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# 11. ENERGY CONSERVATION
# Transportation

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FACTSHEET

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## INTRODUCTION

The transportation sector is a prime conservation target. It accounts for one quarter of our annual energy consumption, it uses energy inefficiently and primarily uses oil.

Of the 71.1 Q Btu* of energy consumed by the American economy in 1975, 18.5 Q Btu was used in transportation and 17.7 Q Btu (96 percent) was oil-derived; gasoline for automobiles, diesel fuel for trucks, trains, and buses, or kerosene for jet airplanes. The internal combustion engines which predominate in transportation are not very efficient, only about 15 percent of the fuel energy is actually used to move vehicles. It is not, of course, possible to build 100 percent efficient engines, but there is much room for improvement.

Transportation figured importantly in the conservation efforts of the '73-'74 Oil Embargo period. The national speed limit was lowered to 55 MPH and efforts were made to reduce the number of miles travelled. Both these efforts succeeded in part. The average speed of automobiles on interstate highways declined by 7.5 MPH in 1974 and total miles travelled during the first 8 months of 1974 were 4 percent lower than the similar period in 1973. Gasoline consumption was reduced by 3.4 percent. An appreciated side effect of the lowered speed was a 17 percent reduction (9,500 fewer deaths) in highway facilities.

While the savings from these energy measures were important and continue to have an effect (the 55 MPH limit is still Federal Law) there are many other ways to reduce consumption.

## RESOURCES AND STRATEGIES

The resources of this technology are the barrels of oil saved. The oil and oil-derived fuels used in transportation in 1976 was 20 percent more then we imported. As is shown in the illustration below, most of that fuel (60 percent) is used in automobiles and the automobiles' dominance has been increasing.

Urban and intercity passenger travel has doubled since 1950. Intercity bus transport has dropped from 5 percent of the total passenger miles in 1950 to 3 percent in 1970 and rail from 7 percent to 2 percent. Air travel, on the other hand, has increased. In urban travel, bus transport has dropped from 20 percent in 1950 to 2 percent in 1970. It is clear that many of the conservation strategies will focus on the automobile.

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*Q, quadrillion Btu's. Energy units and other technical terms are described in the Glossary, Fact Sheet #18.

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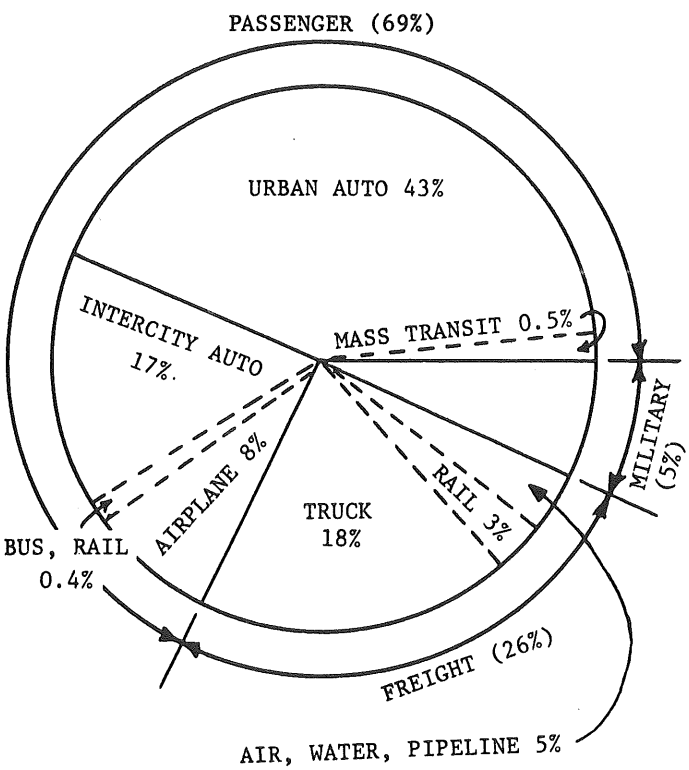
Distribution of Transportation
Fuel Uses-1972




Moving people efficiently: Transportation has two purposes, moving people and moving things. We spend the largest fraction of transportation energy on people. We have already discussed engine efficiency but a more pointed measure is the energy per passenger mile shown below.

The energy price we pay for speed and convenience is evident.

There are three strategies which can bring about more efficient passenger transport. "Load factors", the percentage of capacity carried in a car, plane, or bus, can be increased, engine efficiencies can be improved, and we can try to switch passengers from one mode to another (from the urban auto to mass transit, for instance).

Carpooling is an attempt to improve urban load factors from the present 28 percent (an average of 1.4 passengers in a 5 passenger car). The convenience of driving alone to work and the subsidized parking provided by many employers, however, works strongly against this improvement and little progress has been made.

The overall efficiency of a car as measured in miles per gallon (MPG) depends more on car weight and add-on systems such as air conditioning, automatic transmission and, lately, emission control, than on the engine itself. The national average has dropped over the years and was down to 13.9 MPG in 1974 as compared to 15.5 MPG in 1967. It improved slightly to 15.6 MPG in 1975 and rather dramatically to 17.6 MPG in 1976. While lighter smaller cars contributed to this improvement, a significant share of the credit belongs to the improvements in emission control due to the catalytic converter.

ENERGY DATA FOR PASSENGER TRAFFIC - 1970

Inter-City

| Mode | Average Passenger Capacity | Average Load Factor | Energy Cost (BTU per passenger mile) |
|---|---|---|---|
| Railroad | 69/car | 35% | 2,900 |
| Bus | 41 | 45% | 1,600 |
| Automobile | 5 | 48% | 3,500 |
| Airplane | 106 | 50% | 8,400 |

Urban

| Mode | Average Passenger Capacity | Average Load Factor | Energy Cost (BTU per Passenger mile) |
|---|---|---|---|
| Bicycle | 1 | 100% | 200 |
| Walking | -- | -- | 300 |
| Rail (Trolleys, Subways) | ? | ? | 2,300 |
| Bus | 55 | 20% | 3,800 |
| Automobile | 5 | 28% | 8,500 |

The improvements should continue, and the Federally mandated "sales weighted average"* of 20 MPG by 1980 and 27.5 MPG by 1985 should be achieved. Much of the improvement will be brought about by the reductions in weight; each 400 lb. reduction in a medium sized car produces about one MPG improvement. (Considerations of safety and rideability will ultimately limit this approach). We will eventually see new engine designs and are already seeing increased use of the more efficient diesel engine.

* "Sales weighted average" - The average MPG of all the cars sold by a given manufacturer in a certain year.

Changes in modes of travel could have significant effects but come slowly. The number of mass transit riders was 6 percent greater in 1974 than in 1973 but some of those passengers apparently shifted from walking rather than from automobiles. Mass transit, in fact, has such a small share of the market that even doubling its share will not make a big dent in energy consumption. New transit systems and improvement in older systems will likely have to be combined with penalties for automobile use before a shift to transit becomes an important part of the conservation picture.

The FEA estimates of possible savings (in bbls of oil/day) of three of the measures we have discussed are shown below. The total potential savings are greater than our present domestic oil production.

Energy Impacts of
Transportation Conservation Measures

| Measure | Estimated Fuel Savings in 1980 (bl/day) |
|---|---|
| Increased new car fuel economy by 40% between 1974 and 1980 (20 MPG in 1980) | 690,000 |
| Increased rush-hour auto load factor from 1.2 to 1.6 (carpooling) | 440,000 |
| Double fraction of urban travel carried by transit from 2.5% in 1973 to 5% in 1980 | 52,000 |
| | 1,182,000 |

In intercity travel, the automobile is used a bit more efficiently, averaging 2.4 passengers. Shifting to trains or buses would still save considerable energy. Airplane travel is both the most energy intensive and the most rapidly increasing form of intercity travel. The reduction of airline routes and other measures introduced in the past few years have resulted in some savings, a 13% reduction in fuel use in 1974 over 1973 was reported. In the long run, we may have to approach energy conservation by marking out certain distances for different types of transportation, emphasizing autos for 100 miles or so, trains and buses for 100 to 500 miles and airplanes for the longer distances, for instance.

Moving things: The energy efficiency of various freight modes is shown below.

| Mode | Energy Cost (Btu's needed per ton-mile) |
|---|---|
| Waterway | 680 |
| Pipeline (oil) | 1,850 |
| Railroad | 700 |
| Truck | 2,800 |
| Airplane (domestic) | 62,000 |

The data shows the energy penalty we pay for the door to door delivery by truck and the speed of air freight. These are our most rapidly growing modes of freight transport.

We are somewhat limited in conservation strategies for freight transport. Load factors are already high in most cases. Trucks do get better gas mileage at 55 MPG (in spite of all the controversy) but they move less tons per mile per day this way. There are some aerodynamic improvements possible in truck design (reductions of air drag) which could save 10 percent or so of their fuel. Larger gains, however, would come from shifts between modes, from trucks and planes to trains, for instance.

## NEW TECHNOLOGIES

In spite of the persistent rumors, there are no ultra efficient new engines hidden in the automobile companies' patent files. What we will see, in the near future, are many small improvements such as the electronic ignitions, stratified charge engines, etc. which are already being marketed. There is also considerable ERDA support for longer range improvements. A new, continuously variable transmission which could improve fuel economy by as much as 26 percent is under development. Two new engines, the gas turbine and the stirling engine are receiving much attention. In the gas turbine high velocity, hot gases from fuel combustion turn a turbine. A 100-horsepower version of this engine is being tested by Chrysler, in a compact car in 1977. The Stirling engine is an external combustion engine. The fuel is burned outside the cylinder and the hot, high pressure is then used to drive the piston. Both these engines have important advantages. They can burn any kind of fuel including non-petroluem fuels such as alcohol. They will be more efficient and much cleaner than the gasoline or diesel engines and will not require emission controls.

Electric cars: In many ways, the ideal engine for transportation would be electric. It is efficient, quiet, does not emit pollutants and does not use oil-based fuels. Although the electric vehicle has a long history, and is marketed today, it does not really compete with gasoline powered vehicles.

The major unsolved problem of the electric automobile is energy storage. The common lead-acid automobile storage battery is too heavy. It does not store enough energy per lb., cannot be discharged and recharged enough times, and is too expensive. Lead batteries account for 40-50 percent of the weight of existing electric vehicles and the set, which costs about $600, needs replacing every 3 years or so. We discuss in Fact Sheet #16, "Energy Storage Technology" new batteries, and the fuel cells, which may solve some of these difficulties.

Work is also ongoing on such refinements as "regenerative braking: slowing the vehicle by running the motor as a generator to recharge the battery. With its higher efficiency and the fact that it could largely draw on the nighttime capacity of large power plants, the use of electric autos in urban situations could save considerable energy. It has been estimated that for each one percent of urban passenger car miles taken over by electric cars, 4 billion kw-hrs of electricity would be consumed and 12.6 million barrels of gasoline saved. If it is further assumed that the electricity is produced in a relatively pollution-free way, the potential improvement becomes most attractive.

Other new technologies: By the next century, an even more interesting substitution of electricity in the transportation sector may take place - video communication instead of business flights. It appears that in many of the knowledge or information industries (insurance, finance, education, government, etc.) face-to-face telecommunicators may eventually replace physical meetings. The energy savings potential is great. It is estimated, for instance, that a gallon of gasoline used in an automobile is equivalent in energy to that required for 80 hours of telephone conversation. This may turn out to be the most practical way to replace gasoline by electricity.

SUMMARY

The transportation sector uses one quarter of our total energy directly (at an efficiency of about 15 percent), and as much as 40 percent of the total if indirect energy consumption is added in. It uses a premium and scarce fuel.

Many of the strategies we have described will require changes in attitudes and lifestyles in the private sector but even those which seemingly call for Federal intervention face a dispersal of responsibility across many Governmental Departments and Agencies.

ERDA has set aside, in FY77, $161 million for energy conservation, out of its $6.34 billion total budget. About $28 million of this is to be used to improve transportation efficiency largely through the development of new engines. The targeted goals of energy savings from more efficient use in transportation are 1 to 1.5 Q Btu in 1985 and 9 Q Btu in the year 2000. As we have said, it is quite likely that efforts along social and political lines could produce even greater savings than these purely technological ones. Considering transportation's negative contributions to energy consumption, to the oil shortage and air pollution, a national conservation effort in this sector is urgently needed.

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2. "Energy Consumption for Transportation in the U.S.", Eric Hirst, Oak Ridge National Laboratory, ORNL-NSF-EP-15.

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