engine size, the outside temperature, and how many hours in advance the heater has been activated. While engine heaters offer unequivocal benefits in reliable starting of engines in extremely cold weather, their use cannot, however, be recommended solely as an energy saving measure.

Modified Engines

Engines may be modified to permit use of special fuels including hydrogen, propane, and compressed natural gas. While these types of engines offer certain advantages in fuel economy and reduced engine wear, they are not practical engine alternatives for most drivers due to (1) the limited commercial availability of the fuel, (2) various vehicle operating restrictions (e.g., tunnels), and (3) the difficulty in recovering engine modification costs given the limited use put to the vehicle by the average driver.

Power Transmission

The kind of transmission and the drive axle ratio and the number of gears affect fuel efficiency.

Type of Transmission

The two basic types of automobile transmissions are automatic and manual. Torque converter slippage in automatic transmissions robs the vehicle of power and increases mpg. The slippage is greatest during accelerations and when ascending hills. At steady speeds, it is generally negligible and is eliminated with designs that lock the torque converter at certain speeds. In some vehicles, the energy efficiency losses of the automatic transmission are offset by more economical drive axle ratios than are found in corresponding manual shift vehicles. The penalty suffered by automatic transmissions can range up to 15%, but typically falls in the 5-10% range (EPA, 1973).

While manual transmissions are inherently more economical, their potential is often unrealized due to lack of driver skill. Data appear to show that economies found in manual transmission under tightly-controlled tests often disappear on the road, with automatic shifts evidencing over 7% better fuel economy (EPA, 1980). In other words, inefficient shifting techniques can drive the mpg lower than that obtainable from a well-designed automatic transmission. Unskilled drivers are actually better off with an automatic transmission.

Drive-Axle Ratio

The drive-axle ratio determines the number of times an engine must turn to make the wheels rotate once. A lower axle ratio will allow the engine to turn more slowly, and thus more economically, but with some sacrifice of power (overdrive transmission, 5th gear, does the same). For normal usage, power loss from a 10% ratio reduction is minimal, yet can result in a 2-5% increase in mpg (EPA, 1973). Tests administered to drivers as part of activity described in the next chapter indicate that drivers are not generally aware of the role that drive-axle ratio plays in fuel consumption nor of the options that are frequently available.

Number of Gears

Where additional gears are employed to furnish fuel-efficient gear ratios, they can improve fuel economy. Thus, a 4-speed automatic transmission will provide greater economy than a 3-speed automatic, while a 5-speed manual would deliver greater economy than a 4-speed manual transmission. However, a greater number of gears is not always used to improve the gear ratio. For example, the addition of a fifth gear may be accompanied by changes in the transmission or drive axle that result in the same overall gear ratio as a 4-speed transmission.

To obtain the most fuel-efficient transmission, it is necessary to examine the gear ratios involved. It is also necessary to shift properly. Using higher gears at low speeds or in stop-and-go traffic may actually reduce fuel economy.

If appropriately designed and properly used, 4-speed automatics and 5-speed manual transmissions are capable of improving fuel economy by 10% at cruising speeds (EPA, 1973). While these transmissions currently make up a small share of the market, it is a share that is increasing.

Accessories

Accessories can decrease fuel efficiency in three ways: by consuming power, by adding weight, and by decreasing aerodynamic drag. The trend toward lighter cars and more fuel-efficient engines does not appear to have been accompanied by any decrease in the purchase of accessories. On the contrary, many drivers appear to have used the large gains in economy obtained through purchase of more efficient vehicles to justify the small penalty suffered by the addition of various accessories. This section will discuss those accessories having the greatest impact upon fuel economy.

Air Conditioning

Two aspects of an air conditioner affect fuel economy--weight and power.

The weight of an air conditioner adds to the weight of the vehicle, incurring the weight penalties described previously. While improved design and smaller units (smaller vehicles) have dropped the penalty to under 1%, it is a constant penalty. Over the life of the vehicle, it could amount to $25 - $75.

In percentage terms, the larger source of fuel loss is the power drain of the compressor and fan when the air conditioner is operated. At maximum cooling, penalties average around 7-8% depending upon vehicle speed. At normal settings, the penalty is cut in half.

The absolute magnitude of fuel loss resulting from an air conditioner obviously depends on how often it is operated. The fleet-wide estimate is about 2% (EPA, 1980). In moderate climates, where the air conditioner is used less than a quarter of the time, the penalty would only be in the neighborhood of 1%. However, here is where a paradox arises. What is the point in paying the purchase price and weight penalty of an air conditioner if it is not used? While keeping the air conditioner turned off reduces the fuel loss, turning it on improves the benefit-cost relationship.

Another paradox is encountered in deciding when to use an air conditioner. An air conditioner is most needed when operating at slow speeds where natural ventilation is lowest. Yet, it is at high speeds that the penalty for operation is lowest relative to other penalties (e.g., drag). It is also at higher speeds that the alternative--opening windows for ventilation--begins to make a significant penalty. The penalty, however, never equals that arising from use of the air conditioner (Donoho, 1978).

The purchase of air conditioners has been steadily increasing despite fuel shortages. Those who are greatly discomforted by heat and are able to afford the purchase and use of air conditioning do not seem to be deterred by the prospect of having to pay a higher fuel bill.

The one clearly beneficial step that can be taken in the use of air conditioners is the installation of a cutoff switch to turn off the air conditioner during heavy acceleration. This both reduces power consumption during acceleration and allows the vehicle to accelerate more rapidly into higher, more fuel-efficient gears. The savings of 6-12% during air conditioner operation has been credited to the use of a cutoff switch (Webb, 1981). This could result in lifetime savings in fuel of $150 to $300 for a device that costs less than $20.

Power Steering

The fuel losses incurred by the use of power steering come from the same sources as those arising from the use of air conditioning--weight and power consumption. However, both penalties are considerably less than those associated with air conditioning. On full and intermediate size cars and certain small front wheel drive vehicles, the amount of benefit is probably sufficient to justify the 1-3% fuel penalty (Cornell, 1965). However, in compacts and subcompacts, purchasers should be advised to try operating vehicles with and without power steering before deciding whether the price and fuel costs of power steering is justified.

Roof Racks

Roof racks increase aerodynamic drag, decreasing fuel economy. The amount of drag obviously varies with the size of the rack. A small basket-type rack that is empty causes a fuel loss in the neighborhood of 5%, while a loaded enclosed rack may result in losses up to about 30% (Consumer's Union, 1980). Smaller, but substantial, penalties can also be imposed by other extensions from the skin of the vehicle, such as large extension mirrors or long antennas.

The alternatives to the use of roof racks and other extensions that are available make this area a good one in which to seek behavioral change. Such changes would include:

- avoiding permanent in favor of removable racks where cartop loads are not being carried continually.
- placing loads inside the vehicle instead of on top whenever possible.
- carrying large loads in a semi-trailer so thay can be towed in the vehicle's "wake" rather than on top where they can create enormous drag.

Tires

Much of the energy consumed in using an automobile is dissipated in the form of heat as the automobile tire flexes. The extent of this loss is dependent, among other things, upon the construction of the tire.

Radial Tires

Energy loss is substantially lower in radial tires than in bias-ply tires. While differences of as much as 10% have been reported, the average has been in the neighborhood of 5% (Campbell, 1977; Klamp, 1977; Ontario, 1982). Because radial tires also give longer wear, they have been gradually replacing bias-ply tires on new automobiles.

The most recent generation of radial tires has been referred to as "P-metric," in reference to the letter that precedes their tire size designation. P-metric radials are designed to operate at somewhat higher pressures, thus reducing rolling resistance. It has been estimated that P-metric radials will yield 1%-1.5% better mileage than conventional radials.

As radials have replaced bias-ply tires, so P-metrics will ultimately replace conventional radials. This leaves tire replacement as the area in which to seek behavior change.

Snow Tires

The type of tread employed on snow tires substantially increases rolling resistance. Losses of approximatley 4% when running on dry pavement have been reported (Ontario, 1982). Fortunately, the traction offered by radial tires makes the use of snow tires unnecessary and of little advantage in all but those areas with continual snow throughout the winter. Many States and municipalities have accepted radial tires as meeting the requirements for snow tires on emergency snow routes. Where snow tires are necessary, drivers should be urged to replace them as early in the spring as possible.

EPA Ratings

Vehicles are rated for fuel efficiency through an estimate of mpg provided by the Environmental Protection Agency. If this estimate is accurate, its availability makes it unncessary for purchasers to assess vehicle characteristics for their fuel efficiency implications.

The accuracy of EPA ratings has been studied by a number of organizations. The results of these studies have been summarized by the Environmental Protection Agency (EPA, 1980). The discrepancy between rated and actual mpg, or "slip" as it is called, can be traced to the following sources.

Vehicle

Production--Discrepancies resulting from the production process and existing in the vehicle at the time of purchase.

Condition--Discrepancies resulting from the operating condition of a particular vehicle.

Road

Travel Environment--Discrepancies resulting from the effects of the environment in which the vehicle is operated.

Travel Characteristics--Discrepancies resulting from the manner in which the vehicle is operated (speed, trip length, driving practices).

Vehicle Condition/Road--Discrepancies resulting from interaction between the condition of the vehicle and road charcteristics.

Discrepancies are also produced by the testing procedure itself.

Most of the slip is in a negative direction, that is, the actual mpg is less than the EPA rating. The magnitude of slip can range up to 20%, depending upon the fleet mix and the way in which slip was measured. The average is in the neighborhood of 10%.

The absolute magnitude of slip is not critical to the vehicle selection process so long as it is equal across all vehicles being compared. Most of the sources of slip appear to be relatively independent of vehicle design characteristics, and therefore apply to all vehicles equally. However, slip in mpg appears to vary with level of mpg, being greatest among vehicles with the highest mpg. What this means to vehicle selection is that high mpg ratings must be treated with caution in any attempts to trade mpg off against other factors.

Driver Aids

A number of devices are capable of assisting drivers in improving fuel economy. The two most commonly employed for this purpose are feedback devices and cruise control.

Feedback Devices

Devices which feed back information to drivers as to the efficiency of their operation can help reveal and reinforce more efficient behavior. The most common type of device are vacuum guages and fuel metering devices.

Vacuum Gauges

A vacuum gauge measures the intake manifold vacuum. Since vacuum is correlated with throttle position, and therefore fuel intake, a vacuum gauge becomes an indirect measure of fuel consumption. It is, however, much less expensive to buy and install than a fuel measuring device. A vacuum gauge is generally considered most useful during acceleration, where it can guide the driver to a gradual, and (presumably) fuel-efficient acceleration rate.

There are two major causes of skepticism as to the true value of vacuum gauges in leading to fuel-efficient vehicle operation.

> Relation of Consumption to Efficiency--The measurement of fuel consumption, whether directly through a fuel gauge or indirectly through a vacuum gauge, is not necessarily an index of fuel economy. For example, speeds of 35-45 mph are generally more fuel efficient than lower speeds, even though fuel consumption is higher. Even during acceleration, low fuel consumption is not necessarily fuel efficient. Some large vehicles with automatic transmissions appear to accelerate most fuel efficiently at acceleration rates above the minimum (see the section on "Acceleration" in the Vehicle Operation chapter).

> Role of Acceleration--Even were vacuum gauges to lead to fuel-efficient acceleration, the magnitude of the benefit is open to question in view of the small proportion of total vehicle operating time during which it is accelerating.

A number of evaluations of vacuum devices reviewed by Hinton, et al. (1976) showed gains ranging from 0 to 25% in mpg. However, these studies were not well controlled, were confined to short-range efforts, and yielded widely varying results.

Some investigators have pointed out the potential hazard involved in monitoring a vacuum gauge while driving. This objection has been overcome by the use of devices giving an audible signal. However, many drivers eventually find the sound aggravating and disable the signal device.

Vacuum devices have certain side benefits in helping to diagnose engine malfunctions. Mechanically-inclined drivers may use this aspect of the device to good advantage. However, as an energy-saving device alone, the purchase of a vacuum guage can either be encouraged or discouraged by available data.

Fuel Metering Devices

Seemingly, the type of device that is of greatest value in measuring fuel economy is one that meters the consumption of fuel directly. Most fuel metering devices employ a small turbine inserted in the fuel flow between the fuel pump and the carburetor. The faster the fuel flow, the faster the turbine turns. The three basic types of fuel metering devices are:

Totalizer--This device simply totals the amount of fuel consumed over a particular distance and time. It can measure the total effect of fuel economy practices employed over equivalent routes, or the relative economy of reaching the same destination by different routes.

MPG Indicator--A fuel metering device is coupled with an odometer to provide an instantaneous measure of mpg. An mpg indicator has the advantage over a totalizer of being able to feed back to the driver the fuel efficiency of individual driving practices as employed at the moment. Many indicators also total fuel consumption as well.

Trip Computers--The most sophisticated of fuel metering devices contain small computers to store fuel and mileage information and manipulated in different ways to provide a variety of data including instantaneous mpg, trip mpg, gallons per hour, mpg since last fillup, and so on.

Each of these devices provides more information at greater expense. Cooksay (1981) evaluated two fuel metering devices and found gains from 2.3% to 8.1%. However, this study, like those evaluating vacuum gauges, have focused on short-term effects.

Combination Devices

Cooksey (1981) evaluated the effects of varous combinations of vacuum and fuel metering devices using both visual and aural feedback. Reductions in fuel consumption ranged from less than 1% to 4.5%. The greatest gains were those that employed a combination of visual and aural feedback. Which type of device supplied each did not appear to matter.

As with studies of vacuum devices and fuel metering devices, the results were short term. There is no way of determining the extent to which the gains resulted from better operation as opposed to simply making the drivers energy conscious in all of their driving behavior. It really wouldn't matter what is responsible if the gains were sustained. However, long-term benefits are yet to be measured. Because of the added cost of the devices, their ability to pay for themselves in fuel savings is even more in doubt. They are probably more useful in a training context, as a means of demonstrating the absolute fuel benefits of various practices than they are as an aid in reducing long-term fuel consumption.

Cruise Control

Cruise Control is a device that maintains the speed of the vehicle at a preset level by automatically adjusting throttle position when the speed varies up or down from that selected. It is capable of enhancing fuel economy in three ways:

> Constant Speed--The typical driver allows the vehicle speed to drop frequently, necessitating reacceleration. This consumes more fuel than a steady speed.
>
> Fuel-Efficient Speed--A driver who wishes to operate at a fuel-efficient speed frequently, through inattention, allows the speed to drift into an uneconomical range. The same driver with cruise control can set it at the desired level confident that it will be maintained.
>
> Fatigue--Cruise control relieves the driver of the chore of regulating the accelerator pressure and checking the speedometer. On a long trip, this tends to reduce fatigue enhancing the driver's ability and inclination to employ fuel-efficient driving practices.

A cruise control can only be used effectively on limited-access highways under low-density traffic conditions. For most drivers, these conditions account for a small portion of vehicle operation. It is doubtful that the fuel saved would pay for the cruise control. There is also a situation in which the cruise control is actually fuel inefficient. That situation is driving uphill, where a cruise control will apply more power to maintain the preset speed, rather than employing the more fuel-efficient practice of allowing speed to drop off.

In summary, it is doubtful that use of a cruise control device can be justified as a fuel economy aid.

VEHICLE MAINTENANCE

Keeping a vehicle in top operating condition has been widely advanced as a means of fostering fuel economy. Those forms of maintenance considered most influential in achieving fuel economy are:

- o Engine tuneup
- o Tire inflation
- o Selection of fuels and lubricants.

Tuneups

Increased fuel consumption has been associated with degradation and the performance of vehicle components including:

Ignition--Fouling and incorrect settings of points and plugs

Carburetor--Dirt, deposits and misadjustment

Fuel and Air Filters--Clogging

Engine Timing--Improperly set.

Oil companies and service stations generally encourage periodic tuneups as a means of maintaining high fuel economy. Measures of the effect of tuneups upon fuel consumption are, however, rather equivocal. Gains have ranged from almost zero for randomly selected vehicles (Claffey, 1977) to 2% for sample of volunteers (Hariott and Strum, 1980), to 7.4% for vehicles selected on the basis of poor performance (Walker, et al, 1978). Average gain of 4-5% in mpg was found in tuneup of vehicles that failed to pass an exhaust emission inspection. Of the various items of service constituting a tuneup, spark plug replacement and carburetor adjustment appears to have had the greatest overall effect upon fuel economy (Panzer, 1976).

These results argue against routine, periodic tuneups in favor of tuneups when there is evidence of need. The maintenance philosophy of "don't fix it if it ain't broke" seems to apply to tuneups. One way to determine whether a tuneup is needed is through a program of diagnostic testing, including engine and/or exhaust analysis. However, this can be costly for the ordinary motorist. A less expensive alternative is to keep detailed records of mileage and fuel consumptions, and to schedule either diagnostic analysis or a tuneup when mpg begins to drop noticeably over a period where use pattern and climate has remained constant.

Tire Inflation

As noted previously in the discussion of tire type, substantial energy is dissipated in the heat generated by flexing of the tire as it rolls over the surface. Generally speaking, the lower the tire pressure, the greater the energy loss through this source. Estimates of the amount of loss vary. A recent review of research in this area (Ontario, 1982) found that the variation in air pressure required to produce a 1% change in mpg varied from 1 to 3 psi and averaged about 2 psi.

The amount of fuel that can be saved through proper inflation of tires obviously depends upon the extent to which tires are presently underinflated. A survey of tire pressures by Atwood and Williams (1979) found that, on over a third of vehicles, all tires were underinflated by at least 4 psi or more, and that 60% had at least one tire underinflated by that amount. This suggests that most drivers could obtain a 1-2% gain by keeping their tires properly inflated.

The main reason for such underinflation is probably simple failure to make periodic checks. It is also possible that many drivers check inflation after the vehicle has been driven and the tire is hot. Due to heat, tire pressure will generally read a few psi higher than the "cold" tire pressures recommended by manufacturers.

Most tires are designed to carry from 2-4 psi more pressure than the recommended "normal" pressure. Inflating tires to the maximum levels indicated by manufacturers is in no way detrimental to vehicle performance or tire wear, although it may produce a somewhat harder ride. Inflation to maximum tire pressures could produce another 1-2% gain over that 1-2% gain achievable by avoiding underinflation. The fact that the gain comes without compromise of any travel objectives makes the checking of tire pressure a potentially fruitful area for behavior change.

With the rise of self-service gas stations, and the tendency of many air pumps to be located at out-of-the-way and often inaccessible spots makes the checking of tire pressure more than a matter of simple routine. Drivers need to be encouraged to purchase pressure gauges and to keep them handy in their vehicles to encourage frequent (e.g., monthly) tire checks.

Lubricants

It has been estimated that between 10% and 40% of energy within the engine is consumed in friction between moving parts. The function of engine lubricant is to reduce this friction by creating a film of oil between the parts. Three alternative ways of reducing friction between engine parts is through use of:

- Multi-weight oils
- Friction modifiers
- Synthetic oils

Multi-Weight Oils

An important property of oil is its viscosity, that is, its resistance to flow. Viscosity must be low enough to permit the oil to flow freely, yet high enough to preserve an oil film between parts. Viscosity varies with the weight or grade of the oil, light oil such as SAE-10 having low viscosity, and a heavier oil such as SAE-40 having high viscosity.

The problem in maintaining optimum viscosity is that the viscosity of any one oil will vary with the temperature of the engine. To maintain the same level of viscosity and lubrication, a light oil is required at low temperatures and a heavy oil at high temperatures. This problem is overcome through multi-weight oils whose properties vary with temperature, performing like light oils when the weather is cold and heavy oils when the weather gets hot. Multi-weight oils such as SAE-5-W-30 have been credited with fuel savings of 3 to 4% over single-weight oils in cold weather (Ontario, 1982).

During warm weather, multi-grade oils are not of any particular advantage, and many automobile manufacturers recommend against their use in summer months because of the tendency to break down at high temperatures. However, improvements in multi-grade oils appear to be overcoming this problem.

In the main, drivers should be encouraged to use multi-grade oils except in those few areas where temperatures are moderate on a year-round basis.

Friction Modifiers

Most major oil companies sell oils with additives that increase their ability to reduce friction. These "slippery" oils generally cost half again as much as oil without friction modifiers.

Tests of friction modified oils show 2-3% improvement in fuel economy (Broman, et al, 1978). The fuel efficiency benefits, along with reduced engine wear, make the use of slippery oils marginally cost-beneficial, and their use can be recommended.

Synthetic Oils

Synthetic oils were introduced as an alternative to petroleum-based lubricants shortly after the first energy crisis. Their effect upon friction is similar to that of friction modified oils, producing the same general improvement in fuel economy. However, they cost about twice as much. On the basis of fuel conservation and engine wear alone, they cannot be recommended. Manufacturers of synthetic oil claim that the increased cost can by offset by longer periods between oil changes. However, this reported advantage has not been fully confirmed. In the meantime, automobile manufacturers have not varied their oil change intervals for warranty purposes. Use of synthetic oils cannot, therefore, be recommended at this time.

Fuel

Choice of fuel can have some influence over fuel economy. Those fuels that affect the type of engine, or require modifications to it, have been previously discussed under Vehicle Selection (e.g., diesel, propane, etc.). As far as gasoline engines go, those fuel characteristics over which drivers have some choice and which are also capable of affecting fuel economy are octane and additives.

The octane rating of fuel itself does not affect fuel economy. So long as an engine runs acceptably, increasing octane will not improve mpg. (Bascunana and Stahman, 1976). The only exception is vehicles with knock sensor systems, which automatically adjust timing response to engine knock, frequently produced by fuels of inadequate octane. The adjustments made could increase engine performance at the sacrifice of mpg.

Most common additives do not affect fuel economy either positively or negatively. Probably the best known additive is alcohol, a 10% ingredient of "gasohol." While this mixture of alcohol and gasoline was expected to improve mpg, tests show no increase (EPA, 1980). Given the increased cost of gasohol, its use cannot be recommended as an energy-saving behavior.

VEHICLE USE

The manner in which automobiles are used has an effect upon fuel economy that is probably second in magnitude only to vehicle size. Vehicle use can be divided into two categories: home and work. Each is subject to a somewhat different set of requirements and therefore gives rise to a different set of behaviors.

Home Vehicle Use

Home vehicle use includes all use of a vehicle for purposes unconnected with work, including domestic business (e.g., shopping), social travel, and recreational travel. The ways in which use can be altered for fuel economy include reduced travel, short trip reduction, selecting the time of travel, and selecting routes.

Reduced Travel

The most obvious vehicle use measure that can be taken to reduce fuel consumption is simply to minimize the amount of driving. This means reducing unnecessary travel, such as social and recreational trips, and meeting essential travel needs through alternative transportation modes, including vanpools, carpools, public transportation, bicycling, and walking.

There is evidence that, during acute fuel shortages, this is exactly what happens. Each of the fuel crises occurring in the 1970s was accompanied by increased use of alternative travel modes and reductions in family travel (Hartgen et al., 1979; Phifer, et al, 1979; Stearns, 1976). However, as fuel becomes available again, drivers tend to drift back to their normal pattern of travel.

The effects of the 1979 crisis are well summarized by Hartgen, et al, (1979) when rural and highway traffic dropped about 8%. In New York, weekend travel dropped by 15%, recreational travel by 19%, and use of public parks by 25%. On the other hand, use of mass transit facilities across the country increased from 15% to 30%.

Reports by individual drivers indicated the primary ways of reducing travel involved shopping, including combining shopping trips, shopping closer to home, shopping less often, and shopping on the way home from work (25-47% of drivers). Revising vacation plans was reported by 16-17% of drivers, while use of mass transit was reported by 12-15% (Hartgen and Neveu, 1980).

Direct reduction in travel requires some personal sacrifice, ranging from minor inconvenience to abandonment of travel objectives. Such sacrifice is apparently an acceptable alternative to waiting in long gas lines and facing uncertain fuel availability on trips of any length. However, when fuel is available, neither its cost nor the dependence upon foreign imports that it involves seems sufficient to maintain the spirit of sacrifice.

Short Trip Reduction

One aspect of vehicle use that permits increased fuel economy without the sacrifice of convenience or travel objectives involves the length of trips. Because a vehicle is operating at its lowest level of fuel efficiency during the first few miles of operation, longer trips are more fuel efficient than shorter trips. This fact offers opportunities for fuel economy measures that will become apparent in a moment.

Short Trip Fuel Penalty

First, let us consider the relationship between trip length and fuel economy. Tests of vehicle mpg over trips of varying length performed by Scheffler and Niepoth (1965) and Tobin and Horowitz (1969) show fuel economy increasing logarithmically with trip length to distances of about 10 miles, at which point it begins to level off. MPG at 2 miles is 60% of maximum. A study of home vehicle use described in Volume III of this report confirms these general relationships but evidences a slightly greater penalty for short trips (53% of maximum at 2 miles).

Two factors contribute to the low short trip mpg:

> Cold Start--It is well known that a "cold" vehicle yields its lowest mpg just after it starts. Tests have shown that the mpg after the first 2 minutes (approximately 2/3 of a mile) to be 65-70% of that achieved by a fully warmed-up engine. The loss is attributed to the fuel enrichment required by a cold engine and

the resistance from the high viscosity of engine and transmission lubricants.

Driving Conditions--Most short trips are performed largely in stop-and-go traffic, while trips of greater length generally involve access to roads permitting higher rates of speed. The effect of this difference is evident in studies showing a correlation between speed and trip length (EPA, 1980), with average speed increasing from about 20 mph for trips of 3 miles to about 35 mph for trips of 25 miles.

Short-Trip Travel

Information as to driver travel current patterns comes primarily from Nationwide Personal Transportation Studies (ASIN, 1974). Data from this source show that 62% of family trips are under 5 miles. Some of these are home-work commuter trips and presumably are not capable of being altered. Of family business trips, approximately 74% are under 5 miles.

Nationwide personal transportation statistics are compiled from reports of drivers rather than actual measurement and are therefore suspect. Volume III of this report presents data gathered through surreptitious measurement of actual vehicle travel. While collected on only eight families, it included over 3,000 trips. These data showed 70% of trips involving distances of three miles or less. These trips accounted for 28% of miles traveled and 40% of fuel consumed.

Reducing Short Trips

The extent to which drivers could save fuel by reducing short trips depends upon the number of short trips that could be eliminated. The reason for concentrating upon elimination of short trips is not only the inordinate amount of fuel consumed but the likelihood that these trips involve a higher percentage of unnecessary travel than longer trips. Most trips of 3 miles or less are believed to involve family business, primarily shopping. It is difficult to believe that the several short trips that the average family makes in a day are all really necessary. Skepticism is reinforced by the Hartgen and Neveu (1979) finding that the primary way of reducing family travel during fuel crises is by reducing the number of shopping trips.

The idea that many short trips are unnecessary does not imply that the objectives of the trips are frivolous but rather that they could be achieved with reduced travel by:

Consolidating--Where several trips are made to the same destination for different purposes, they might be consolidated in a single trip.

Combining--Where several round trips are made to different destinations, they might be combined or linked into a single trip.

All that these measures require is a little advance planning. They allow fuel consumption to be reduced without any real sacrifice of travel objectives. That is what makes improved vehicle use such an attractive approach to energy conservation.

Evidence collected in Volumes II and III of this report suggest that drivers are aware of the short trip fuel penalty and themeans by which it can be minimized. However, they appear to greatly underestimate magnitude of the penalty involved and the number of short trips they make with the result that they greatly underestimate the amount of fuel that short trips are costing them.

Selecting Time of Travel

The time at which drivers elect to make trips can affect fuel economy. Among the more important time-related factors are the following:

> Temperature--The lower the outside air temperature, the lower will be the vehicle's mpg. Newer and smaller vehicles seem more affected by mpg than older and larger vehicles. The most recent estimates of the effect are about a 4% mpg change for each 10 degrees farenheit of temperature change (Claffey, 1981). Scheduling long trips for warmer times of the year, and scheduling winter trips during the day rather than the evening, will improve fuel economy.
>
> Road Surface--Fuel losses on wet and snow covered pavement can result in mpg losses up to 30% (Claffey, 1971). Reducing travel on slippery surfaces reduces fuel consumption as well as the likelihood of an accident.
>
> Traffic Density--On any given road, mpg drops with increased traffic density. Losses can range up to 5% for density alone (Claffey, 1971). By scheduling traffic at times of lowest density, drivers can save fuel as well as time and aggravation.

While the collective benefits of the suggested use patterns will save fuel, it is difficult to believe that many drivers will be in a position to implement them. Not many drivers have the flexibility to schedule their trips according to the dictates of fuel economy. Those drivers who do alter their use in the manner indicated are more likely to do so for other reasons, e.g., saving time.

Selecting Route

The route that a driver chooses to reach a destination can have a significant effect upon fuel consumption. The most route influential factors are the following:

> Road Surface--The nature and condition of the road surface can affect traction, rolling friction, and vehicle suspension in a way that degrades vehicle performance and fuel economy. MPG losses

vary from 2-5% for broken and cracked pavement to as much as 50% in heavy sand and gravel (EPA, 1980).

Road Speed--Roads that enable the vehicle to maintain its speed in a fuel-efficient range permit much greater fuel economy than those that involve stop and go traffic. MPG losses vary with attempted speed and number of stops but can range up to 50% (Claffey, 1977). As noted earlier, congestion is also a factor in vehicle speed and fuel economy.

Hills--The mpg that vehicles use going up hill is never quite made up going downhill. Fuel losses in traveling hilly terrain can range up to 40% (EPA, 1980) for very steep grades. Trips through hilly areas, while scenic, are fuel inefficient.

Curves--Friction in curves reduces vehicle mpg. The difference between the straight and curved road amounts to a difference of about 1% in mpg, vehicles with power steering losing slightly more than those with manual steering (EPA, 1980).

Work Vehicle Use

Use of the vehicle for work purposes rarely allows reduction in trips, short or otherwise, or variations in the time or route of travel. Since the actual travel is fixed, the only thing that can be changed is the mode of travel. Two alternative travel modes are ride sharing and use of public transportation.

Ride Sharing

Ride sharing--car pooling and van pooling--has been widely promoted for reasons other than energy savings, including reduced congestion, pollution, and need for parking. From the individual's perspective, it has the advantages of reducing vehicle costs, both travel costs and vehicle purchase costs, where another vehicle is needed for home use.

As an energy saver, ride sharing has the obvious advantage of being able to multiply passenger miles by the number of occupants in the vehicle. The relationship is not the direct multiple it has often been portrayed because of the following factors:

Circuitry--The pool vehicle must travel a circuitous route on both ends of a trip, picking up and dropping off passengers. This circuitry adds 15-20 percent to the average travel distance (unless passengers drive their own vehicles to a common pick-up point, which results in an even greater loss).

Vehicle Use--Where the purpose of a car pool is to allow the family vehicle to be used for other purposes, the vehicle freed may be engaged in trips it would not otherwise make.

Weight--The additional weight of the vehicle absorbs some of the additional MPG.

As a means of achieving fuel reductions, ride sharing is limited by such constraints as (1) limited access to pools, particularly van pools, (2) incompatible work hours, and (3) social barriers. While some studies have reported increases in ride sharing as high as 15% during crisis periods, efforts to promote ride sharing during normal times rarely attracts more than 2% of travel. In its review of ride sharing, a Congressional report (1977) concluded that efforts to promote ride sharing "produced modest gains at best."

Public Transportation

Public transportation in the form of bus and rail transit have the ability to extend the passenger mile per gallon well beyond automobiles, car pools, or van pools. Increased use of existing public transportation facilities is clearly an energy saver. During the energy crisis of 1979, public transportation ridership increased up to as much as one-third. (Hartgen, et al., 1979) However, as the crisis subsided, travel dropped off again.

As a means of reducing energy consumption, public transportation is limited by two factors:

Limited Access--The number of people having access to existing public transportation facilities is limited. Depending upon the area, increases of 25-33 % probably represent the maximum increases in ridership available through expanded use of existing facilities.

Construction Costs--Increased access to public transportation is only obtainable through an increase in the transportation network itself. Because of the costs of the energy required to lead to expansion in the public transportation network, and the limited additional ridership it would produce, gains in fuel efficiency through construction of additional facilities are likely to be marginal. In the case of some transportation forms (e.g., rail), expansion may actually be counterproductive (Congress, 1977).

VEHICLE OPERATION

A great deal of attention has been focused upon improving the way in which a vehicle is operated in order to improve fuel economy. While the fuel economy that can be secured from improved operating practices is relatively small, in comparison with that attainable from proper vehicle selection and use, it is an inviting target for behavior change because of the little that the driver has to give up in order to obtain it. It doesn't require any sacrifice of travel objectives, or of time and comfort in attaining those objectives. The practices that are capable of leading to improved fuel economy include (1) maintaining efficient cruise speed,

(2) optimum acceleration, (3) minimizing unproductive fuel use, and (4) maintaining momentum.

Cruise Speed

Two elements of cruise speed have fuel efficiency implications: rate and variability.

Rate

Up to about 35 mph, increases in cruise speed are accompanied by increases in mpg, owing primarily to the favorable transmission gear ratios they bring. However, beyond this point, mpg begins to drop due to sharp increases in aerodynamic drag. A volume of research shows that the optimum cruise speed ranges between about 35 mph for smaller vehicles and 40 mph for larger vehicles (EPA, 1980). Beyond this speed range, mpg begins to fall off quite sharply for smaller vehicles, less so for larger vehicles. At 70 mph, most vehicles are getting only 60-70% of the miles per gallon they obtain at 40 mph.

Obviously, few drivers are willing to abide 40 mph cruise speed on a limited access highway capable of safely accommodating much higher speeds. Most automobile travel is done to go from one place to another, and few drivers are willing to spend any more time than is absolutely necessary completing the trip.

The national maximum speed limit of 55 mph represents what the National Congress has been willing to accept as a reasonable compromise between individual goals of minimum travel time and national goals of minimum fuel consumption and accident risk. Surveys of attitudes have repeatedly shown that the majority of drivers support the 55 mph speed limit. Surveys of prevailing speed in areas with current enforcement of the limit show that the majority of drivers are in compliance.

The testing of driver knowledge described in Chapter 4, as well as that described in Volume II of this report, show that the drivers are generally familiar with the most fuel-efficient fuel ranges. However, they don't seem to be aware of the magnitude of fuel economy loss at higher speeds, nor the disproportionate penalty paid by smaller vehicles. In addition, some owners of compacts and subcompacts feel that the large gain in fuel economy realized in their choice of a vehicle justifies small losses through inefficient operation.

Variability

For any cruise speed, it is more fuel efficient to maintain a constant speed than to allow speed to vary. First, each time speed drops, it is necessary to accelerate to return to cruise speed, and it takes more fuel to accelerate than to maintain speed. Secondly, when speed varies, some of the travel is performed at a higher rate of speed than would be the case if speed were constant. For example, a driver who varies between 50 and 60 mph, may average 55 mph. However, because the relationship of speed to aerodynamic drag is nonlinear, the increases in drag experienced at 65 mph are not offset by the decrease experienced at 50 mph. The net aerodynamic drag varying between 55 and 65 mph is therefore higher than that experienced in cruising at a constant 55 mph. A study cited by Weiers (1980) estimates the fuel loss when varying over 10 mph range between 1 and 1.5 mpg.

Acceleration

The relationship between vehicle acceleration and mpg is one of the more controversial aspects of vehicle operation. An early study by Binz and Banowetz (1973) found mpg losses of from 23% to 25% in increasing rate of acceleration from "easy" to "hard." Hull & Williams (1981), testing vehicles by means of a dynamometer, found improvements of up to 10% in mpg from very rapid to very slow accelerations. The range of mpg was greatest for large vehicles, although they appeared to suffer the least by hard accelerations. Donoho (1978) found little relationship between acceleration and mpg for large vehicles, but substantial losses for hard acceleration by small vehicles. Studies by Claffey (1977) and Evans (1978), as well as studies described in Volume II of this report, show both gains and losses from rapid acceleration, depending upon driving strategy and size of vehicle.

The relationship between acceleration and mpg differs between manual and automatic transmissions. In the case of a manual shift, the relationship is probably too dependent upon shifting strategy to be easily analyzed. The most fuel-efficient strategy is one in which the vehicle is upshifted at the lowest rpm possible without placing strain upon the engine. Accelerations between shifts are probably most efficient in the "easy" (e.g., .1g) range.

In vehicles with an automatic shift, the fuel penalty paid by rapid accelerations is somewhat offset by the fact that rapid accelerations get the vehicle more quickly into higher, more fuel-efficient gear ranges. The evidence seems to indicate that smaller vehicles are most fuel efficient at low rates of acceleration--in the .1g range. Some larger vehicles appear to reach their optimum at a somewhat more moderate acceleration (.2g), although the penalty for a slower acceleration is not substantial. A hard acceleration (.3g) appears to be detrimental for any vehicle.

In practical terms, what research appears to show is that drivers can avoid a fuel penalty by avoiding hard, "jackrabbit" starts. Whether they realize any benefit from a very gentle acceleration is questionable, particularly if they are driving a heavy vehicle. The small variation in mpg obtainable from a true optimum acceleration, coupled with the small portion of the driving cycle that accelerations account for, suggests that outside of discouraging very rapid accelerations, this is not a particularly fruitful area for encouraging behavioral change.

Minimizing Unproductive Fuel Use

The use of fuel is unproductive when it is not moving the vehicle. Three forms of unproductive fuel use are:

Pumping--Pumping fuel into the carburetor by means of the accelerator when the engine is not running.

Idling--Allowing the engine to run at idle speed while the vehicle is not moving.

Revving--Causing the engine to race above idle speed while the vehicle is not moving.

Two of these, pumping and revving, are so clearly a waste of fuel as to make the collection of data unnecessary. Most automobile engines are designed to start without fuel being pumped into the carburetor. The excess fuel is simply wasted. Revving the engine does not cause it to warm up appreciably faster than idling, and the extra fuel is also wasted.

Idling at least serves some purpose. It allows a cold engine to warm up before it is subject to the strain of moving the vehicle. It also allows the engine to keep running while the vehicle is stopped for short periods, making it unnecessary to restart the engine. The value of both forms of idling has been studied in relation to the amount of fuel consumed.

Cold Engine

Some vintage vehicles, and newer vehicles in poor operating condition, are not driveable until the engine warms somewhat. However, for late-model cars, very little warmup is necessary. In warm weather, 10-15 seconds is sufficient. Even at temperatures as low 0°, automobile manufacturers recommend a warmup of only 15-30 seconds before putting the vehicle in motion. However, until the engine reaches its normal operating temperature and lubricants are flowing smoothly, low accelerations and moderate speed are recommended in order to avoid engine wear (Ontario, 1982).

Short Stops

It is estimated that 10 seconds of idling while the vehicle is stopped consumes more fuel than is required to restart the engine and to replace the electrical energy used by the starter (Ontario, 1982). This means that for stops of 10 seconds or more it is more fuel efficient to turn the engine off than to leave it running. The idea that this will cause excessive starter wear is not supported by automobile manufacturers.

There is, of course, always some danger that an engine that is stopped will not restart. For this reason, in heavy bumper-to-bumper traffic, drivers might be excused for not turning off their engines for stops of short duration. However, for very long stops caused by long traffic light cycles or extremely heavy traffic, the very small danger of being disabled and tying up traffic seems worth taking in view of the fuel that can be saved.

Driver Awareness

Drivers are, of course, aware that an idling engine consumes gas. However, results from written tests indicate that few recognize the extent of fuel loss--that every minute of idling consumes enough fuel to drive the average vehicle about 1/6th of a mile. While no data on the amount of cold-start and short-stop idling that actually occurs could be found, casual observation indicates that many drivers warm their engines up for long periods on cold days and very few drivers turn their engines off for stops over 10 seconds. The extent of fuel-inefficient behavior in this area, coupled with the lack of any real obstacles to behavior change, makes it a fruitful one for efforts at improvement.

Maintaining Momentum

It takes more fuel to generate momentum than it does to maintain it. Once momentum is obtained, it is therefore fuel efficient to keep it than to lose it and have to build it up again. There are two principal ways in which the momentum of an automobile is lost: use of the brake and operating uphill.

Use of the Brake

Every time the brake is applied, the energy required to build up momentum is dissipated through the brake linings in the form of heat. There are, of course, many occasions in which the brakes must be applied. However, many applications of the brake are unnecessary. Some of the more common examples are:

- o Stopping because of some path obstruction (e.g., construction zone, stalled traffic) when a simple lane change would allow the vehicle to keep moving.
- o Using fuel to maintain speed or accelerate toward an obstruction that will force the vehicle to stop anyway (e.g., traffic light, stop sign).
- o Using fuel to maintain speed or accelerate toward an obstruction that may disappear (e.g., a red light that is about to turn green, stalled traffic that is about to move again).
- o Braking in response to a reduction in the speed of the vehicle ahead, when a greater following distance would have allowed the speed change to be absorbed through coasting.

None of the behavior changes required to conserve fuel involve any sacrifice in travel needs. The first three simply require attending to conditions far enough ahead to anticipate the need to change position or speed. The fourth simply requires ample following distance.

No data bearing specifically upon unnecessary braking have been reported. However, Evans (1978) reported that a group of drivers responding to a direction to "minimize fuel consumption" by minimizing stops obtained a 16% improvement in mpg as well as a 3% improvement in average mph over drivers instructed to "drive normally." In dynamometer tests, Hull and Williams (1981) obtained 8-14% improvements in fuel economy in travel regimes in which stops were replaced by slow speed operation.

Hills

The most fuel-efficient way to climb a hill is to make maximum use of the vehicle's momentum. It is far more fuel efficient to allow momentum to carry the vehicle to the crest of the hill than to accelerate on the hill. Not accelerating will, of course, allow speed to drop, a factor that increases trip time and can be hazardous to overtaking vehicles under certain circumstances. However, the more that momentum can be safely used, more efficiently will the hill be climbed. Where the vehicle's momentum at any speed will not be sufficient to allow the grade to be climbed, a gradual increase in speed to build up momentum before reaching the hill is more fuel efficient than having to accelerate on the hill.

The amount of fuel that can be saved through effective use of momentum in climbing hills is impossible to state in general terms, since it depends not only upon the many specific characteristics of the hills themselves but upon the frequency with which they are encountered and the hill-climbing technique drivers currently employ. However, the simple advice to drivers to attempt to maintain a fixed accelerator position and allowing speed to fall off (where traffic conditions permit) rather than attempting to maintain a fixed speed is certainly warranted.

Total Vehicle Operation

Estimates of the fuel savings possible from changes in general vehicle operation behavior can be obtained from studies in which drivers were taught a broad array of operating techniques and the effect upon their fuel consumption was assessed. A survey of such studies performed by Hinton, et al, (1976) showed gains of between 10 and 20% in total fuel economy. In the study cited, the measure of effect was administered immediately after training and evidenced the immediate effect of the instructions rather than long-term benefits of training.[1]

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1 One study carried out by the Department of Energy (1978) purported to show a long-term effect of driver training upon mpg. However, when pre-training differences are controlled for, the effects disappear.

CHAPTER 3

BEHAVIORAL INFLUENCES

A number of efforts have been mounted to induce drivers to adopt various of the fuel-efficient behaviors described in the preceding chapter. These efforts may be categorized in terms of the behavioral influences through which change may result. These influences include:

- o Information
- o Incentives
- o Feedback
- o Appeals and prompts

The effects of these influences have been extensively reviewed by Shippee (1978) and by Stern and Gardner (1979). The most pertinent citations from these reviews, together with some additional references, are summarized in the following paragraphs.

INFORMATION

Communicating information about behaviors in each of the four categories of behavior described in the preceding chapter is fundamental to any attempt to influence the behavior of individual drivers. The information to be used in seeking more fuel-efficient driving behavior can be divided into two categories:

> Enabling Information--This category consists of information intended to enable drivers to behave more fuel efficiently. It includes information of the following types:
>
> > Procedural--Information concerning procedures for fuel-efficient operation, e.g., acceleration procedures, tune-up procedures.
> >
> > Technical--Information about the technical characteristics of vehicles and other influencing factors that help drivers select fuel-efficient courses of action, e.g., mpg ratings, optimum tire pressure, visual indicators of fouled spark-plugs.
> >
> > Conceptual--Information about the relationships between variables influencing fuel efficiency, such as the effect upon mpg of such factors as trip length, rolling resistance, air conditioner operation.
>
> Motivational Information--Information that helps to motivate drivers to operate fuel efficiently. The most fundamental type of motor vehicle information is that which enables drivers to see the fuel efficiency implications of various behaviors. These categories of motivational information parallel those of enabling information, including:

Procedural--Procedures for determining fuel efficiency implications, e.g., life cycle costing procedures.

Technical--Technical information showing the effect of various behaviors upon fuel efficiency, e.g., percentage fuel loss at speeds over 55 mph.

Conceptual--Fuel efficiency relationships showing the effect of fuel-efficient behaviors, e.g., cold start fuel penalty.

It is apparent that the same information can play both an enabling and motivating role. The effect of enabling information on short-term changes in driving behavior can be seen in the studies of improved vehicle operation described in the previous chapter, all of which depended on information to develop requisite abilities. As mentioned at that time, the duration of the behavioral changes is unknown. In the absence of some confirmation indicating the benefits of the fuel-efficient behavior to the drivers, gains would not be expected to endure very long.

In studying energy conservation outside of driving, the informational programs that have provided both enabling and motivational information have a significant effect upon consumption behavior (Geller, Ferguson, and Brasted, 1978). However, a program that presented only enabling information failed to improve conservation of electricity by apartment dwellers (Shippee, 1978). Even the studies that did have a favorable effect took place at a time when rising fuel prices created a strong incentive to conserve. On the basis of their review, Stern and Gardner (1979) conclude that information on how to save fuel "is effective only as part of a larger conservation program."

INCENTIVES

Incentives may be of two types--extrinsic rewards supplied by a program or those occurring intrinsically without program intervention.

Extrinsic Incentives

A variety of extrinsic incentives have been shown to be effective energy conservation motivators including:

- Monetary Reward
- Competition
- Recognition
- Goals

Monetary Reward

The most effective incentive appears to be--not surprisingly--monetary reward. Contingent monetary rewards, usually combined with feedback, have been shown to be successfull in a number of studies (Winett and Nietzel, 1975; Kohlenberg, Phillips, and Proctor, 1976; Hayes and Cone, 1977; Winett, Kaiser, and Haberkorn, 1977; Winett, Kagel, Battalio, and Winkler, 1978; Stern and Gardner, 1979; Reichel and Gelel, 1979). Such reward programs have reduced electricity consumption dramatically (e.g. 30% in the Winett, Kaiser, and Haberkorn study).

The Hayes and Cone study revealed two important considerations in relation to reward/feedback programs:

1. When rewards are great monetarily, the addition of feedback has little effect--i.e., people will conserve solely for the money providing the reward is great.

2. The average reduction in energy usage decreases monotonically with reductions in payment.

The latter finding is important because it appears that monetary incentives are efficacious only so long as people perceive the reward as providing a good return on their investment of conservation effort. Studies by Slavin and Wodarski (1977) and McClelland and Cook (1978) found that monetary incentives--in the form of rebates for conservation in the former study and prize money to conservation contest winners in the latter--were effective initially. However, the effects dissipated shortly thereafter when subjects found the money to be either too little (e.g., $1.95 rebate for a month's worth of conservation) or too late (e.g., the prize money was not distributed at the end of a two-week contest period but, rather, once all seven two-week contests had been completed).

Competition

Competition has been shown to be an effective conservation motivator. A competition for a monetary reward (Newson and Makranczy, 1977) produced 10-15% reductions in electricity use among contest winners and a 5% reduction in use among the losers (who entered the second competition with a somewhat defeatist attitude). This contest apparently succeeded because the reward was high ($100 to the winner of the month long contests) and was distributed immediately at the end of each contest.

Competition apparently can be effective even when an extrinsic reward, such as money, is absent. Winett, Kaiser, and Haberkorn (1977) attained an unusually large (20%) reduction in consumption by including feedback data on a "control group's" consumption rate. Winett, et al., suggest that this information element produced a competitive "mindset" that spurred subjects on to greater efforts of conservation.

Recognition

Another, apparently successful low-cost incentive would appear to be recognition of effort. Seaver and Patterson (1976) gave subjects who reduced their consumption below year-earlier levels a decal proclaiming "We are saving oil." Paired with feedback, this contingent reward produced a 17% cut in oil consumption. One explanation for its effectiveness may be that, once the existence of this previously unannounced contingent reward became known (through word-of-mouth communications among subjects), people were motivated to increase their conservation efforts with the more personally palatable justification that their behavior satisfied intrinsic motivations (e.g., doing their part for a national goal) as opposed to a "crass" commercial motivation (e.g., conserving only for the money).

Goals

Another means of enhancing motivtion to conserve appears to be providing people with a demanding conservation goal. Becker (in press) found that posing a difficult conservation goal (20% cut in electricity consumption) increased the effectiveness of feedback information more than posing an easy (2% reduction) goal. McClelland and Belsten combined the goal-setting approach with a monetary incentive (a 16% reduction in energy use would bring a $335 reward for dormitory residents; an 11% cut would yield $215; and a 6% drop would bring an $85 reward). Though the results of this study were confounded by prior treatments, energy consumption dropped by as much as 25% in this study.

Intrinsic Incentives

Intrinsic incentives are those outcomes of the behavior being sought that provide their own reward. The role of intrinsic incentives cannot be subject to the same scientific inquiry as extrinsic incentives since they are not subject to systematic manipulation. They can, however, be discussed. The primary incentives intrinsic to energy saving behavior are:

- Monetary savings
- Time savings
- Convenience
- Safety
- Public benefit

While certainly there are other incentives that may relate to particular behaviors or used for particular audiences, the categories listed probably are the most useful for NEEDS because they have broad relevance.

Monetary Savings

The chance to save money is a strong incentive for most people, and communications that emphasize the potential monetary savings of fuel- efficient behavior are likely to become increasingly effective as the sharp rise in fuel prices continues. By far the most significant cost of operating an automobile is the cost of gasoline, and a reduction in the amount of money spent on gasoline is certainly one of the primary rewards of fuel-efficient behavior.

Fuel-efficient behaviors, however, can reduce not only the amount of money drivers spend on gas, but other attendant costs of operation as well. For example, vehicle wear is reduced by fuel-efficient operation, maintenance, and use. Overall transportation costs may be reduced by the use of public transportation or ridesharing. The possibility of reducing or even eliminating costs other than fuel costs (e.g., tolls, parking, repairs) deserves special emphasis because those costs are often less obvious to drivers than the cost of gasoline.

Not all fuel-efficient behaviors will be cost-beneficial for all drivers. Using public transportation is a case in point; it may be less costly for some people and more costly for others. There will be some people who simply do not have access to public transportation. When a given behavior can produce monetary savings for some drivers but not for others, communications can either (1) supply information that allows a driver to make a decision in his own individual case or (2) ignore the issue of monetary savings altogether, relying instead upon other incentives to motivate fuel-efficient behavior.

Time Savings

The opportunity to save travel time may provide an effective incentive for some drivers. Even where drivers who place a high value on time are already doing what they can to save it, program communications may be able to suggest areas for time savings of which those drivers are unaware.

The time savings incentive will not be uniformly applicable to all categories of fuel-efficient behavior. Most behaviors will produce at least indirect time savings. Behaviors that save gas and reduce vehicle wear will mean less time spent on trips to the gas station and less time lost while the car is in the shop. More direct savings can result from behaviors in the category of vehicle use--combining and chaining trips certainly saves time. Other behaviors may not save time but may allow for better use of time. For example, using public transportation or ridesharing could actually make the trip a little longer but, in that case, communications could emphasize the opportunity to use time more enjoyably by reading or in conversation.

In the area of vehicle operation, fuel-efficient behaviors will not reduce the amount of time it takes to get from point A to point B. Behaviors such as driving at moderate and steady speeds cannot be offered as ways of saving time. Nevertheless, communications can make use of the issue of time by providing information to negate the common false belief that aggressive driving and speeding will save time.

Convenience

A related but independent incentive is travel convenience. Drivers may be motivated by the ease of being driven to work by someone else, or the convenience of a planned shopping trip which eliminates duplication of driving effort.

Again, communication can negate beliefs about the inconvenience of fuel-efficient behaviors. For example, the belief that comfort must be sacrificed in buying a smaller, more economical car may be countered by communicating the relative ease of handling, parking, etc.

Safety

Many fuel-efficient operating techniques are also safe-operating techniques. Fuel-efficient vehicle use reduces traffic thus reducing accidents, and a well-maintained vehicle is more likely to be a safe vehicle. Program communications may thus include safety as an additional reason to adopt fuel-efficient behavior. Again, erroneous beliefs that small, fuel economical cars are necessarily unsafe can be rebutted.

Public Benefit

While the incentives discussed so far apply primarily to the rewarding consequences of fuel-efficient behavior at the personal or family level, benefits at a larger, public level may also motivate individuals' behavior. At a national level, the benefit to the U.S. of fuel conservation may be emphasized--the avoidance of dependence on foreign oil, the avoidance of the need for more restrictive controls on energy consumption (e.g., rationing), etc. At local levels, the negative consequences of automobile travel on air quality, accidents, congestion, etc., may be used to motivate efficient vehicle use behaviors. As mentioned before, such incentives may be particularly effective in tipping the balance of a cost-benefit decision towards fuel-efficient behavior.

Although public benefit may not be an effective incentive when it conflicts with personal benefit, when the two coincide, motivation should be additive. Further, public benefit has the advantage of allowing larger (and perhaps more impressive) figures to represent costs and potential savings.

FEEDBACK

Incentives and appeals provide reasons for individuals to behave fuel efficiently. Information feedback does not communicate additional reasons, but may serve to quantify, reinforce, or make salient the reasons which already exist. Feedback may provide information either about the fuel efficiency of one's behavior, the consequences thereof, or both. It may be provided either immediately or delayed, by either mechanical (electronic) or nonmechanical means.

Feedback Methods

There are two basic methods of providing feedback to drivers on the fuel efficiency of their vehicle operation: immediate and delayed.

Immediate Feedback

Mechanical devices for providing immediate feedback to drivers as they are driving were described in Chapter 2 under "Driving Aids." The two primary types of devices are fuel metering devices and vacuum gauges. Both devices provide instantaneous feedback on vehicle operation, to allow the efficiency of operating techniques being employed at the time to be evaluated. Fuel metering devices also accumulate fuel efficiency information over time to provide feedback on vehicle use and maintenance.

Delayed Feedback

Various research studies have employed manually-kept records of mileage and fuel consumption similar to manual "audits" of energy use in other applications (e.g., home energy audits). Manual systems necessarily impose a delay in obtaining feedback. The biggest shortcoming of manual feedback is the difficulty in getting people to collect the necessary information. In research studies, it has generally been necessary to provide some extrinsic reward to assure that the necessary information is collected (Shippeé, 1979). While such incentives may be acceptable for collection of research data, they are not practical as an element of a feedback system intended to support voluntary fuel conservation.

Effectiveness of Feedback

Evidence as to the effectiveness of immediate feedback devices was summarized in Chapter 2. The value of delayed feedback in vehicle fuel efficiency has not been adequately assessed, due to the problems just noted. Providing feedback on energy consumption has been shown to be an effective means of reducing home energy use. Typically, information fed back to consumers includes:

- the amount of energy (e.g., electricity) consumed per day, expressed in terms of dollars and cents.
- the amount of energy consumed to that point in the week.
- the amount of energy that would be consumed over an entire week if the last day's rate of consumption held steady.
- the percentage above (or below) baseline levels represented by the last day's consumption rate.

However, Palmer, Lloyd, and Lloyd (1978) found that feedback was effective <u>only</u> when cost information, relating consumption rates to monetary savings, was included.

Another element crucial to feedback effectiveness is when it is given to subjects. In general, it appears that feedback leads to improved conservation behavior only when it is provided contiguously with performance (Ammons, 1956; McCormick, 1976). <u>Ad hoc</u> feedback provided mechanically (e.g., through lights which flash automatically when an appliance is being used inefficiently or when consumption is approaching peak usage levels) has been shown to be effective (e.g., Kohlenberg, Phillips, and Proctor, 1976; Becker and Seligman, 1978).

Daily feedback induced reductions of home electricity consumption by 18% in one study (Hayes and Cone, 1977) and by 20% in another (Winett, Kaiser, and Haberkorn, 1977). The less frequently feedback has been provided, the less impressive have been the results. Feedback provided but four times a week produced only a 10.5% reduction in electricity use (Seligman and Darley, 1977). Becker and Seligman (1978) found feedback given only about every 2.5 days produced no effect at all. Weekly feedback schedules (Kohlenberg, Barach, Martin, and Anschell, 1978; Winett, Kagel, Battalio, and Winkler, 1978) and monthly feedback schedules (Seaver and Patterson, 1976; Riegel and Salomon, 1974) failed to produce significant conservation as well.

One attractive aspect of using feedback as a conservation motivator is that it need not be continued ad infinitum. Winett, Neale, Williams, Yokely, and Kauder (1978) found that feedback administered daily can be gradually withdrawn without loss of effectiveness.

APPEALS AND PROMPTS

Appeals and prompts are both non-informational exhortations to act. They differ with respect to their specificity. An appeal is a general exhortation to engage in a particular category of behavior in general. Well-known examples in the area of energy conservation are "55-a law we can live with," displayed on a bumper, or "55 saves gas" appearing on a billboard. A prompt, on the other hand, is a message intended to stimulate a particular activity at the time the prompt appears.

Prompts are similar to (and sometimes overlap with) feedback devices in that they reinforce already existing driver motivation. Examples of prompts are a small sign next to a light switch saying "turn me out before you go," or symbolic prompts such as an added notch over speedometer reading of 55 mph.

Prompts for energy conservation appear to be somewhat more effective than general appeals. A general exhortation to conserve energy, was included with an information kit distributed by Heberlein (1975) and appeared to have had no effect. Winett (1978) also found a general appeal to be ineffective, whereas a specific prompt induced 60% more compliance with a request to douse the lights.

While personal, highly specific prompts do appear to increase the incidence of conservation behaviors, it must be noted that their effectiveness is limited. Tuso and Geller (1976) found that only 15-30% of their subjects responded to prompts in the desired fashion.

CHAPTER 4

TARGET AUDIENCES

It is expected that communicating information about fuel-efficient behaviors to members of the driving population will enable and encourage them to decrease their fuel consumption. The next step then is to identify those segments of the population to whicn such communication should be directed, and the behavioral areas which should be emphasized in communications with various target audiences.

This chapter provides estimates of the relative impact that information communicated to various segments of the driving population is likely to have upon total U.S. fuel consumption. Estimates are based upon two sources of data.

- o Data regarding the size, amount of travel, purchasing power and trip characteristics for each potential audience.
- o Results from information deficiency testing which indicate the potential for improving the awareness of drivers in each of the potential audiences.

Data Collection and Analyses

For purpose of data collection and analysis, the driving population was divided into the following six target groups believed to be relatively homogeneous with respect to transportation characteristics.

1. Secondary Student
2. Post-Secondary Students
3. White Collar Workers
4. Blue Collar Workers
5. Home Managers
6. Retired Persons

Table 1 presents information relevant to the populations' estimated impact on U.S. fuel consumption, based primarily on 1970 figures. Though more recent data are available for some of the populations in the table, they could not be inserted without upsetting comparison between groups.

TABLE 1

CHARACTERISTICS OF TARGET AUDIENCES

TARGET AUDIENCE	PERCENT OF TOTAL POP.	PERCENT OF VEHICLE MARKET	PERCENT LICENSED	AVERAGE MILEAGE
Secondary Students	8%	3.0%	86%	4,633
Post-Secondary Students	7%	12.0%	94%	8,260
Professionals	8%	14.1%	84%	9,891
Managers	6%	7.4%	87%	7,779
Sales & Clerical	13%	15.9%	75%	6,939
Crafts	7%	11.4%	91%	8,128
Operators	12%	15.2%	84%	5,973
Service Workers	8%	6.3%	74%	4,454
Farmers	1%	1.7%	87%	10,149
Home Managers	20%	*	85%	5,733
Retired	5%	8.8%	64%	6,195
Segment Average	8.3%	8.3%	83%	7,825

* Data unavailable.
All figures based on 1975 census estimates and 1970 mileage data.

Table 2 presents the results of information deficiency testing given to a total of 1,182 drivers from eight target groups in 1978. Drivers were tested on their knowledge of fuel-efficient behaviors in the four areas discussed in Chapter 2. Knowledge deficiencies may indicate areas which deserve emphasis in program communication.

Secondary Students

Characteristics

Secondary students were isolated as a major target audience both because of their unique driving characteristics and their special accessibility through high school driver education (as well as other) programs.

Secondary students' mobility is limited, as is indicated in Table 2 by comparing their average of 4,633 miles driven per year with the combined population average of 7,825--about 40% lower. Their vehicle purchasing power is also limited--Table 1 shows they account for only 3% of new vehicles sold.

TABLE 2

INFORMATION TEST RESULTS

The Table Shows the Percent of
Test Items Answered Correctly Within
Each Content Area for Samples of
Each Target Audience

TARGET AUDIENCES	SAMPLE SIZE			CONTENT AREA: VEHICLE USE			VEHICLE SELECTION			VEHICLE OPERATION			VEHICLE MAINTENANCE			TOTAL WEIGHTED SCORE		
	M	F	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.
Secondary Students	113	38	151	39	38	39	47	42	46	39	37	38	43	39	42	42	39	41
Post-Secondary Students	158	68	226	49	45	48	60	48	57	48	46	48	68	51	63	57	48	52
Professionals	143	39	182	61	51	59	72	60	69	63	54	61	75	64	73	68	58	66
Managers	114	18	132	60	55	59	68	61	67	61	60	61	76	68	75	67	61	66
Clericals	11	107	118	60	47	48	56	52	52	57	47	48	64	58	59	58	51	52
Crafts	65	--	65	56	--	56	64	--	64	55	--	55	75	--	75	63	--	63
Home Managers	--	57	57	--	44	44	--	53	53	--	44	44	--	53	53	--	49	49
Retired	12	39	51	48	47	47	64	53	56	59	43	47	68	55	58	61	50	53

When they do drive, social and recreational trips account for more miles than any other trip purpose. This is shown by Table 3, which gives the distribution of trip frequency and miles traveled by trip purpose for drivers aged 16-20. Although not all of these drivers are students, the high percentage of students in this age bracket (78%) should support the applicability of these data in a student population.

TABLE 3

TRIP PURPOSE INFORMATION FOR 16-20 YEAR OLD LICENSEES

TRIP PURPOSE	PERCENT OF AUTOMOBILE TRIPS	PERCENT OF VEHICLE MILES OF TRAVEL	AVERAGE TRIP LENGTH MILES
Earning a Living	27.3	27.6	7.6
Family Business	22.9	16.6	5.4
Civic, Educational and Religious	17.6	16.6	6.7
Social & Recreational	31.0	38.4	9.3
Other	1.2	1.4	9.1
TOTAL	100.0	100.0	7.5

Source: Nationwide Personal Transportation Study, Report No. 10, U.S. Department of Transportation/Federal Highway Administration, May 1974.

Information Deficiencies

Information testing revealed that secondary students ranked the lowest among all population segments, probably reflecting their inexperience in driving. Their overall correct response rate was only 41% compared to the population average of 56%. Their knowledge of vehicle use, operation and maintenance was commensurate with their total performance. Surprisingly, their highest score among the four content areas was in vehicle selection (46%), although still low compared with the population average of 59%.

Program Implications

Secondary students as a group drive fewer miles per year than most other potential targets. They also purchase fewer cars. Thus their potential for contributing to an immediate reduction in fuel consumption may be less than for groups which contribute more to current consumption.

However, this target group does have unique characteristics which may be exploited. First, knowledge testing has shown that this group more than any other lacks information regarding fuel-efficient driving. Secondly, already in-place driver training programs have unequaled resources to provide extensive training in fuel-efficient operating techniques as well as other content areas. Building on a lack of rigidly set inefficient driving habits, communications to secondary students now may produce further impact in future years, when driving and buying power have increased.

Post-Secondary Students

Characteristics

This group was considered separately from secondary students. Although both groups may be accessed through education institutions, post-secondary students are no longer accessible through driver education programs. Also, the driving characteristics of post-secondary students are more similar to those of the adult driving population.

The post-secondary student population is one of the smaller target groups. It consists of individuals attending two or four year colleges and universities. Since data on driving characteristics are not available specifically for this group, data for 20-24 year olds were used. These data only partially match, and about 30% of college age youth do not attend college.

Although few in number, post-secondary students have the highest licensing rate (94%), and their annual average of 8,060 miles driven is above the overall average. This makes the group a good target for programs aiming at vehicle operation, use, and maintenance. As far as vehicle selection is concerned, although their yearly contribution to new-vehicle purchase of 12% is over the average value of 8.3%, nearly 70% of these purchases are already foreign or compact vehicles.

TABLE 4

TRIP PURPOSE INFORMATION
FOR 21-25 YEAR OLD LICENSEES

TRIP PURPOSE	PERCENT OF AUTOMOBILE TRIPS	PERCENT OF VEHICLE MILES OF TRAVEL	AVERAGE TRIP LENGTH (miles)
Earning a Living	37.9	36.0	10.0
Family Business	30.1	23.3	8.2
Civic, Educational and Religious	5.8	5.7	10.6
Social & Recreational	24.9	32.2	13.7
Other	1.3	2.8	23.9
TOTAL	100.0	100.0	10.6

Source: Nationwide Personal Transportation Study, Report No. 10, U.S. Department of Transportation/Federal Highway Administration, May 1974.

Table 4 shows that, like secondary students, post-secondary students also cover a significant proportion of the miles they travel on social and recreational trips. For this group, however, earning a living accounts for a slightly greater proportion.

Information Deficiencies

Table 4 shows that post-secondary students still scored low compared to other groups in their fuel-efficiency knowledge. Only for vehicle maintenance did their average score reach the overall population average. Perhaps this may still be due to driving inexperience, but more likely there are other reasons as well. Students in this age bracket may not yet have reached the stage where financial and family responsibilities require that they seek out ways in which to economize, or where such information is routinely communicated to them.

Program Implications

Members of this group will soon be entering occupational (target) groups characterized by high mileage. For this reason, efforts to improve their fuel economy may show relatively high impact in the long run.

With regard to vehicle selection, the high percentage of the group's current purchases are in the more economical vehicle classes. However, there is a lot of fuel economy variation even within classes, and their knowledge regarding vehicle selection was relatively poor.

White Collar Workers

Characteristics

Professionals, managers, sales and clerical workers are combined into a single target group on the basis of a common working environment. (Military and government workers cut across these categories.) This common environment gives rise to both common informational requirements and potential delivery sytems.

White collar workers are more numerous, drive more miles, and purchase more cars than any of the other target groups. Most remarkable are the proportion of the new vehicle market they account for (37.4%), and the amount of miles they drive--both figures about 50% higher than the second highest group--blue collar workers.

Not surprisingly, Table 5 shows that trips to work account for a majority of the miles traveled by white collar workers. All trip purposes show fairly consistent proportions between the constituent population segments.

Information Deficiencies

White collar workers were the most informed target group on fuel efficiency. Professionals and managers averaged 10 percentage points over the population average, and were consistently more informed in all four content areas. Only clericals scored slightly lower than the overall population average.

The data contained within the vehicle use category for professionals reveals an interesting finding. While their responses to the items on trip planning showed relatively little deficiency, their score for the subset on getting to work was only 41%.

Program Implications

Clearly, in terms of absolute impact on fuel consumption, the magnitude of this group's driving-related activity makes it a prime target for efforts to improve fuel economy.

The data indicate two areas which deserve particular emphasis--vehicle selection and use. The purchasing power of this group and the tendency for their relatively high incomes to permit the purchase of larger cars makes them a prime target for vehicle selection information. Although their knowledge in this area is already relatively high, the great potential

TABLE 5

TRIP PURPOSE INFORMATION FOR WHITE COLLAR WORKERS

TRIP PURPOSE	AUTO TRIPS %	MILES DRIVEN %	AVERAGE TRIP LENGTH (miles)
	PROFESSIONALS		
Earning a Living	47.1	48.3	10.1
Family Business	26.5	15.8	5.9
Civic, Education & Religious	7.2	3.8	5.3
Social & Recreational	17.9	31.0	17.3
Other	1.3	1.1	-
TOTAL	100.0	100.0	9.9
	MANAGERS		
Earning a Living	51.4	55.3	12.3
Family Business	25.7	15.1	6.8
Civic, Education & Religious	4.3	1.4	3.7
Social & Recreational	17.2	27.0	18.0
Other	1.4	1.2	-
TOTAL	100.0	100.0	11.4
	SALES & CLERICAL		
Earning A Living	48.9	58.2	10.3
Family Business	24.9	14.8	5.1
Civic, Education & Religious	7.0	4.0	4.9
Social & Recreational	17.9	21.3	10.4
Other	1.3	1.7	-
TOTAL	100.0	100.0	8.7

Source: Nationwide Personal Transportation Study, Report Nos. 10 and 11, U.S. Department of Transportation/Federal Highway Administration, Washington, D.C., December 1974.

impact of the vehicle purchase decision ensures that whatever improvement is possible will have significant effect.

The relative impact of information displayed by professionals regarding alternative means to get to work suggests another important area where still more remains to be done. This is particularly true in view of the large percentage of miles (and gas) which such trips consume. Information on the subset of behaviors in the vehicle use area dealing with alternative means to get to work is particularly appropriate for this group.

Blue Collar Workers

Characteristics

Craft workers and operators are treated together, again because of similarities in their work environment. As a target group, they are third in size, and are second only to white collar workers in miles traveled. Their share of vehicle purchase is commensurately large at 26.6%.

An interesting difference between the two blue collar groups is worth noting. Although operators are more numerous, Table 1 shows that they average only 5,973 miles per year, compared with the 8,128 miles averaged by craft workers. Thus, while operators still travel more total miles than do craft workers, the difference is not as large as would be expected from their greater number. The high rate of licensing for craft workers may contribute to this fact, but the different mileage averages cannot be so explained. Table 6 may suggest the source of this difference. It shows that, while craft workers drive 22% longer to get to work, they drive almost 1-1/2 times as far for social and recreational purposes as do operators.

Informational Deficiencies

Operators were not represented in the deficiency testing. Craft workers averaged the highest of all population segments other than the professionals and managers of the white collar target group. Their 63% correct response rate was 7% above the overall average. Not too surprisingly, they were most knowledgeable about vehicle maintenance. Although their Vehicle Use score was above average, again the subject of items on ride sharing produced a low correct response rate (38%).

Program Implications

Because of the magnitude of their driving, blue collar workers, too, provide a promising target for efforts toward fuel consumption. This group being less homogeneous than the others, cognizance must be taken of possible differences in requirements between operators and craft workers.

The longer work and social/recreational trips made by craft workers should be considered in efforts to promote improved vehicle use and selection. Vehicle selection and use must be tailored for different travel requirements. While the longer work trip might make craft workers a more

TABLE 6

TRIP PURPOSE INFORMATION FOR CRAFT WORKERS AND OPERATORS

TRIP PURPOSE	AUTO TRIPS %	MILES DRIVEN %	AVERAGE TRIP LENGTH (miles)
	CRAFT WORKERS		
Earning a Living	44.1	46.9	11.3
Family Business	28.6	14.0	5.1
Civic, Education & Religious	5.3	1.8	3.5
Social & Recreational	21.6	36.9	17.7
Other	0.4	0.3	-
TOTAL	100.0	99.9	10.4
	OPERATORS		
Earning a Living	44.2	47.0	9.0
Family Business	27.6	17.9	5.5
Civic, Education & Religious	6.2	3.3	4.6
Social & Recreational	21.2	30.9	12.2
Other	0.8	0.9	-
TOTAL	100.0	100.0	8.4

Source: Nationwide Personal Transportation Study, Report Nos. 10 and 11, U.S. Department of Transportation/Federal Highway Administration, Washington, D.C., December 1974.

attractive target for ride-sharing efforts, for instance, the greater variability in their work hours and location might make ride sharing less practical. Such considerations would have to be addressed to avoid misuse of limited program resources.

Home Managers

Characteristics

Home managers are a highly significant part of the driving population, partly because their sheer numbers--29 million--makes them by far the largest target group. Ninety-nine percent are women and average age is much older than other target groups--over one-fourth are 65 years or older.

Although the average annual mileage of home managers is unknown, a rough estimate of 5,733 miles per year was based on mileage data by age and sex. Although this figure is much lower than the population average of 7,825, when multiplied by the large number of licensed drivers, home managers still constitute the largest single population segment for total miles driven per year. While trip purpose data are not available, it can be assumed that the home managers make many short trips, as they typically take care of family business.

Vehicle purchase data specifically for home managers are not available either. However, women outside the labor force (including home managers, students, retired, unemployed) own 16% of all domestic vehicles and are the principal drivers of 23%. Thus, they may constitute an important influence on vehicle selection.

Information Deficiencies

Information testing revealed that home managers are about as poorly informed as students are regarding fuel efficiency, averaging seven points below the combined population average of 56%. Their correct response rate in the Vehicle Use and Vehicle Operation categories (44%) was the lowest of all four populations. However, within the Vehicle Use category, their correct response rate was better than other populations for items pertaining to non-work trip combination, (e.g., ridesharing).etc.

Program Implications

Over all, home managers show a clear deficiency in fuel efficiency information relative to the rest of the population. Unlike students, however (whose scores were similarly low), members of this group are not likely to gain in driving experience or be exposed to additional sources of information. Even more disconcerting, home managers drive more miles per year than all students combined, most travelled for purposes that involve fuel-inefficient short trips.

For these reasons, it is critical that home managers be targets for fuel efficiency efforts. Their worst deficiencies were evidenced in Vehicle Use and Vehicle Operation--areas which are so important given the short, stop-and-go nature of the trips they are likely to make. Home managers should be prime targets for information in these areas, if appropriate delivery systems can be utilized.

Retired Persons

Characteristics

Retired persons constitute the smallest of the potential target audiences, both in size and estimated miles driven (figures based on mileage data by age and sex). The low percentage of licensed drivers in this group (64%) and the low average miles driven per year (6,195) contribute to this outcome. While national trip purpose data are unavailable specifically for retired persons, the data for elderly drivers in Table 7 indicate that family business accounts for a larger share of trips as age increases.

TABLE 7

TRIP PURPOSE INFORMATION FOR ELDERLY DRIVERS

TRIP PURPOSE	AUTO TRIPS (PERCENT) Age		AVERAGE TRIP LENGTH (MILES) Age	
	61-70	71 & over	61-70	71 & over
Earning a living	35.1	11.9	8.6	8.6
Family business	36.1	53.9	6.0	5.7
Civic, educational and religious	7.5	5.5	3.4	5.7
Social and recreational	20.2	27.1	14.8	14.3
Other	1.1	.0	16.6	8.5
TOTAL	100.0	100.0	8.6	8.4

Source: Nationwide Personal Transportation Study, No. 10, U.S. Department of Transportation/Federal Highway Administration, May 1974.

A recently completed analysis of data collected from elderly drivers in four States shows that, even among the "retired," work-related travel accounts for as many trips as family business (McKnight, Simone, and Weidman, 1982).

Information Deficiencies

Not enough retired individuals participated in the knowledge testing to constitute an adequate test group. Test results in Table 4 are shown for individuals who were over 65, but not necessarily retired. The table shows that their average total score, and scores for all behavior categories were consistently 3-5 percentage points below the average scores for all groups.

Program Implications

This audience has the smallest impact on fuel consumption. Vehicle selection is to a great extent dictated by the needs of age while vehicle operation may be strongly ingrained and hard to change. However, it also may have the greatest flexibility in adapting behavior patterns to the needs of fuel efficiency. Moreoever, it is likely to be more cost-sensitive then other age groups. Therefore, it still represents a potentially attractive target for efforts to improve efficiency of Vehicle Use.

CHAPTER 5

PRESENTATIONAL MATERIALS

Previous chapters have presented the fuel-efficient behaviors, the factors necessary to both enable and motivate their adoption and the characteristics of audiences to which such information should be communicated. In this chapter, the materials appropriate for program communication are identified and discussed. These materials include:

Printed Materials

- Fact Sheets
- Pamphlets
- Text Books
- Instructor Guides

Audiovisual Materials

- Visuals
- Audio (Radio Spots)
- Slide/Tapes
- Films
- Videotapes

Display Materials

- Posters
- Billboards
- Models/Mock-ups
- In-car Feedback Devices

PRINTED MATERIALS

Printed messages generally have the advantage of being able to present complex information in detail, and of allowing the reader to review the material until it is fully understood. On the other hand, unlike audiovisual materials, for instance, printed materials must rely on the reader's motivation to actively pursue tne information to be conveyed. Thus, to ensure maximum effectiveness, printed materials must be made to appear "worth reading" unless targeted to an audience whose interest can be assumed (e.g., in instructional programs).

Short Print Pieces

While printed materials have the capacity for greater length and therefore depth, particular purposes and/or delivery systems may require that a shorter print piece be used. Such materials might range from single 8-1/2" x 11" printed "fact sheets" to brochures or pamphlets of several pages.

Characteristics

What distinguishes short print pieces from longer materials is that the information conveyed is limited in one to two ways:

> Breadth--Rather than dealing with all fuel-efficient behavior, or even a single area, the topic of a short print piece is best limited to a single behavior or set of closely related behaviors. One example might be a pamphlet limited to the "short-trip penalty" and what can be done about it (within the context of the broader "vehicle use" content area).
>
> Depth--Brevity also limits the depth in which any subject can be treated. This limits the use of short print pieces to "tips," "hints," and similar somewhat superficial treatment of topics. References to more penetrating treatment of subject matter should be provided for those who are interested.

In addition to their fulfilling a particular purpose, short print pieces have practical advantages as well. Their brevity makes them both relatively inexpensive to produce and distribute in mass (as hand-outs, bill-stuffers, media articles or "take one" displays) and also more likely to be read in their entirety than longer print pieces.

Available Materials

The following short print pieces dealing with fuel-efficient driving are available:

- The Drive For Conservation, Atlantic Richfield Company (ARCO), 515 South Flower Street, Los Angeles, California 90071 - Booklet.
- Ease On Down The Road, U. S. Department of Transportation - Booklet.
- Engine Cooling Systems For Fuel Economy, Ministry of Energy, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8 - Pamphlet.
- Gas Mileage Guide, United States Environmental Protection Agency - Booklet
- The Gasoline Mileage Book, Shell Oil, P. O. Box 61609, Houston, Texas 77208 - Pamphlet.
- Gas Watchers Guide, American Automobile Association, 8111 Gatehouse Road, Falls Church, Virginia 22041 - Pamphlet.
- To Help You Save Gas, Nebraska Energy Office, PO Box 95085, Lincoln, Nebraska 68509 - Pamphlet

- How Smart Drivers Save Gasoline, Mobile Oil Corp., 150 East 42nd Street, New York, NY 10017 - Pamphlet
- How to Conserve, Canadian Automboile Association, 150 Gloucester Street, Ottawa, Ontario K2POA6 - Pamphlet
- How to Save Gasoline and Money, U.S. Department of Energy - Pamphlet
- Management of Vital Energy, (M.O.V.E.), International Harverster, 401 N. Michigan Ave., Chicago, Illinois 60611 - Pamphlet)
- The More Miles For Your Money Book, Shell Oil, PO Box 61609, Houston, Texas 77208 - Pamphlet)
- Operation Bus and Truck Patrol (BAT Patrol), Maryland State Police and National Public Services Research Institute (U.S. Department of Energy)
- Records Talk, Maryland State Police - Pamphlet
- Routes to Fuel Economy, U.S. Department of Energy - Pamphlet
- Safe and Fuel Efficient Driver (S.A.F.E.) Maryland State Police and National Public Services Research Institute (U.S. Department of Energy) - Pamphlet
- Taking a Little Ride, U.S. Department of Energy - Booklet
- Truckers Guide to Fuel Savings, Voluntary Truck and Bus Program, U.S. Department of Transportation
- Why Conserve, Canadian Automobile Association, 150 Gloucester St., Ottawa, Ontario K2POA6 - Pamphlet
- 16 Steps to Conserve Energy on N.C. Highways, North Carolina Energy Division, PO Box 25249, Raleigh North Caolina 27611 - Pamphlet
- 17 Tricks to Save Fuel and Save $, Voluntary Truck and Bus Fuel Economy Program, U.S. Department of Transportation - Pamphlet

Textbooks

Textbooks, sourcebooks, and manuals are longer printed materials whose purpose is to teach the full array of fuel-efficient behavior in some depth. Their comprehensiveness assumes a motivated reader, in doing them most appropriate as an adjunct to instruction. Their content should convey all the fuel-efficient behaviors in all four content areas--Vehicle Selection, Maintenance, Use and Operation, as well as the concepts which underlie those behaviors (see Chapter 3 on informational requirements.

Since the use of textbooks often depends upon their integration into existing instructional programs, content must be easily adapted to different courses. To facilitate such adaptation, textbooks should provide comprehensive indexes and be organized into relatively small, self-contained units.

Two available texts are:

- How to Get More Miles Per Gallon, Raymond Sikorsky; St. Martin's Press, New York, NY, 1978.
- More Miles Per Gallon Guide; Second Edition, Ronald M. Weiers. Chilton Book Company, Radnor, PA., 1980.

Instructor Guides

Whenever fuel economy information is to be conveyed in an instructional setting, materials are necessary which can effectively guide instructors.

Characteristics of Instructor Guides

Instructor Guides may range from a simple "moderator's guide" to facilitate the presentation of a fuel economy film to a small local group, to a full set of lesson plans for a fuel-efficient driving course.

The wide variation in the extent to which instructors in various settings may be able or willing to address the fuel economy subject area, dictates that as much flexibility as possible be built into the instructional procedures and corresponding materials. Configuring subject matter into a set of self-contained "modules" will allow instructors or administrators to integrate instruction into appropriate slots in an already existing curriculum, or to omit some modules entirely. Those who wish to teach fuel efficiency as a separate and complete topic may still do so.

An example of modular content would be separate instructional units covering the classroom and behind-the-wheel phase of instruction in operating techniques. Such a structure would allow behind-the-wheel instruction in those programs with the resources needed to carry it out and classroom-only instruction for programs lacking such resources.

Available Instructor Guides

The following instructor guides are designed to teach voluntary energy conservation:

- Conserving Energy in Fleet Operations, New York State Energy Office, 1982.
- Driver Energy Conservation Awareness Training (DECAT), U.S. Department of Energy.

- Driver Energy Conservation Awareness Training For Trucks (DECAT-T), U.S. Department of Energy.

- Driver Training Guide, Michigan safety Administration, 1982.

- Energy Conservation Curriculum Guide, Ohio Department of Education, Driver Education Section.

- Energy Education Resource Guide for Driver Education, Richard Meyerhoff, Iowa Department of Public Instruction, 1981.

- Instructors Manual For Energy Efficient Driving, Doron Precision Systems, Inc., PO Box 400, Binghamton, NY 13902

Visual Materials

Transparencies and slides can be used to supplement oral presentations in informational or instructional programs as well as in television announcements. Capable of presenting both verbal and graphic content, visuals are most valuable in communicating information that benefits from being seen, such as:

- Outlines of subject matter, e.g., fuel efficiency instruction program.

- Lists of key information items, e.g., driving tips.

- Spatial relationships, e.g., trip consolidation maps.

- Theoretical relationships, e.g., the effect of aerodynamics upon air resistance.

Even when supporting visuals add neither information nor clarification, the imagery which they supply may aid in the retention of concepts whose verbal representations might otherwise be forgotten. The only visual aids discovered in the review of available materials are those that accompany certain of the instructor guides listed earlier.

Audio Materials (Radio Spots)

Audio presentations are associated with one specific mode of delivery--radio. Twenty, thirty, or sixty second radio "spots" have the unique advantage of being able to reach drivers through their radios while they are actually driving. All of the fuel-efficient operating techniques, as well as vehicle use behaviors (e.g., "Is this trip really necessary?") would be appropriate topics for radio spots targeted to drivers on the road. Because of their brevity, radar spots are more effective in reminding drivers than in introducing new information.

No generally available radio spots could be found in preparing this report.

Audiovisual Materials

Audiovisual materials include films, videotapes, and slide-tape presentations. They may be used on a stand-alone basis (e.g, group presentations, television public service announcements) or as a teaching aid in support of classroom instruction.

Audiovisual materials have two major advantages over printed materials:

> Interest--Colorful, vivid, and dynamic presentation of information generally evokes greater audience interest and attention and requires less effort to absorb than does printed material.
>
> Ease of Understanding--Those same qualities of vividness and dynamism may also aid in the illustration of concepts which are more difficult to understand when merely transmitted verbally.

Audiovisual materials may be used alone or in conjunction with printed materials to capture the advantage of both media. As a teaching aid they also have the advantage of providing a degree of uniformity of instruction. How beneficial this feature is depends upon the quality of the material.

Slide/Tape Presentations

Slide/tape shows represent a form of presentation midway between still graphics and motion picture film or videotape (discussed below). Where a self-contained audiovisual presentation is desired but motion is not required, a series of 35mm photographic slides or film strip may be accompanied by either a taped or live narration. The scope of presentation may range from a 20- to 30-second sequence suitable for a televised public service announcement to a much longer (e.g., 10-20 minute) sequence intended for instructional programs or group assemblies.

Advantages of Slide/Tape Presentations

The advantage of slide/tape shows over still graphics (or slides) alone is that once a consistent and effective presentation is developed, it can then be delivered by a wide variety of agents with differing amounts of expertise, but with relatively consistent results. When the depiction of motion is not essential, slide/tape progams can have advantages over motion picture film and videotape as well.

> Cost--Because they are less costly both to produce and exhibit, slide/tape shows are more easily developed by organizations with limited resources and more likely to be exhibited as well.

Tailoring--Both the narration and specific slides may be conveniently tailored to specific target audiences. In a presentation on trip planning, for instance, separate taped narrations can be targeted to adult or high school age drivers, and slides may be inserted which contain local shopping centers and highways for more personal impact.

Flexibility--A slide show may be conveniently interrupted by the instructor for elaboration at any point to ask questions or to employ an alternative instructional method. This makes it a much more flexible adjunct to classroom instruction.

Slide/tape presentations should be more appropriate for vehicle use, selection and maintenance behaviors than for the more dynamic fuel-efficient operating techniques.

Available Slide/Tape Presentations

Slide/tape presentations dealing with energy-efficient driving include the following:

Better Mileage Driving, Doron Precision Systems, Inc., PO Box 400, Binghampton, NY 13902--Film Strip/Tape Presentation.

Cutting The Cost, University of Wisconsin, Wisconsin Energy Extension Service--Slide/Tape Presentation

The Drive For Conservation, Atlantic Richfield (ARCO), 515 S. Flower Street, Los Angeles, CA, 90071--Film Strip/Tape Presentation

Driver Energy Conservation Awareness Training (DECAT), U.S. Department of Energy--Slide/Tape Presentation.

Driver Energy Conservation Awareness Training For Truck Drivers (DECAT-T), U.S. Departmetn of Energy--Slide/Tape Presentation.

Driving Tips to Save Dollars, Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA, 15096--Slide/Live Narration Presentation.

Ease on Down the Road, U.S. Department of Transportation--Slide/Live narration Presentation.

Energy Conservation Education for Oklahoma Drivers, Oklahoma Department of Energy--Film Strip/Tape Presentation.

Energy Conservation Guide, Ohio Department of Education--Film Strip/Live Narration Presentation.

Gallon Challenge, Doron Precision Systems,, Inc., PO Box 400, Binghamton, NY 13902--Film Strip/Tape Presentations

Gas Savers: Routes to Fuel Economy, U.S. Department of Energy--Slide/ Tape Presentation.

Practicing Better Mileage Driving, Doron Precision Systems, Inc., PO Box 400, Binghampton, NY 13902--Filmstrip/Tape Presentation.

More Miles Per Gallon, "Trip Tips for Fuel-Savers," Professional Arts, Inc., Stanford, CA--Film Strip/Tape Presentations.

Motion Picture Films

Motion picture film is the most vivid and dynamic audiovisual medium short of an actual in-car demonstration. Like the other presentational materials, films may range in scope--from those intended for 20-, 30-, or 60-second television spots dealing with a circumscribed behavior or set of behaviors to longer and more comprehensive feature films, and television programs. Films may thus be designed for delivery by the mass media, local organizations, instructional programs. or all three.

Use of Motion Picture Film

The great expense of motion picture production dictates that presentations be reserved for those behaviors which most deserve the benefit of its unique properties. Of the fuel-efficient behaviors, operating techniques would seem to most warrant treatment in motion picture film--both because of the inherent motion in the behaviors themselves and because of the potential for animation to vividly illustrate concepts such as air resistance, momentum, and gear ratios. In addition, however, other behaviors might be determined critical enough to justify the extra expense of providing for relatively passive and enjoyable reception by television or other group audiences.

Available Films

Motion Picture films currently available include the following:

Driving Economically...It's Up To You, (1978), 16mm, 15 minutes, Modern Talking Picture Service, New Hyde Park, NY 11040.

Gasoline and How to Stretch It, U.S. Department of Energy, 16mm.

Running On Empty (1978), 16mm, 28 minutes, U.S. Department of Energy.

Safe and Fuel Efficient (S.A.F.E.), American Automobile Association and the National Public Services Research Institute, 16mm, 20 minutes.

Saving Energy on the Road, Ramsgate Films, Santa Monica, CA, 16mm.

Who Cares, (1980), 16mm, 21 minutes, Visucom, PO Box 5472, Redwood City, CA.

Working Together to Conserve Energy (1976), 16mm, 14 minutes, Walter J. Klein Co., 6301 Carmel Road, Charlotte, NC 28211.

Videotape

Closely related, yet distinct from motion picture film, is the medium of videotape. There are both advantages and disadvantages in the use of videotape relative to motion picture film. The decision of which to use will necessarily depend upon the intended purpose of the presentation, as well as the types of foreseeable delivery systems.

Advantages of Videotape

The use of videotape has four advantages over film:

Ease of Production--The capability of videotape to allow immediate review and editing of what is being recorded often makes it more convenient than motion picture film to record stimulus material that cannot be reliably programmed in advance, such as in-traffic scenes. If some unanticipated event detracts from the scene, that fact can be discovered right away while the scene can be conveniently re-shot.

Economy--Because videotape is less expensive than film, it is an economical way to record events or presentations being put on for reasons other than to be recorded. Such events might range from a panel discussion among fuel economy experts to a local fuel economy "rally." The local interest generated by such events should encourage delivery by local television stations as well as other local delivery systems (e.g., schools, clubs).

Ease of Delivery--Sometimes a specific mode of delivery will be facilitated by the potential for videotape to be broadcast simultaneously to different viewing screens in different rooms. This is most likely, for example, in an instructional setting where delivery is to be made to different classes in different rooms. Another advantage for the instructional setting is that the room need not be darkened for viewing, thus allowing students to take notes during the presentation.

To Provide Instructional Feedback--The ability of the tape to be recorded over allows the use of videotape to provide feedback to drivers in a behind-the-wheel instructional setting, in high school driver education, where many drivers are unable to fully attend to their fuel-efficient (or inefficient) behavior while safely keeping the car on the road. The capability of videotape for immediate review would allow such drivers the opportunity to critique their own performance (or that of others) in the relative comfort of the classroom.

As with motion picture film, the production of videotape material is expensive. Its use should therefore be limited to occasions where research or common sense dictates that its benefits justify its cost.

Available Materials

None of the films listed in the previous section were available in videotape format at the time this report was prepared. However, some producers were planning to offer cassettes in the near future. Interested parties should contact film producers to inquire as to the availability of cassettes.

DISPLAY MATERIALS

The materials discussed under this heading are distinguished from other audiovisual materials primarily in that the information which they communicate is displayed--usually in a fixed location--rather than presented to an audience. While this type of material is rarely publicly available, it uses and advantages merit discussion.

Posters

Posters can be made to be eye-catching, and can be targeted to specific audiences when displayed on work place, school or community bulletin boards. The material they present must be limited in scope to either introduce a single behavior or circumscribed set of behaviors, or else remind audiences of those behaviors for which they have already been introduced. Such reminders might be particularly effective when displayed in the settings for the behaviors they address. For instance, a poster on maintaining tire pressure could be displayed by gas stations, vehicle selection at car dealers, and vehicle use at shopping centers, etc.

Billboards

Their location within view of highway drivers makes billboard messages appropriate for addressing fuel-efficient driving behaviors--particularly operating techniques. Since billboards can be viewed for but a moment, the amount of information must be curtailed. Thus, the use of billboards would be limited to reminding drivers of information introduced elsewhere.

Models/Mock-ups

For exhibits or to aid instruction, a model or mock-up of fuel economy related processes can prove both illustrative and eye-catching. Vehicle characteristics such as carburetion, aerodynamic design, and rolling resistance are particularly amenable to such display.

In-Car Feedback Devices

Fuel-economy related in-car feedback devices include vacuum gauges and fuel-flow meters with a variety of read-outs (discrete or continuous, visual or audible, inches, gallons, mpg., etc.). In addition, there are other feedback devices intended for other purposes which have bearing on fuel economy as well (e.g., speedometers, tachometers, accelerometers).

In-car feedback devices have been used both as instructional aids and reminders. Their use as reminders was discussed under "Vehicle Selection" in Chapter 2. As instructional aids, in-car feedback devices have been used to instruct both novices and experienced drivers. Among experienced drivers, gains up to 20% have been reported (Hinton, 1976). However, among novices, this benefit fails to appear (McKnight and Goldsmith, 1981). The main reason is that overacceleration rarely occurs among novices. The instances of overacceleration that do occur appear to be associated with lack of coordination rather than a heavy foot. Until novices have had sufficient practice to develop requisite vehicle handling skills, use of in-car devices as instructional aids appears unproductive.

CHAPTER 6

DELIVERY SYSTEMS

The term "delivery system" refers to any program, organization, or group of people that plays a role in disseminating information to a target audience. This section of the report will describe systems that are appropriate to the delivery of information under a NEEDS program.

INTRODUCTION

Almost any program, organization, or group of people can play a part in the delivery of energy-efficient driving information. However, those whose mission, experience, interest, and/or qualifications involve communication of information to drivers are the most appropriate candidates. This section will focus upon these groups.

Delivery of information involves three major functions:

Dissemination of information to drivers.

Development of materials and procedures needed for dissemination of information.

Support of development and dissemination through research, funding, information about the program.

A great number and variety of organizations are capable of carrying out one or more of the functions involved in the delivery of energy-efficient driving information. For discussion purposes, these organizations will be categorized as follows:

- o Governmental agencies
- o Educational agencies
- o Regulatory agencies
- o Employers
- o Private organizations
- o Mass media

GOVERNMENTAL ORGANIZATIONS

In the discussion of delivery systems, a "governmental organization" is one that is primarily concerned with establishing regulations and policy that influence, directly or indirectly, the energy efficiency of driving. It does not include organizations whose primary function is educational, regulatory or service (to be discussed later) even though they may be a part of Federal, State, or local government.

Department of Energy

The U.S. Department of Energy has the primary responsibility within the Federal Government for fostering energy conservation. At a national, regional and State level, DOE agencies provide support to the development of materials and dissemination of information.

National--DOE, to support the delivery of information, has included:

- o Development of printed materials, instructional guides, and films, for use throughout the country.
- o Training representatives of various agencies in fuel-efficient driving techniques.
- o Research and development in various areas of voluntary conservation, particularly ridesharing and public information programs.
- o Co-sponsorship of the government-industry voluntary truck and bus fuel conservation program.

State Energy Offices--Energy offices within the States have supported fuel-efficient driving programs through:

- o Funding of the development of materials and programs of information through schools, service organizations, and other groups within the State.
- o Serving as a source of energy information for the public and private organizations.

Regional Offices--As mediators of State-Federal relationships, regional offices can support information delivery by serving as sources of technical information as well as information pertaining to the availability of materials nationally and within the region.

Energy Extension Service--The Energy Extension Service of DOE furnishes energy efficiency information and materials upon request.

The fostering of fuel-efficient driving behavior has not received a high priority within the overall DOE program. Only about 5% of projects funded at the State level fall within this area. However, a number of significant efforts have been funded by States including the development of fuel-efficient driving curricula for schools as well as research supporting energy-efficient driving, such as a study of in-car feedback devices.

Department of Transportation

The involvement of the U.S. Department of Transportation in fostering fuel-efficient driving has occurred primarily in the setting of vehicle performance standards. The potential of DOT as a link in the delivery of information and materials concerning fuel-efficient driving derives from:

- Its knowledge of driver behavior and ways of modifying it.
- Its close contact with public and private organizations dealing directly with drivers, achieved primarily through the State Federal Highway Safety program.

Thus far, the role of DOT in support of information delivery has been a modest one. The organizations within the DOT structure primarily responsible for the efforts that have been undertaken are the following:

National Highway Trafafic Safety Administration--NHTSA has sponsored research and development leading to the development and assessment of programs in home vehicle use, driver education, and tne training and management of commercial vehicle operators, as well as providing co-sponsorship of the voluntary truck and bus program.

State Highway Safety Offices--The Federal-State safety program is managed at the State level through State highway safety offices. While the mission of these offices is safety, there are many areas in which safe and fuel-efficient driving overlap, the single best example being efforts to seek compliance with maximum speed limits.

Federal Highway Administration--FHWA has supported a number of research and development projects dealing with ridesharing including carpooling and vanpooling.

Actually, a number of efforts concerned solely with fuel efficiency have been carried out under safety programs. They are primarily driver education guides and reflect the closeness of the relationship between State highway safety offices and the driver education program.

The future involvement of DOT in energy conservation is clouded. Because of its understanding of driver behavior and long association with agencies involved in influencing driver behavior, it is probably best equipped of all Federal agencies at present to provide effective support to energy-efficient driving programs. Indeed, much of the success of DOE programs at the Federal and State level are due in part to the participation of DOT agencies.

Department of Education

Efforts to infuse energy efficiency into education across the nation have been undertaken by the U.S. Department of Education. Since driver education does not receive much attention from DOE, information concerning fuel-efficient vehicle operation will reach drivers somewhat obliquely through programs in science education, vocational education, and home economics.

Summary

It is apparent that no governmental agency is prepared to exercise leadership in fostering fuel-efficient driving at either the Federal or State level. The emphasis given to driving behavior in Department of Energy is rather small, particularly in relation to the amount of energy that is consumed by drivers and the gains that may be attained from changes in driver behavior, as projected in Chapter 2. Certainly, there is nothing comparable to the efforts that the Federal Government exerts in enhancing safety of driving behavior. There is some indication that attention is being given to fuel-efficient driving within State energy offices as they become better acquainted with the agencies and organizations that are traditionally involved in the delivery of information and instruction to drivers.

Much of the effort to foster fuel-efficient driving at both the national and State level has occurred within safety programs of the Department of Transportation. While energy-efficient driving has been able to take advantage of an existing capability and communication network, lack of a clear energy efficiency mission has stood in the way of any major effort and probably will continue to do so.

EDUCATIONAL AGENCIES

The leading, and almost exclusive, deliverer of driving instruction is high school driver education. Approximately three million students a year participate in the programs. While they represent but a small fraction of the total population of drivers, the great volume of information that can be communicated, and the ability to provide in-car instruction, makes driver education one of the most valuable deliverers of fuel-efficient driving instruction. Research described in Volume II of this report discloses that, while strongly motivated to employ fuel-efficient driving practices, high school students are currently very deficient in their understanding of fuel-efficient driving--both before and after completing driver education (McKnight and Goldsmith, 1981). The same study revealed that, while driver education can improve understanding of fuel-efficient driving, it is limited in its ability to teach fuel-efficient operation by the student's deficiencies in vehicle handling skill.

Driver education is administered through State and local educational agencies as well as individual high schools.

State Departments of Education

The role of State departments of education includes primarily (1) establishing curricula for use throughout the State, (2) serving as an information clearing house, and (3) disbursing State funds in support of driver education. The first of these functions is probably the most important in fostering fuel-efficient driving. The State curriculum exerts a strong influence on the way driver education is taught throughout the schools, particularly where compliance with the curriculum is necessary for reimbursement or issuance of driver education certificates (where they are required for licensing drivers under the age of 18).

A number of States have prepared special curricula for introduction of fuel efficiency into driver education. One way of making fuel-efficient driving mandatory is through legislation requiring that it be included in driver education programs. At least one State has passed a law to that effect.

Local Education Departments

Since high school education programs are funded primarily at the local level, the education departments and school boards of individual counties, cities, or school districts also influence what is to be taught. The influence is greatest in the purchase of materials such as films, visuals, or in-car devices.

In attempts to promote fuel-efficient driving, it is obviously more difficult to reach thousands of local education departments than the 50-plus State departments of education. The best point of contact is generally the supervisor of driver education. Avenues of communication include mailouts as well as presentations through meetings of State supervisors conducted under the State Department of Education, State associations of driver education teachers, and State highway safety offices.

Schools

In the last analysis, it is the individual driver education teacher who determines more than anyone else what is to be taught in a driver education program. They are primarily responsible for the content and method of their own instruction. Moreover, the purchase of materials is generally initiated by individual teachers.

The size of the driver education teacher population makes individual contact difficult and expensive. The single best route is generally through representatives of publishers and media houses who regularly visit schools to vend materials on all subjects. This approach will be discussed later in connection with media organizations as delivery agencies. Otherwise, State and local departments of education offer the best means of reaching driver education teachers with materials and methods for teaching fuel-efficient driving.

Other Educational Institutions

While high schools far outstrip any other educational organization in ability to disseminate fuel-efficient driving information, a few colleges and universities provide instruction in beginning driving, defensive driving, and fuel-efficient driving under adult education programs. The small number of such programs really doesn't justify an effort directed toward them specifically. Since the instructors are shared with driver education and other delivery systems, no special effort is really needed.

REGULATORY AGENCIES

The regulation of drivers takes place primarily through licensing and enforcement. Thus far, the only fuel-efficient driving practice that truly is subject to regulation is compliance with the maximum speed limit, and that regulation is based as much on safety as it is upon fuel conservation. Nevertheless, the mechanisms that have been developed to foster safe driving can also be exploited for purposes of fuel conservation.

Licensing

The purpose of the licensing process is to help protect the public. While protection against injury and property damage is the primary objective, it is not unreasonable to extend the objective to include protection against waste of energy resources.

Some states include fuel-efficient driving information in their driver manuals. In some cases, the inclusion is simply the result of an administrative decision while in others it is required by State law. Legislative approacn is certainly to be preferred since it allows fuel-efficient driving to be included in written and road tests. Such a requirement could go a long way toward alleviating the knowledge and skill deficiencies that currently exist among licensed drivers.

Regulation does not end with issuance of a license. Licensing agencies in most States maintain programs to improve the performance of drivers convicted of traffic violations. Participation in an informational or instructional program is a feature of most "driver improvement" programs. However, since fuel-inefficient driving is not a violation of the law, there is no logical basis for the inclusion of fuel efficiency except to the extent that it reinforces behavior that is required by law (e.g., maintaining an adequate following distance). Here again, the best way to get fuel efficiency into instruction is through legislation either allowing or requiring administrators to include it.

Enforcement

Enforcement of fuel-efficient driving is concentrated upon the one practice required by law--compliance with the maximum speed limit. However, in many States, law enforcement agencies have exercised broad leadership in programs having to do with vehicle operation. In many States and localities, the driving public looks to the police for authoritative answers to questions about driving. That position of leadership can be and has been exploited in programs designed to foster fuel-efficient driving. Both safety and fuel efficiency have been combined in public information programs sponsored by law enforcement agencies, particularly the State police. In addition to providing a service to the public, it helps to give law enforcement agencies a more favorable image.

EMPLOYERS

Over three-fourths of the driving public is gainfully employed and spend about a third of their waking hours on their employer's premises. This gives the employers a great potential in the delivery of fuel-efficient driving information. For discussion purposes, it is helpful to distinguish between employers in general and those that operate their own fleets.

Employers in General

Involvement of employers in providing information and instruction can vary from simple dissemination of information through printed materials to the administration of instructional programs. In the latter regard, employers have been among the chief sponsors of driving programs for experienced drivers. People are far more willing to participate in driving instruction on "company time," than on their own time.

The major obstacle to employer-sponsored instructional programs in fuel-efficient driving is the lack of any direct benefit to the employer. The "defensive driving" courses given in the past could be justified economically by an anticipated reduction in lost work time due to accidents. Employers have relatively little to gain by improving the fuel efficiency of their employees' off-duty driving. A program of recognition and awards sponsored by Federal and State governmental agencies and by employer associations might help to stimulate participation. In the absence of such a program, efforts to involve employers in dissemination of fuel-efficient driving information will probably have to be scaled down to use of printed materials, posters, and occasional short presentations.

In addition to providing information and education, employers are in the best position to foster ridesharing programs. Employers can assist in the creation and operation of carpools, vanpools, and other ridesharing programs through (1) handling the logistics of coordination, (2) arranging favorable work schedules, and (3) providing such incentives as preferred parking and vehicle purchase or operation subsidies. The mechanics of operating ridesharing programs fall somewhat outside the scope of this report. However, providing the information and incentives to encourage ridesharing behavior is relevant and represents an aspect of fuel-efficient driving that is particularly appropriate to employers.

Fleet Operators

When employers operate their own vehicles, their potential for encouraging fuel-efficient driving is enhanced by two factors:

- They have much greater control over the behavior of employees who operate company vehicles than employees in general.

- They have the incentive of reduced fuel costs.

Employers that have instituted fuel-efficient driving programs have reported long-term gains of from 10% to 15% under well-controlled evaluations (Wiltshire, 1980).

Efforts to reduce fuel cost can be directed toward individual drivers, groups of drivers, or the entire fleet operation. To be effective, the program must provide the following "three Ms":

Motivation--The success of individuals or the group in fuel conservation must be reinforced in some manner, such as special recognition, awards, or benefits (e.g., gifts, trips). Generally speaking, the recognition is more important than the material value of the incentive and the expenses can be borne through reduced fuel costs. Employers tend to shy away from cash rewards because (1) they are quickly spent and lose their symbolic value, and (2) often end up as a bargaining item in labor agreements.

Measurement--There must be some reliable method of measuring the fuel consumption of drivers, individually or as a group. Such feedback is needed both as a basis for providing incentives and simply as a means of letting participants know how they are doing.

Management--A fleet fuel efficiency program must have the agressive and continuous support of management if it is to prove effective. The program must be accepted as an integral part of fleet operation and not just a short-term campaign.

ORGANIZATIONS

A great number and variety of organizations are capable of serving as the agents for delivery of fuel-efficient driving information. Prospects include business, service, and community groups. The advantages of such groups in the delivery of fuel efficiency information and training include:

- The audience provided by the group membership and ease of access to the audience through normal group communications (e.g., newsletter, meetings).

- The availability of group leaders to arrange for the delivery of information by securing materials, delivering instruction, distributing information, etc.

- The ability of groups to secure media coverage in advertising group information dissemination activity.

Very few private organizations have actually shown a willingness to serve as delivery agencies in the dissemination of the information. Notable exceptions are the automotive industry, automobile groups, and consumer groups.

Automobile Industry

During and following the fuel crisis of the 1970's, it was the oil companies that took the lead in disseminating fuel efficiency information. Probably the most ambitious of the oil company efforts was the Atlantic Richfield Company's Drive for Conservation information and education program, publicized through a series of energy "fairs" across the country. Other oil companies disseminated informational materials on fuel conservation, including the following:

- Mobil Oil--"How to Drive for Maximum Fuel Economy."
- Standard Oil--"Tips from Pro Drivers", "How to Stretch Fuel Dollars", Tips for Energy Savers, In and Around the Home, On the Road, and in the Marketplace."
- Shell Oil--"The Shell Answer Book" series.

As the fuel crisis eased, and as oil company revenues dropped, the magnitude of the information dissemination program declined. However, oil companies are still leaders among the organizations disseminating fuel efficiency information. Much of the oil company effort was part of an effort to improve an unfavorable image that grew out of the fuel crisis. How long this will endure, there is no way of telling.

Automobile companies have also taken part in dissemination of fuel efficiency information. While most of the effort has involved publicizing the fuel efficiency of their own vehicles, many companies have inserted in their owner's manuals information concerning fuel-efficient operation and maintenance.

Automobile Groups

Outside of industry, the groups that have played the greatest part in disseminating fuel efficiency information are those that have some direct connection with vehicle operation. Of these, the American Automobile Association has been the most active, distributing film strips, pamphlets, and bumper stickers to high schools and community organizations through member clubs. While the American Automobile Association is the largest of the automobile clubs and the most active in disseminating fuel efficiency information, there are other national and regional automobile groups that are capable of disseminating information to their memberships through their organization publications.

The National Safety Council provides instruction intended to improve driving through their Defensive Driving Course. This course could provide a medium for delivery of fuel-efficient instruction to several hundred thousand drivers a year. While a combination of the DDC and fuel-efficient instruction was shown to be effective in improving fuel economy (Weiers, 1977), it has not become a part of the regular instruction program.

While not basically an automobile-oriented group, the American Association of Retired Persons and National Retired Teachers Association has developed their own driver improvement course which is taught by and for its own membership. This course is safety-oriented and designed primarily to aid members in obtaining insurance discounts. However, it could be expanded easily to incorporate fuel efficiency information. The testing program described in Chapter 4 establishes a need for such information, while the plight of many retirees on fixed incomes establishes a need for instruction that will help save on fuel bills.

Consumer Groups

Organizations established to help consumers would have a natural interest in disseminating fuel efficiency information. Of the various consumer groups, Consumer's Union of the U.S., Inc. has been by far the most energetic in providing fuel efficiency information to its membership. In addition to providing fuel efficiency ratings of automobiles to about two million people through its magazine "Consumer Reports," it also produces film and special reports which are made available to its membership and the general public.

Most other consumer organizations such as American Council on Consumer Interests, Automobile Owner's Action Council, and the National Center for Community Action, while active in advancing the interest of consumers, do not have a system for delivering information to drivers of automobiles on a large scale.

MASS MEDIA

Of all of the delivery systems considered, the mass media have the potential for reaching the largest audience and in the shortest period of time. Studies have shown mass media are capable of effecting changes in behavior (Wilde, 1971, 1976).

Despite their great potential, mass media have certain limitations in the dissemination of fuel efficiency information. Most serious of these are the following:

> Limited Duration--The interest of both the public and the media in any issue tends to be of limited duration--from a few weeks to several months. The most successful uses of media in achieving behavior change are therefore achieved through campaigns of limited duration. This would make mass media most useful in advising drivers during periods of acute crisis, but not so useful in maintaining interest in fuel economy during long periods of general fuel availability.

Cost--The only way to ensure that information reaches a large segment of the population through mass media is through paid advertising. Unless commercial sponsorship can be found, the cost is generally prohibitive. Even public service announcements, while disseminated without cost, can be expensive to produce, particularly if they are to be sufficiently attractive to be used often. Whether the limited audience reached by public service announcements justifies the expense of their preparation is questionable.

Interest--Since there is no way to assure that people pay attention to messages they deliver, mass media are most effective when there is already a high degree of interest in the issue addressed. They are less useful in delivering information intended to generate or maintain interest--one of the more important aspects of fuel efficiency information.

Television

Television is clearly the most powerful medium for delivery of any information, fuel efficiency included. The cost of prime time advertising largely precludes its use for public service broadcasting, even with commercial sponsorship. Public service announcements tend to draw a small audience because of the hours at which they are shown. However, if sufficiently attractive, they can capture the interest of both television stations and their audiences. Public service announcements can take any of the following forms:

Video Announcements--Twenty- to thirty-second video or film announcements dealing with individual information items, such as driving or maintenance "tips." Video announcements are effective but rather costly to produce.

Slide Announcements--A multi-image slide with a 27-second voice-over audio tape dealing with an individual topic. While less expensive to produce than video announcements, slide announcements have more difficulty gaining air time.

Film Clips--Short films, often several minutes in duration, dealing with a topic in somewhat greater depth than the announcements described above. They may be sections of sound film, or films with a sound-over narration done locally to capture local interest.

Television is not limited to use of prepared announcements. News and community affairs programs can be used to deliver any information that might be considered newsworthy. Such would include an event like a fuel economy rally, a discussion among fuel economy experts, or a short course on fuel-efficient driving.

Because of the expense, television is probably the most sensitive of the three media to public interest. Information on fuel efficiency abounded during the during the fuel crisis of the '70s, but gained little coverage after that. Unfortunately, materials are seldom retained by stations after interest wanes.

Radio

While dramatic, and more limited with respect to the information it can effectively provide, radio has the following advantages in delivery of fuel efficiency information:

- It can reach drivers while they are operating the vehicle in order to simulate and reinforce fuel-efficient driving behavior.
- Because it is less costly, information can be presented a great deal more frequently, an important feature for information that is intended primarily to remind drivers of things they already know.
- Because most stations handle their own programming (versus network programming), they are much more receptive to contributed material. This includes not only public service announcements but panel discussions and information presented through phone-in talk shows.

Print Media

The term "print media" encompasses a wide range of specific delivery systems, including the following:

- Newspapers
- Magazines
- Business publications
- Trade journals
- Airline publications
- Company publications
- Brochures and pamphlets

Since the number of pages in print media varies with the amount of information to be presented, there is no counterpart to the uncommitted air time that permits public service broadcasting in TV and radio. On the other hand, if information can be presented in an interesting fashion, it can make its way into the particular publication's regular copy without difficulty. The amount of information could vary from short press releases for newspapers to full-length articles for magazines. Particularly appropriate targets are:

> Small Newspapers--Because of their small staffs, small local dailies and weeklies rely more heavily upon prepared copy than large metropolitan papers.
>
> Targeted Publications--Magazines and newspapers targeted to a particular age group, leisure time activities, nationalities, etc., are frequently in need of material tailored to their audiences. It is frequently easy to couch fuel efficiency information in terms that make it particularly appropriate for specific audiences.

As with other mass media, the print media abound in material dealing with fuel efficiency during and shortly after periods of acute shortage. As interest has waned, so has the coverage.

CHAPTER 7
DESCRIPTION OF RESEARCH PROGRAMS

The study of means by which drivers may reduce fuel consumption through modification of behavior relative to vehicle selection, maintenance, operation, and use represents the first of two efforts taking place under the National Energy Efficient Driving System (NEEDS). The second effort was a program of research intended to discover ways of bringing about behavior change. It was obviously not possible to investigate all fuel saving behaviors within a single research effort. It was necessary to select from the full list of behaviors discussed in Chapter 2 a limited number having the highest potential benefit. The selection of behaviors for further study was the last step in the first phase of the NEEDS program.

SELECTION OF BEHAVIOR AREAS

For the purposes of selection, potential benefit was viewed as a joint function of (1) the amount of fuel that could be saved on a nationwide basis by bringing about the behavior change, and (2) the a priori likelihood of bringing about a long-term behavior change.

For these reasons, vehicle selection did not appear to be a potentially fruitful area for behavioral research.

The various transportation behaviors discussed in Chapter 2 were reviewed and assessed in terms of their potential for change. The results of this effort may be summarized here.

Vehicle Selection

The reduction of fuel consumption available through the purchase of more fuel-efficient vehicles is great--probably the greatest of any other type of transportation behavior. However, the attractiveness of this behavior as a target for research is limited by the following:

- Downsizing by manufacturers has already achieved significant reductions in fuel consumption, being in fact a major contributor to the nationwide reduction in fuel consumption occurring since the 1979 crisis.
- Drivers appear to be highly knowledgeable in the fuel efficiency of various vehicles and have been shifting to smaller, more fuel-efficient vehicles by themselves.
- The benefits of change in vehicle selection are slow to accrue because of the slow rate at which new vehicles enter the fleet.

Vehicle Maintenance

The gains in fuel efficiency available from improved vehicle maintenance are very meager. The two major sources of fuel inefficiency are vehicles out of tune and under-inflated tires.

Tuneups--The benefit of promoting tuneups as a route to fuel efficiency is attenuated by the small number of vehicles that are seriously out of tune at any time.

Tire Inflation--Because of the prevalence of under-inflation and the fuel penalty it exacts, tire inflation is an important issue. However, it is rather circumscribed for an objective of research.

Vehicle Use

Use of the vehicle may be divided into two categories: work and home use.

Work Use

Change in vehicle use for work purposes, i.e., commuting, largely involves use of alternative transportation modes: ride sharing and public transportation. Neither of these seem to be particularly fertile areas for research. Ride sharing has already been the target of abundant research. Given the barriers to expansion in ride sharing, it did not appear as though additional research would have significant payoff.

Increasing use of existing public transportation facilities has already received a great deal of attention. Given the number of factors that influence the use or non-use of public transportation, it did not seem likely that a study focusing upon the energy benefits would have an appreciable impact.

Family Use

In contrast with use of the vehicle for work purposes, home use has received very little attention. However, as noted in Chapter 2, it appears to be a potentially fruitful area for study. First, much of the domestic travel is recreational and therefore not essential. There is evidence that a significant portion of the reduction in travel that occurred during the 1970's fuel crises has been achieved through eliminating recreational travel. Secondly, much of the home travel consists of very short trips. Short trips warrant study both because of the presumption that many of the short trips could be combined into a fewer number of longer trips.

Vehicle Operation

Research has demonstrated that gains of 10-20 percent in fuel efficiency can be obtained through changes in vehicle operating behavior. However, the ability to achieve the required changes in behavior on a long-term, programmatic basis has not been demonstrated. None of the studies reviewed attempted to assess the durability of changes through follow-up measures. Nor, have any previous studies demonstrated the feasibility of reaching any large segment of the driving public.

The fact that most fuel-efficient driving behaviors can be achieved without cost and without any appreciable sacrifice of travel objectives gives encouragement to efforts to bring about behavior change.

Selection of Research Areas

Of the areas of behavior reviewed, those showing the greatest potential for a program of research were home use of vehicles and vehicle operating techniques. Both were areas of behavior in which (1) changes in individual behavior could be expected to produce substantial improvements in fuel efficiency, (2) the number of drivers and vehicle miles affected to be expected to have a substantial impact upon overall fuel economy, and (3) data bearing upon the ability to produce long-term behavior changes was sparse.

The selection of home vehicle use and vehicle operating techniques is not intended to imply that other areas are not potential candidates for research. However, given the limits of time and funds available for study, these two areas seem to have the greates potential payoff.

VEHICLE OPERATING TECHNIQUES

A major obstacle to bringing about change in vehicle operating techniques has been the lack of a system for reaching drivers to bring about behavior change. Improving vehicle operating technique requires development of skill which, in turn, requires in-vehicle instruction. It is difficult to reach the mass of drivers with such instruction. The efforts that have taken place so far have been largely one-time affairs and were carried out primarily to demonstrate the effects of instruction. Very few of the programs have continued, and those that have reach a very limited segment of the driving population.

The one delivery system that is capable of providing in-vehicle instruction to a large number of drivers is high school driver education.

While high school driver education students comprise only about three percent of the country's driving population, they represent an attractive target for an energy-efficient driving program, particularly one that focuses upon operating techniques.

1. The availability of vehicles allows the behind-the-wheel training that may be needed for teaching operating techniques.

2. The length of driver education programs--generally 36 hours of actual instruction--permits the extensive training needed to inculcate efficient operating habits.

3. Most novices, driver education students, are more malleable and, therefore, likely to be more receptive to the development of energy-efficient driving habits.

4. Gains in energy efficiency that are achieved with high-school-age students can be extrapolated over an entire driving lifetime.

A research program was undertaken to determine the effectiveness of driver education as a means of achieving an increase in the efficiency of vehicle operation.

Research Objective

The overall objective of the Driver Education research study was to determine whether driver education was capable of yielding changes in the fuel efficiency of vehicle operating behavior. Within this overall objective, the following specific questions were to be answered:

- What are the deficiencies of the audience to be addressed by the programs?

  Driver deficiencies that can hamper fuel-efficient driving include lack of knowledge, inappropriate attitudes, inadequate skills, and poor driving habits. The nature and magnitude of deficiencies characteristic of high school students had to be determined before there could be any attempt to develop training programs that addressed them. For example, a program providing incentives to driving fuel-efficiently would be useless if the major deficiency were ignorance of fuel-efficient driving skills. On the other hand, use of incentives would be appropriate if the major problem were poor attitudes.

- How much and what kind of behind-the-wheel instruction is necessary?

  Behind-the-wheel instruction is costly because of expenses involved in obtaining, maintaining, and operating the vehicles, and in providing the high teacher/student ratio needed. The minimum amount and kind of in-car instruction needed had to be determined.

- What is the role of in-car aids?

  Many of the programs that have been cited for achieving fuel savings used in-car aids and displays such as vacuum gauges and fuel flow meters. The need to use them in training may be an obstacle to widespread program implementation. While these devices themselves are not extremely expensive, their purchase and installation adds significantly to the cost of in-car instruction. Moreover, if these aids turned out to be necessary for maintaining the skills acquired through their use, then the need for students to obtain them once formal training was completed could dilute the effects of the program.

o <u>How are energy-efficient techniques to be integrated into driver education?</u>

Given its defensive posture these days, driver education is in no position to expand in order to incorporate energy-efficient driving instruction. Therefore, the prospects for widespread implementation depend greatly on how easily energy-efficient driving instruction can be integrated into current driver education programs.

Methods

To answer these questions, a three-phase study was undertaken. The first phase studied the nature and extent of young driver knowledge of, attitudes towards, and skill in fuel-efficient driving. The results of Phase I were applied to the development of the driver education program designed to overcome these deficiencies. While the research program was concerned solely with operating techniques, the driver education program encompassed the full range of fuel-efficient behaviors. This was necessary in order to be able to gain the program's implementation in high schools so that operating techniques could be studied.

The second phase of the study involved an evaluation of in-car training methods, including the role of the following:

<u>Instrumented Feedback</u>--In-car devices to provide feedback on the fuel efficiency of operation.

<u>Instructor Feedback</u>--Feedback by instructors on both the fuel efficiency of vehicle operation and the students' proficiency in carrying out fuel-efficient operating behaviors.

<u>Observer Feedback</u>--Feedback from fellow students on the fuel efficiency of operation and use of fuel-efficient operating behaviors.

The effectiveness of instruction was assessed for both the knowledge test and an in-car performance measure.

The third phase was a study of instructional methods in which classroom instruction was compared with a combination of classroom instruction and the in-car method revealed as best in Phase II. Effectiveness was again assessed through knowledge and performance measures. The final product was a high school fuel efficiency driving program involving both classroom and in-car instruction.

Results

All of the programs produced significant changes in knowledge regarding the four major categories of fuel-efficient driving: vehicle selection, vehicle maintenance, vehicle use, and vehicle operation. However, none of the programs had any significant effect upon overall vehicle operation. Neither of these two overall findings varied as a function of instructional method--in-car instruction was no more effective than classroom instruction, nor did the type of in-car instruction have an effect. The failure of actual vehicle operation to benefit from energy-efficient driving instruction of any kind was attributed to the meager control over the vehicle manifested by driving by the great majority of students. Briefly stated, they had all they could do to keep the vehicle on the road. They simply did not have "experimental capacity" to attend to the needs of fuel-efficient driving.

Taken as a whole, the results indicated that driver education, while capable of laying the groundwork for energy-efficient driving through development of the requisite knowledges, is not an appropriate system for the development of skills. Rather, development of skill and fuel-efficient driving must await the mastery of more fundamental vehicle control skills through experience. Unfortunately, people who possess the requisite basic skills are rarely motivated to seek driving instruction.

This problem is not confined to the teaching of fuel-efficient driving. There is evidence that much of the instruction students receive in safe operation of motor vehicles is wasted because the students are not skillful enough in basic vehicle operation to absorb the instruction. This problem has led to the suggestion that new drivers receive only probationary licenses and be required to return for safety-oriented instruction before being awarded a regular license. Should such a scheme come to pass, fuel efficiency could be coupled with safety instruction in the second phase of driver education.

The methodology and results of the driver education program are described in: National Energy Efficient Driving System (NEEDS), Final Report, Volume II, Driver Education Program.

HOME VEHICLE USE PROGRAM

The purpose of the Home Vehicle Use study was to obtain an estimate of the amount of change obtainable in use of home vehicles. The specific changes sought were reduction in the number of short trips through better trip planning.

Changes in home vehicle use are not going to occur in the absence of some means of changing them. The means had to be practical; there is no point in determining the degree of behavior change available from some approach that could not be practically employed in teaching the driving population at large. The method employed was a combination of instruction acquainting drivers with procedures for and benefits of short trip reduction and a system of providing feedback on the results of their efforts. Studies described in the discussion of behavioral influences in Chapter 3 have underscored the importance of providing feedback as well as instruction. Two methods of feedback were employed in the study:

> Manual Feedback--Driver maintained logs of mileage and fuel consumption.
>
> Instrumented--A dash-mounted device providing immediate feedback on fuel, distance, and MPG for each trip.

These two systems represented end points of a continuum of feedback systems, one a very simple and inexpensive system, the other a sophisticated and rather expensive system.

While there was obvious interest in the effectiveness of the information and feedback systems, primary concerns still lay with the magnitude of the behavior change that can be obtained, regardless of method.

Research Objectives

The specific research questions addressed by the home vehicle use study may be summarized as follows:

What is the Effect of Information and Feedback upon the Length of Trips?

Improved vehicle use means reducing fuel consumption without sacrifice of travel objectives. It has been hypothesized that objectives are most readily obtained by reducing the number of very short trips through combining and consolidating trips. More efficient vehicle use should therefore see a reduction in the number of short trips. Changes in driving needs and fuel availability could bring about changes and total travel that might obscure the effect of reductions in absolute number of short trips. Therefore, the study also examined the effect of the program upon the percent of short trips and mean trip length.

What is the Effect of the Feedback Program upon Fuel Consumption?

If the number of short trips is reduced, there should be a savings in fuel. This would show up in the reduction in the amount of fuel consumed per unit of time (e.g., week, month). Again, changes in overall travel could prevent the effects of the program from showing up in absolute fuel consumption. Therefore, fuel consumption in relation to distance--mpg--was also used as a measure of effect.

What is the Relative Effect of Manual and Instrumented Feedback?

While the study's primary focus was upon amount of change, rather than the means by which it was obtained, any differences between the two feedback systems would have a substantial impact upon efforts to extend the change beyond the study to the population at large. A manual system, supported only through printed materials, would be a good deal more readily implemented on a nationwide basis than an instrumented system requiring the purchase of in-car displays. Therefore, differences between the two systems were assessed for their fuel-saving benefits in relation to their costs.

Methods

The study of changes in home vehicle use through manual and automated feedback involved monitoring the trips, mileage, fuel consumption of eight home vehicles prior to and following the introduction of feedback. A device capable of measuring and recording the distance traveled and fuel consumed on individual trips was installed under the hood of each vehicle. The vehicle owners, having agreed to the installation, were aware of the device's presence. However, they were not aware of the purpose until baseline data had been collected.

All of tne owners received a pamphlet describing ways of reducing fuel consumption through a reduction in short trips. In half of the vehicles, the owners also received a form upon which they could record their mileage, fuel consumption, and mpg manually. In the other half of the vehicles, a dashboard device was installed informing the drivers at to the length of each trip, the amount of fuel consumed, and the mpg.

Results

Neither of the two groups evidenced any significant decrease in the number of short trips, the ratio of short to long trips, total mileage, or mpg. The instruction and feedback systems alone appeared to be ineffective in modifying use of family vehicles.

With the failure to find a significant effect, an additional procedure was introduced for both groups. "Profiles" showing the pattern of fuel consumption during both baseline and feedback periods were prepared for each vehicle. Interviews were held separately with the drivers of each vehicle during which the profiles were reviewed, the nature of the trips discussed, and the fuel reduction goals arrived at. In addition, the instrumented feedback device was adjusted to show both instantaneous and trip mpg. (This feature had not been employed during the initial phase.)

Neither one of the steps had a significant effect upon short trips, total mileage, or fuel consumed. There was a significant increase in mpg for the group receiving instrumented feedback, but it was apparently achieved through something other than a change in pattern of short trips (e.g., operating techniques).

During the interviews, it became apparent that the majority of drivers were not very responsive to the program. Most claimed that they had already adjusted their vehicle use to the higher cost of fuel and didn't feel any further change in behavior was necessary. People who were driving recently-purchased smaller vehicles pointed out that one of the advantages of their increased fuel economy was not having to be concerned about a few unnecessary trips.

The experiment took place following the fuel crisis of 1979. Fuel was once again abundant and this price had stabilized. Drivers simply weren't energy conscious. The results of the experiment tend to confirm the observations of other investigators to the effect that fuel conservation efforts among drivers are stimulated primarily by (1) shortages in fuel and the need to wait in line at gasoline stations, and (2) price increases (as opposed to a high but stable price level). During these conditions, drivers will voluntarily seek any possible way of stretching out the period between fill-ups.

The results of the experiment were not interpreted as negating the need for a program to encourage better use of vehicles. On the contrary, the interviews revealed that few participants were aware of the inefficiency of their own vehicle use. They were surprised by the number of short trips they were taking and the amount of fuel it was consuming. Indeed, probably the most important finding was the extent to which the number of short trips exceeded the estimates not only of the participants in the study but of drivers in general (as reported in nationally compiled statistics). This finding suggests that even when conditions are such as to motivate drivers to seek ways of reducing fuel consumption, efforts will fall short of achieving maximum fuel economy. At that time, the results of efforts similar to that undertaken in the study described should realize greater success.

The methodology and results of the Home Vehicle Use study are described in detail in "National Energy Efficient Driving Systems (NEEDS), Final Report: Volume III, Home Vehicle Use.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the study that has been described in this report, the following conclusions and recommendations are offered.

CONCLUSIONS

Knowledge of Fuel-Efficient Practices

While the American driving public is generally knowledgeable in most aspects of fuel-efficient driving, it is uninformed and misinformed on many issues that are highly critical to fuel economy. These may be summarized as follows:

> Vehicle Selection--While the public recognizes the general relationship between vehicle class (full size, mid-size, compact) and fuel economy, it is not fully aware of the impact of choices within class, including engine size, transmission, and accessories.
>
> Vehicle Maintenance--The public generally overestimates the impact of tuneups and lubricants upon fuel efficiency and underestimates the importance of tire inflation.
>
> Vehicle Operation--Generally speaking, the public tends to place far too much emphasis upon use of the accelerator (acceleration and speed) and too little upon use of the brake (conserving momentum).
>
> Vehicle Use--While the public is generally aware of the fuel penalty involved in short trips, it tends to underestimate the number of short trips taken; and the magnitude of the fuel penalty involved.

Encouraging Fuel Conservation

Efforts by governmental agencies and the private sector to encourage fuel economy have not been very successful and are not likely to be. During periods of acute fuel shortage, steeper rising fuel prices, or economic hardship, most motorists will initiate efforts to conserve fuel without encouragement from outside sources. When these conditions no longer prevail, it appears little can be done to alter behavior relative to purchase, maintenance, operation, or use of vehicles.

There is some evidence that the fuel economy realized through the purchase of more fuel-efficient vehicles, stimulated by the fuel crisis of the 1970s, has inhibited other forms of conservation. Some purchasers of smaller vehicles feel that they have "already done enough," while others acknowledge that the purchase of a small vehicle was intended to allow them the luxury of certain fuel-inefficient practices elsewhere.

Teaching Fuel-Efficient Operation

Fuel-efficient vehicle operating behaviors offer an attractive target for conservation efforts because of the ability to secure substantial gains in fuel economy (10-20%) without sacrifice of personal travel objectives. However, efforts to foster development of vehicle operating skills have encountered a dilemma. The only existing system for delivering driving instruction--driver education--is not suitable because of the novice driver's lack of the basic operating skills upon which fuel-efficient practices must be built. On the other hand, the experienced drivers, who had the basic skills needed to profit from fuel-efficient driving instruction, are not accessible through any operating delivery system. This situation reduces instruction in fuel-efficient operation to the dissemination of procedural information through (1) classroom instruction in driver education, and (2) public information programs directed toward the motoring public.

Fleet Energy Conservation

The conclusions rendered concerning the public's general lack of interest in most aspects of fuel-efficient driving do not generalize to operation of commercial vehicle fleets. While commercial vehicle operation was outside the scope of the present study, it is worth noting that efforts at fuel conservation directed toward fleets have realized considerably more enduring success than that aimed at conservation by individual drivers. A combination of high fuel prices, bad economic conditions, and intense competition have driven companies maintaining large fleets to seek ways of reducing their fuel bills. Research has shown that a strong management interest, accompanied by an accurate record system and worker incentives can produce long-term savings in the neighborhood of 15%.

Federal Participation

When fuel is again in short supply and drivers are motivated to conserve fuel, an intensive effort will be needed to help overcome the specific information deficiencies revealed by the present study. In the past, this need has been met primarily through the private sector--by oil companies, motor vehicle manufacturers, automobile clubs, among others. However, the private sector cannot do the job alone. A substantial effort on the part of the Federal Government is needed. The benefits of federal involvement have been well demonstrated by the success of the voluntary truck and bus program.

Currently, responsibility for fuel-efficient driving at the federal level is divided between the Departments of Energy and Transportation. Attempts to foster voluntary conservation by individual drivers have not benefited from the same level of coordinated effort as did the voluntary truck and bus program. Informing the motoring public about fuel-efficient driving is not a high priority at the present time within either of the two Departments. The same lack of priority is reflected in State agencies operating under federal funding.

RECOMMENDATIONS

No recommendations for immediate action appear appropriate. However, it is recommended that the Federal Government prepare for the inevitable fuel shortages to come by forming a task force similar to that under which the voluntary truck and bus program operated. The mission of this task force would be to prepare a plan for action at the federal level to assure the dissemination of pertinent and up-to-date information concerning ways of conserving fuel. The composition of the task force should include representation from the Federal Departments of Energy and Transportation, State highway safety offices and energy administrations, colleges and universities, research and development organizations, fuel-related business organizations, and private groups having experience and interest in fuel conservation.

The plan should include identification of the following:

- The most critical information needs of drivers in general and specified target audiences.
- Critical research that should be carried on during the interim in order to provide for the most effective and efficient dissemination of information when the need arises.
- Available materials that could be used in their present form, or adapted quickly and inexpensively as the need for them arises.
- Appropriate systems for the delivery of information to drivers, including individual organizations within each system indicating a willingness to take the lead in information dissemination.

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