Saving Highway Fuel—
The Engineer’s Role

CARLTON C. ROBINSON
Executive Vice President
Highway Users Federation for Safety and Mobility
Washington, D.C.

POLL ON ENERGY SHORTAGE—PEOPLE UNCERTAIN

During the last week in January, the Highway Users Federation commissioned the Gallup organization to conduct a poll of public attitudes. A number of the questions asked related to the subject of my talk today: “Saving Highway Fuel.”

The first, and perhaps, most basic question was, “Do you believe the United States faces a shortage of energy?” Of the approximately 1,500 representative Americans who responded, 48% answered yes, 44% answered no and 8% were on the fence. The second question was, “If you had to choose between a system of government rationing of gasoline which would reduce your driving by 20% or a tax that would raise the price of gasoline to you by ten cents a gallon, which would you prefer?” Forty-two percent would prefer rationing, 48% would prefer the ten cents a gallon tax and 10% had no opinion.

In both cases, the nearly equal division of opinion suggests a great deal of uncertainty on the part of the American public, as to whether we have a problem, what the problem is, and what we should do about it.

DILEMMAS OF THE ENERGY SHORTAGE

I think we are all confused by conflicting signs. On the one hand, political leaders are calling for high taxes, import quotas, even rationing. On the other hand, the corner service station is giving away premiums with every sale of gasoline. Perhaps I can help to describe the problem, perhaps even the dilemma which we seem to be facing in the area of energy in this country.

Capital Outflow for Oil Strain on Economy

First, there is no shortage of energy in the near term in the world or even in the United States. We use energy in a number of forms. About 40% of the energy we consume in this country is from oil and about 40% of that oil is imported. Problem number one is that imported
oil is very expensive. It cost the nation about $25 billion in 1974. I am sure you all know how much $25 billion is. It is roughly the market price of two General Motors Corporations. It is also about half of the normal annual growth in living standard in this country. If half this added wealth continues to go overseas, we must forego that increment in improving life-style. I am sure you are also aware of moves by various Arab leaders to use their growing hoard of dollars to make minor purchases such as Pan American World Airways or Lockheed Aircraft Corporation. This out-flow of capital necessary to pay for oil imports is putting a major strain on our economy; that is problem number one.

Energy Consumption Varies Directly With GNP and Living Standard

Problem number two is that a high level of energy consumption and a growing level of energy consumption has been associated in the past with our growing gross national product and growing standard of living.

Figure 1 shows the growth rate in per capita energy consumption since World War II. It has been increasing at about 4% per year. This has been about the same rate of growth as our gross national product. In fact, since about 1920, the ratio of energy consumption and gross national product has been remarkably consistent. Periods of lower energy use as shown on this chart in 1949 and 1954 are associated with economic recession.

Another and remarkably close correlation is shown in Figure 2 in which the solid line is the actual total civilian employment and the dashed line is an estimate of employment based on .6 jobs for every million Btu's of energy. The correlation is remarkable. The problem then, or perhaps the dilemma, is to find a way to reduce the drain on our economy of $25 billion a year and do this in a way which does not throttle our economy or our level of employment.

ADMINISTRATION VERSUS CONGRESS ON REDUCTION OF IMPORTED OIL

Administration—Curb all Petroleum Uses, Congress—Curb Auto Use

As you all know, the administration has proposed a gradual increase in the tariff on imported oil and various other domestic price changes to discourage consumption through the price mechanism. Congressional leaders have opposed this approach, indicating a preference for import quotas, allocation, gasoline rationing (if necessary), and massive taxes placed on automotive gasoline. The principal difference then in the
two approaches is an administration approach which would spread the cost and thus the incentive to conservation across all petroleum uses, and a congressional approach which would concentrate all the conservation efforts on automotive travel. We do not believe that the latter is a practical nor equitable approach.

**Auto Use—14 Percent of all Energy**

Figure 3 is an overall picture of energy supply and consumption in the United States. Of all energy used, 14% goes for automotive
Fig. 2. Actual Versus Calculated Civilian Employment (Millions of Persons) as a Function of Total Energy Consumption. This function is:
Civilian Employment = 38.36 + 0.6045 \times \text{Total Energy Consumption}

travel and two-thirds of that is for such essential travel as commuting, work and business, and family business (such as shopping, doctors visits, etc.). As this chart shows, a typical American family uses about the same amount of energy heating its home as it does driving its automobile and, in fact, uses about the same amount of energy heating water as it does for all of its vacation and pleasure travel.

**Big Savings in Oil Possible in Auto Use**

If President Ford’s goal of reducing oil imports by two million barrels per day by the end of 1977 is achieved solely through a reduction in automotive travel, this would require about a 30% de-
ENERGY SITUATION IN MID 1973

<table>
<thead>
<tr>
<th>Supply</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other</td>
<td>Commuting 34%</td>
</tr>
<tr>
<td>Domestic Petroleum</td>
<td>Work &amp; Business 8</td>
</tr>
<tr>
<td>Imported Petroleum</td>
<td>Family Business 20</td>
</tr>
<tr>
<td></td>
<td>Education/Religion 5</td>
</tr>
<tr>
<td></td>
<td>Social 27</td>
</tr>
<tr>
<td></td>
<td>Vacation &amp; Pleasure 6</td>
</tr>
</tbody>
</table>

|                         | 2/3                  |
| Industry               | 32%                  |
| Elect. Gen. Loss       |                      |
| Commercial             |                      |
| Residential            |                      |
| Freight, Farm & Public Trans. | 11 |
| Automobile             | 14%                  |

100

100

crease in auto use. We do not believe that is feasible. Currently, automotive travel uses about 40% of all petroleum consumed in the country. Its equitable share of a reduction might therefore be set as high as 40%. In an attempt to look into the future and see what practical results would be, we have assumed, arbitrarily, that automobile travel could achieve 50% of the total savings in oil instead of 40%.

Figure 4 shows the result of this assumption in terms of overall highway travel. On the left side of the chart you will note a steady increase from 1965 to 1973 which is in fact at a rate of about 4.7% per year. There was a decline in 1974 of a little over 4%. The President's goals would require a further decline of 6% in 1975 and 3% in 1976 and again in 1977, for a total reduction of 16% below the 1973 peak. This would be followed by a period from 1977 to 1980 a very gradual increase in travel, not because of greater fuel availability, but because of the impact on new, more energy efficient vehicles in the operating fleet.

In about 1980 fuel from Alaska, possibly from the Outer Continental Shelf, and from more complete recovery methods in existing fields would become available. Travel would again begin to increase until, in about 1983, it would exceed the 1973 peak.

These projections may not, of course, come true or at least may not exactly follow the scenario I have described. They indicate, however, some very real possibilities which would have a significant effect on highway transportation and on the work which we, as highway officials must do. If approximately true, the travel reduction shown on this figure will be deeper and longer than occurred in the depression period of the mid-30's and, although not as severe, of longer duration than the travel restrictions of World War II.

Differing from both of these periods, however, our domestic population will continue to rise and at least we hope that our civilian domestic economy will continue to grow. Our job will be to accommodate this situation through conservation and best use of the highway transportation system. Figure 3 shows where some of this conservation can take place. The largest single use of automotive fuel is commuting from home to work and it is in this area in which I believe we can make the quickest and largest conservation gain.

ENERGY SAVINGS BY CARPOOLING

*Government and HUF Push Carpooling*

Work trip carpooling is a proven, effective energy conservation measure that can be implemented at little or no cost. In the Gallup
Fig. 4. Past and Projected Highway Travel (Billion Vehicle Miles)—Highway Users Federation, 2-5-75.
survey I mentioned earlier, 52% of respondents said that, faced with rationing, they would look first to carpooling as a means to conserve. Eighteen percent, incidentally, said they would switch to transit. Prior to the energy crisis, work trips had the lowest vehicle occupancy of all passenger car uses. Yet, many of these trips had common origins and destinations, therefore a potential for more efficient vehicle use. This was recognized. The federal government and private organizations, including the Highway Users Federation, set up programs to encourage and help form carpools.

These initial programs have been effective. Federation follow-ups with companies participating in our carpool promotion workshop series show significant increases in employee carpooling. For example, the Northern Natural Gas Company of Omaha had an additional 27% of their employees forming carpools, and Bell Helicopter at Fort Worth had 20%.

Amount of Fuel Saved by Carpooling

The success of these first carpool promotion programs supports the validity of early estimates of the fuel saving this conservation measure could achieve. For each shift of 10% of driver-only commuters to carpools, the federation staff estimated that the fuel saving would be $1\frac{1}{2}\%$ of total annual highway transportation fuel use.

3M Vanpool

Carpool experience to date clearly shows that imaginative, incentive-oriented programs will be successful. Typical of this is the vanpool program initiated by the 3M Company in St. Paul. This program, using company-owned vehicles, has grown from an initial trial with six vans to a fully subscribed, major program with 57 vans and a waiting list of over 1,000 employees. This program now results in a reduction of about $1\frac{1}{2}$ million vehicle miles of work trip travel per year and an annual fuel saving of over 100,000 gallons.

Number of Single-Occupant Vehicles High

Carpooling is not necessarily easy to achieve but it is achievable to a far greater extent than presently exists. Figure 5 shows that in 1970, 62% of work trip travel was by single-occupant vehicles. On a passenger-mile per vehicle-mile basis the average occupancy of a work-destined vehicle is 1.6. To reach a target goal of 2.0 will require cutting the amount of travel in single occupant cars by one-third. To reach an occupant goal of 2.4 would require cutting travel by both single and double occupancy cars by one-third. The single most important ingredient, if we are to reach a goal of 2.4, would be the substantially greater use of vans.
INCENTIVES TO CARPOOLING

Climate by Employer

A number of incentives for greater carpooling exists or can be created. Certainly, employers have a vitally important role in establishing matching systems, in creating a climate favorable to group riding and in providing incentives such as preferred parking.

![Table]

<table>
<thead>
<tr>
<th>People per Car</th>
<th>Present</th>
<th>Cut Singles 1/3</th>
<th>Emphasize Vans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Total People</td>
<td>Percent of Total Cars</td>
<td>Percent of Total Vehicles</td>
</tr>
<tr>
<td>1</td>
<td>62</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>80</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>12</td>
<td>36</td>
</tr>
<tr>
<td>4-6</td>
<td>5</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>Van</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>200</td>
<td>239</td>
</tr>
</tbody>
</table>

Source: Present from Nat. Personal Trans. Study, FHWA, 8/73 — other columns computed with assumed distributions. Other distributions are possible and may be equally feasible.

Fig. 5. Commuter Auto Utilization (Passenger Miles Per Vehicle Mile)
Economic Cost of Urban CBD Commuter Trips, Urbanized Areas Greater Than 1,000,000 Population
Cost Per Person Per 10 Mile Trip

<table>
<thead>
<tr>
<th>MODE</th>
<th>COST $</th>
<th>0</th>
<th>$100</th>
<th>$200</th>
<th>$300</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTOMOBILE - 1 OCCUPANT</td>
<td>2.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAIL TRANSIT - KISS AND RIDE ACCESS</td>
<td>2.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAIL TRANSIT - WALK ACCESS</td>
<td>2.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAIL TRANSIT - PARK AND RIDE ACCESS</td>
<td>2.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAIL TRANSIT - BUS ACCESS</td>
<td>1.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTOMOBILE - 16 AVERAGE OCCUPANCY</td>
<td>1.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUS - EXCLUSIVE Lanes</td>
<td>0.78-2.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTOMOBILE - 2 OCCUPANTS</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTOMOBILE - 3 OCCUPANTS</td>
<td>0.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUS - CONVENTIONAL</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTOMOBILE - 4 OCCUPANTS</td>
<td>0.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTOMOBILE - 6 OCCUPANTS</td>
<td>0.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VANPOOL - 9 OCCUPANTS</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 6. Comparison of Commuter Costs for Various Modes.

Economics

Economics also has a part to play as Figure 6 shows. Vanpools and carpools are among the most economic means of urban commuter travel, substantially more efficient in terms of economic costs than many forms of public mass transit.

Roadway Design Should Encourage Carpooling

Roadway incentive can do much to encourage carpool and vanpool use. Examples such as reserved lanes leading to the San Francisco Bay Bridge, the exclusive lanes on the Shirley Highway in Washington and bypass lanes entering freeways in Southern California, have proven that such priority treatment is workable and works. Priority lanes for car and bus pools on city streets have been in operation since July in the Miami area, and have application in many cities around the country—if traffic engineers will seize the opportunity to make this important contribution.

Improved Urban Traffic Flow

Programs to improve urban traffic flow also merit consideration as fuel conservation measures. Each stop or slowdown increases fuel consumption. In urban driving, stops can easily double fuel consumption.
and increase travel times 10% to 40%. Five stops in one mile of
driving will cut gasoline mileage by about a third, on the average.

Studies have shown that stop-and-go driving and other traffic
delays can be reduced by improving traffic regulations and controls.
In Los Angeles, travel times improved 20% to 25% on streets
where new techniques of traffic signal control were used. A study
in Inglewood, California, found that retiming signals in the 60-
intersection system would result in up to a 71% reduction in vehicle
delay and a 13% reduction in stops. This traffic improvement would
result in a 19% fuel saving for daytime users of the system.

Traffic control measures like these will not eliminate all inefficient
fuel use. However, these measures can save fuel.

Studies by the federation staff lead us to believe that utilizing
traffic engineering techniques with which we are all familiar, can
increase urban auto efficiency and conserve 1% of the nation's highway
fuel. Other benefits in increased capacity and a higher level of travel
service are obviously desirable byproducts.

DRIVERS CAN INCREASE GAS MILEAGE

There are several things drivers can do to get better gas mileage.
Among these are keeping his car properly tuned, driving smoothly in
traffic, switching to radial tires, and planning combined trips.

Periodic Tune-Ups

Periodic tune-ups are a big help in saving fuel. Faulty ignition
timing can cut gas mileage and so can poorly maintained emission
control devices. Dirty air filters, misfiring spark plugs, and malad­
justed carburetors all can waste fuel.

Speed Reduction

Speed reduction is another energy saver. Although the current
maximum 55 mph speed limit has achieved travel speeds that are more
characteristic of a 60-mile limit than a 55 mph one, it has been an
effective fuel conservation measure. In the first six months of 1974
there were approximately 210 billion vehicle miles of travel on roads
where the 55 mph speed limit could be expected to reduce speeds. If
this travel had been made at the driving speeds that prevailed before
the energy crisis, an estimated 5.67 million additional gallons of fuel
a day would have been required. This represents a saving equal to
approximately 2% of the average daily use of highway fuel.
FACTORS AFFECTING VARIOUS URBAN PASSENGER TRANSPORTATION MODES

So far, we have talked about how to make the system work better. Now, let's consider how to make it work differently. One energy saving measure which has enjoyed widespread publicity is the potential fuel saving allegedly offered by shifting urban passenger travel from automobiles to transit. Because of considerable differences of opinion on the relative energy efficiencies of the various urban passenger transportation modes, I'd like to discuss the factors that affect these efficiencies in some detail.

Measures for Comparing Alternative Energy Efficiencies Needed

The relative energy efficiencies of the various transportation modes differ widely. Part of this is related to the type of service provided. For example, high-speed air service is less energy efficient than the slower service by bus or train. However, when the service provided is similar, shifts to a more energy-efficient mode can be considered. When considering a shift, direct measures for comparing the alternative energy efficiencies in actual operating conditions are needed. The Highway Users Federation commissioned a report* that develops comparison measures of this type. It examined most of the alternates for urban passenger transportation. Figure 7 shows the results.

The Measure—Passenger-Miles Per Equivalent Gallon of Gasoline

Passenger-miles per equivalent gallon of gasoline is the measure used to compare the energy efficiency of alternate modes. This measure is the product of the vehicle efficiency, expressed as vehicle-miles per equivalent gallon of gasoline; and system-use-efficiency expressed as passenger-miles per vehicle-mile. The efficiency measures in the report are not theoretical. They are based on the best available measurements of real world operations.

Must Consider the Entire Work-Trip System

To make a realistic comparison of energy efficiencies of typical work trips, how the passenger gets to the rail or bus service must also be considered. A complete look at the efficiency of the system must account for the total trip, including feeder lines, auto use, and other mixes.

---

Mass Transit Efficiency Better in Bigger Cities

The range in system-energy-efficiencies indicates how urban area size and development limits the energy savings that may be expected through modal shifts. As those factors determine to a great extent the magnitude of major corridor trip making, they also limit the level of transit use.

For example, bus transit, with the same vehicle efficiency in large and small cities, has significantly different energy efficiencies in different size cities. Peak hour operation in large cities is more energy efficient, 93.1 passenger-miles per gallon, as opposed to 46.6 in small cities, because of higher average loadings. The same is true for rail transit as shown by the rail-walk bar which represents Chicago and New York as the two extremes of the range. The BART system falls about in the middle near the 70 figure shown for vans. These differences in relative energy efficiencies have to be taken into account when planning and funding national programs for urban transportation.

Savings in Diversion of Auto Passenger Miles to Buses

Considering the relative small energy savings shown in Figure 5, a reduction can be achieved by a shift to transit. The magnitude is dependent upon the amount of diversion to transit that can be expected. This was the subject of a study by the Transportation Systems Center of the U.S. Department of Transportation.†

The study investigated the potential diversion with a major program to expand the number of buses in service and increase the number of riders per bus. Even with these service improvements, it was estimated that no more than 10% of riders would divert from auto to bus travel. With this diversion, the energy saving would amount to about 1% of the total fuel used in transportation.

For intercity passenger trips, the Transportation Systems Center study estimated that a 6% diversion of auto passenger miles to buses might be possible. This diversion would result in saving .5% of total transportation fuel.

SUMMARY

In summary, highway transportation can and should contribute equitably to a national goal of energy conservation—but it can't do it all! All highway fuel is less than 20% of the total energy used annually, and much of this cannot be diverted without affecting the basic fabric of our society.

The objective of a successful program should be to conserve fuel but preserve mobility: to practice conservation not austerity. The program should allow each American maximum latitude to determine which contributions he will make to the common goal. Such a program cannot be mandated but reasonable goals can be reached.

Highway and traffic engineers can do a great deal to see that these potential conservation efforts come about. In some cases this may mean doing some new things. In other cases it means doing some old things but doing them better. In all cases it means approaching the work and the responsibilities which each of us have with a view toward energy conservation as a vitally important national and personal goal.