THE OUTLOOK FOR TRANSPORTATION ENERGY

An Overview and Summary of Conservation Plans in Virginia

by

Woodrow J. Halstead
Consultant

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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FOREWORD

This report gives a preliminary evaluation of some of the factors involved in transportation energy and the potential effect of expected changes in the energy situation on the programs and the operations of the Virginia Department of Highways & Transportation. The objective is to provide a general understanding of the broad aspects of the energy problem and to make the Department's administrators and others aware of the ongoing effort directed at the problem by the Research Council. Although reference is made to ongoing efforts by the operating divisions, the report does not include the total energy related activities of the Department of Highways & Transportation. Groups involved in activities not within the scope of this project may well have other energy related projects planned or under way. More detailed analyses, conclusions, and recommendations will be included in subsequent reports of this or related studies conducted by the Research Council.

ABSTRACT

This report gives a preliminary evaluation of some of the factors involved in transportation energy and the potential effect of expected changes in the energy situation on the programs and the operations of the Virginia Department of Highways and Transportation. The objective is to provide general understanding of the broad aspects of the energy problem and to make the Department's administrators and others aware of the ongoing effort directed at the problem by the Research Council.

The present program includes a study of the energy conservation opportunities in four general areas:

1. Highway Construction and Maintenance

2. Highway Operations

3. Highway Lighting

4. Operation of Highway Department Facilities

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INTRODUCTION

A general review is being conducted of the potential effects of changes in the availability and costs of energy on the operations and plans of the Virginia Department of Highways and Transportation. An overview of energy concerns at the national level makes one realize how energy affects all aspects of our lives – from the amount of hot water used in the shower, to the availability and cost of food, to the price of gasoline.

The complexity of the total energy problem emphasizes the need for planning and coordination at the national level. A recognition of this need is indicated in the national energy plan that President Carter has submitted to Congress. This comprehensive plan is controversial in a number of aspects and is the subject of much debate in Congress. The debate, however, centers around the level of federal government action or the feasibility of certain features of the plan. There is little, if any, disagreement that a coordinated effort affecting all elements of the national economy is needed. Nor is there disagreement with the basic data presented in support of the national energy plan that point unmistakably to the serious consequences of a do-nothing attitude.

Thus, while at this writing the details of the federal program have not been determined, it is desirable that all state and local governmental agencies associated with activities consuming major amounts of energy assess their potential roles and probable effectiveness in present or future efforts to conserve energy and to develop programs that will reduce dependence upon petroleum and natural gas. In particular, there is an immediate need to assess the opportunities to conserve energy within present systems and to implement proven energy saving procedures or initiate research and development to obtain needed additional information relating to such procedures. Research and development should also be initiated to develop systems and techniques that use less energy or energy from less critical sources than now used.

To properly understand the energy situation with respect to transportation, it is first necessary to establish the relationship of transportation to the total energy picture. Accordingly, this preliminary report provides a summary of some of the major considerations involved and a discussion of some of the constraints blocking easy solution to problems.

ENERGY USE AND SOURCES

A number of reports are available that present statistics on the uses of energy by different economic sectors and the amounts of energy contributed by different sources. In general, the figures given in these reports are consistent with each other within a few percentage points. However, for the major part the statistics quoted in this overview have been taken from the National Energy Plan(1) submitted by President Carter to Congress; the pamphlet entitled "Energy in Focus: Basic Data",(2) which was prepared by the Federal Energy Administration for use by James F. Schlesinger, Jr. in developing the energy proposal for President Carter; or from the NCHRP Synthesis Report 43 on "Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation".(3) The viewpoint expressed by Kash and his coauthors in their report on "Our Energy Future"(4) is reflected in the guidelines with respect to constraints and needed research and development at the national level.

The "common denominator" used in most reported energy analyses in the United States is the Btu, which is, of course, the amount of energy (heat) required to raise the temperature of one pound of water $1^{o}F$. Since this unit represents a relatively small amount of energy, the multiple unit "quad" is often used as the basis for broad energy analyses. A quad is one quadrillion (10^{15}) Btu's (1.055×10^{18})J. It takes 172 million barrels (27.5 million M^3) of oil to supply one quad of energy.

The change in the pattern of fuel use over the last century is depicted in Figure 1 from reference 1 . The indicated changes in percentages of energy from different sources reflect the relative cleanliness and convenience of petroleum fuels for the generation of electricity as well as the advent of the "automobile age", which is based almost entirely on petroleum fuels. Figure 1, however, fails to show the very large increase in total energy consumption during the period covered. Data presented in "Energy in Focus: Basic Data" show that in 1900 a total of 9.6 quads (10.1×10^{18}J) of energy from all sources were used.[2] In 1976 the total energy consumption was 74.2 quads (78.3×10^{18}J), an eight-fold increase. This increase in overall energy consumption is also illustrated by the fact that the energy derived from coal increased from 6.8 to 13.7 quads (7.2 to 14.5J), even though the percentage of the total represented by coal dropped from 71.3% to 18.6%. In 1976, petroleum and natural gas were the sources of 74.5% of the total energy used. These data are given in Table 1, which includes figures for various years from 1860 through 1976.

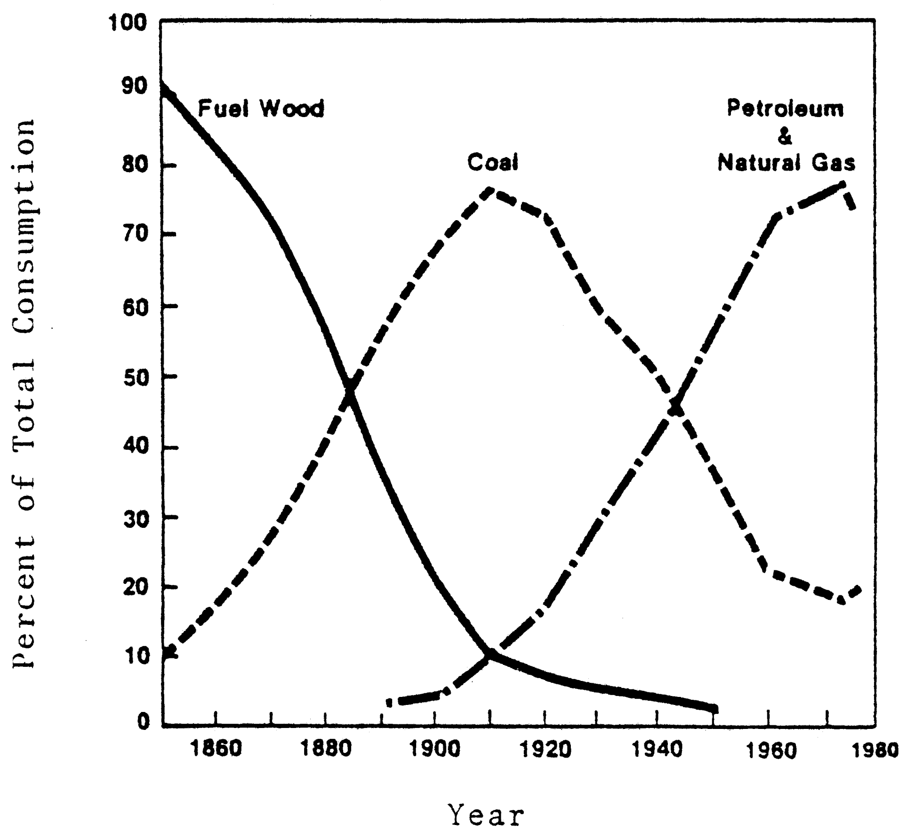


Figure 1. The United States has shifted fuel use patterns. Source: U.S.Bureau of Mines and Federal Energy Administration.[1]

Table 1

Historical Energy Consumption Patterns — 1860-1976

Year	Total	Fuel Wood		Coal		Petroleum and Natural Gas		Hydropower		Nuclear	
	quads	quads	percent	quads	percent	quads	percent	quads	percent	quads	percent
1860	3.1	2.6	83.5	0.5	16.4	—	0.1	—	—	—	—
1880	5.0	2.9	57.0	2.0	41.1	0.1	1.9	—	—	—	—
1900	9.6	2.0	21.1	6.8	71.3	0.5	5.0	0.3	2.6	—	—
1920	21.3	1.6	7.5	15.5	72.8	3.4	16.1	0.8	3.6	—	—
1940	25.0	1.4	5.3	12.5	50.1	10.2	40.9	0.9	3.7	—	—
1950	34.0	1.2	3.3	12.9	36.7	19.7	55.9	1.4	4.1	—	—
1960	44.6	—	—	10.1	22.8	32.8	73.5	1.7	3.7	—	—
1970	67.1	—	—	12.7	18.9	51.5	76.8	2.7	4.0	0.2	0.3
1975	70.6	—	—	12.8	18.2	52.6	74.6	3.2	4.6	1.8	2.6
1976	74.2	—	—	13.7	18.6	55.2	74.5	3.1	4.2	2.0	2.7

Sources: Bureau of the Census; Bureau of Mines.

The relative position of transportation energy is illustrated by Table 2, which gives a breakdown of the 1976 energy consumption in terms of various major economic sectors.

Table 2

Energy Consumption by Major Economic Sectors

Commercial/residential	–	20.2 percent
Industrial	–	25.4 percent
Transportation	–	25.6 percent
Electricity generation	–	28.8 percent

Source: Table 1-D in "Energy in Focus: Basic Data"(2)

Figure 2, taken from the National Energy Plan,(1) depicts the sources of the energy for each sector. In this presentation the energy for electricity generation has been prorated between the commercial/residential sector and the industrial sector and added to the amounts shown. Very little electric energy is presently consumed in transportation as is indicated in Figure 2. Figure 2 shows that in 1976 the transportation sector consumed the equivalent of 9.5 million barrels (1.52 million M^3) of oil per day. This figure includes both gasoline and diesel oil as well as the energy consumed in refining them. Another source (Table II-B, reference 2) indicates that the actual amount of gasoline alone used in 1976 was 7.0 million barrels (1.12 million M^3) per day.

According to the statistics given in reference 2, the petroleum products used in transportation in 1976 amounted to 42% of the total 17.4 million barrels (2.78 million M^3) per day of refined petroleum products used in the United States.

Despite current efforts to convert electric generation plants and other industrial processes to the use of coal in lieu of oil or gas, and efforts to conserve energy in all fields, all projections show that the total number of barrels of petroleum products consumed each day is likely to continue to increase over the next 7-8 years. This fact indicates that the amount of oil imported by the United States will also increase.

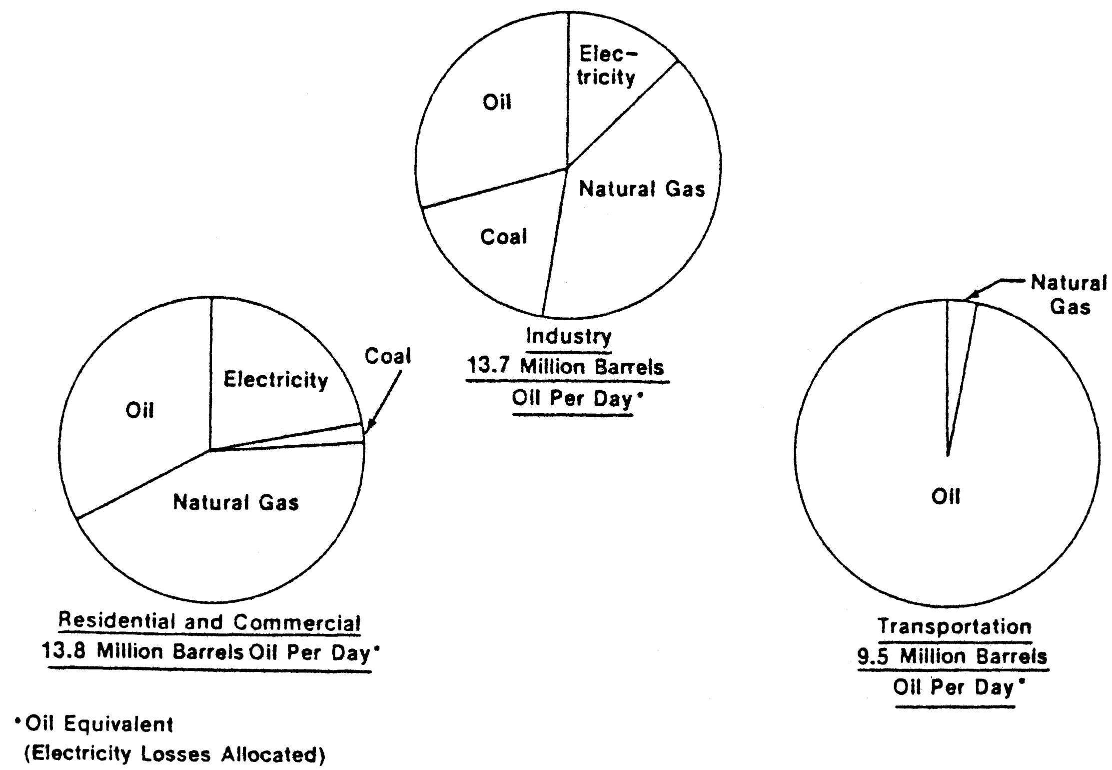


Figure 2. U. S. energy consumption by sector and source, 1976. Source: Federal Energy Administration(1).

The total recoverable world oil resources, past and present, are usually estimated to be about 2 trillion barrels (0.3 trillion M^3).(1) More than 360 billion barrels (57.6 million M^3) have already been consumed. At the present time proven crude reserves are estimated to be 600 million barrels (96 million M^3). Since 1940 world consumption of oil has grown at an average rate of 6.6%. Obviously, this high rate of increase, which is compounded each year, cannot continue. The National Energy Plan report states that, "Even assuming that the annual rate of increase could be reduced to 3% and if it were possible [which it is not] that production could keep pace with that rate of growth, the world's present estimated recoverable resources would be exhausted by 2010." The report further points out that despite the uncertainty with respect to the rate of future consumption the bulk of the world's supply of oil created over hundreds of millions of years will have been substantially consumed within about four generations.

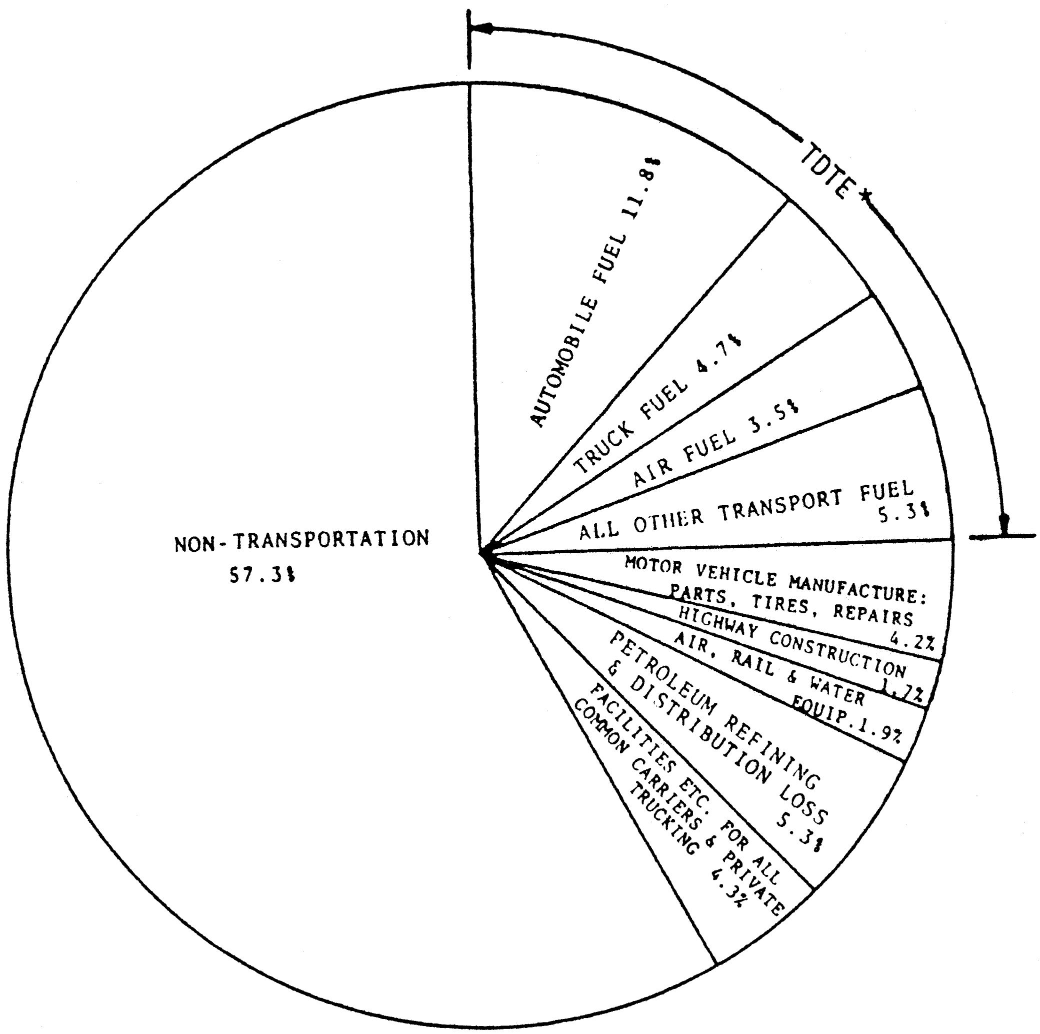
In view of these fundamental facts it becomes obvious that neither the United States nor the rest of the world can long continue to rely on petroleum and natural gas for the bulk of its energy. As pointed out in the energy report to Congress, immediate action is required.

While there are a number of political implications in the federal energy plan which are not discussed here, the basic strategy of the plan is to immediately, or as soon as possible, reduce U. S. dependence on foreign oil and the country's vulnerability to interruptions in the supply. In the medium term the need is to keep U. S. imports low so as to weather the period during which oil production reaches its capacity and begins to fall off; in the long term the objectives are to have renewable and essentially inexhaustible sources of energy for sustained economic growth. To accomplish the aims of the national energy plan, it is first necessary to practice energy conservation in all areas of the economy since, in essence, elimination of waste is the most economical of new sources of energy. Examples of some of the measures that have significant payoff are the reduction of gasoline consumption by building more efficient cars and by more economical travel practices; improvement in home insulation; and conservation through maintaining heating thermostats at 65°F (18.7°C) in winter and cooling thermostats at 78°F (25.5°C) in summer. A second significant part of the plan is to promote the use of coal or other more plentiful sources of energy in lieu of oil or gas for industrial uses and the generation of electricity. A third part involves development of new energy technologies based either on renewable (solar) sources or basically inexhaustible (nuclear fusion) sources.

SPECIAL CONSIDERATIONS PERTAINING TO TRANSPORTATION ENERGY

As indicated in the breakdown of energy uses cited earlier, direct transportation energy represents about one-quarter of the national energy use. However, when the indirect energy related to transportation is also considered, the total rises to 42.7% of the energy consumption.(3) The indirect energy is that used in the manufacture of transportation components (planes, autos, buses, trucks, tires, highways, terminal facilities) and refining and distribution losses. The relative amounts of energy used for the various elements is depicted in Figure 3, which is taken from the NCHRP Synthesis Report No. 43.(3)

The various components of the direct transportation energy are shown in Figure 4, which is also taken from reference 3. As indicated, the highway component amounts to 75% of the total — 68% being attributed to cars and light trucks and 7% to heavy trucks and buses.



*TDTE - Total Direct Transportation Energy

Figure 3. Components of transportation energy as a percentage of total energy used. Source: NCHRP Report No. 43.(3)

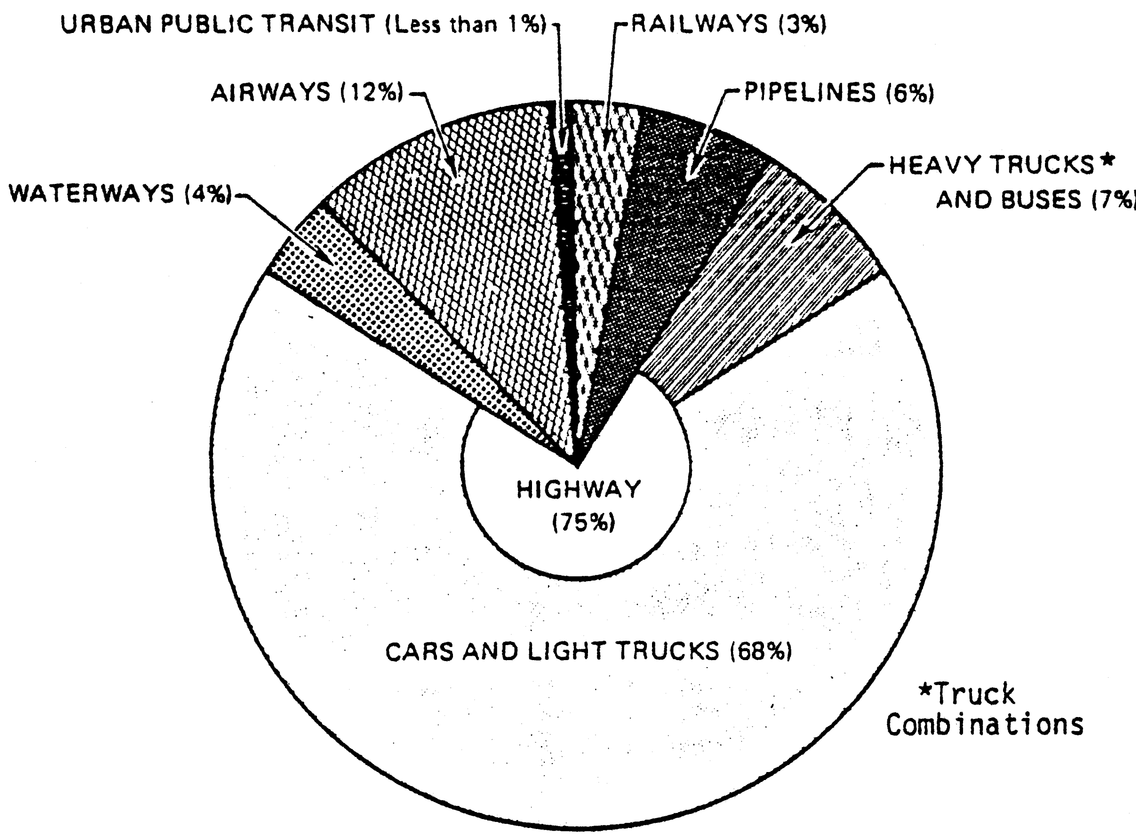


Figure 4. Components of direct transportation energy, 1972. Source: NCHRP Report No. 43.(3)

The most recent information issued by the Federal Highway Administration shows that in 1975, 113.6 billion gallons (18.2 billion M^3) of motor fuel (gasoline plus diesel oil) were consumed. This is an average of 311.2 million gallons (1,183 million litres) per day. Perhaps the enormous size of this daily quantity can be better understood by a hypothetical calculation. If only one pump were available to dispense such fuel and each vehicle was to receive 20 gallons (76 litres) to fill its tank, a total of 15,560,000 vehicles would be required. Allowing 30 feet (9.1 m) for each vehicle, the line formed would be over 88,000 miles (141,000 km) long, or about 3.5 times around the earth at the equator.

The above illustration emphasizes the great impact of highway transportation on energy consumption in general and on the consumption of liquid fuel from petroleum in particular. Such figures also explain why it is important to increase the efficiency of highway transportation through both increased occupancy of the vehicles and increased efficiency in miles per gallon for each vehicle. For example, an average increase of 10% in miles per gallon for each vehicle would result in savings of approximately 4% of the petroleum energy used annually. This latter amount is more than double the energy used annually in all highway construction and maintenance activities. One should not conclude from this example that conservation in construction and maintenance activities are unimportant — all efforts are needed. While some activities are not sufficiently repetitive to make a national impact on energy consumption, the net result of energy conservation for any specific activity or project is a monetary saving which, in most cases, will be in proportion to the energy saved.

STATE CONCERNS

From the standpoint of the Virginia Department of Highways and Transportation, it is necessary to look at two broad questions. These are:

1. How can the Department best spend its dollars to attain an overall reduction in the use of energy for the total transportation system and still maintain satisfactory levels of service?

2. How can the Department best reduce the amount of energy used in its own operations and thereby reduce the costs of providing the required facilities and service.

The first question involves such activities as widening or rebuilding pavements to eliminate traffic congestion, installing better control devices to achieve an even flow of traffic by eliminating starting and stopping, promotion of car pools, and provision of special bus lanes for mass transit. All of these activities provide savings to the people using the facility. These savings accrue to each person involved each time use is made of the facility so that the overall impact on the state or national use of energy is significant.

The second question relates to general construction and maintenance activities and the operation of facilities. Included are such items as the amount of energy used for fuel in vehicles, heating and cooling buildings, etc. The energy savings involved in each of these activities may not have a significant impact on the total national energy use, but they do have a large impact on the operational budget of the Department because energy savings translate into dollar savings.

In the overall analysis it is important that no opportunity to conserve energy be overlooked. However, care must be taken to consider the long-range impacts of conservation measures. Failure to provide funds (and energy) for adequate maintenance or needed new construction could ultimately result in the waste of much greater quantities of energy than that "saved" by curtailment of construction or maintenance activities.

It is also true that all modes of transportation are important and that each must be considered. In the total program it will be necessary to consider the impact of trade-offs between modes — especially the transportation of goods by water and rail in lieu of by the highway.

RESEARCH COUNCIL PROGRAM

As its initial effort in the energy field, the Research Council is conducting a state of the art review in four specific areas relating to highway transportation. These are:

1. Highway construction and maintenance.

2. Highway operations and traffic control.

3. Highway lighting.

4. Operation of highway department facilities.

A separate report or documentation of a specific course of action is planned for each of the subject areas listed. These reports will set forth the energy saving alternatives that are available to Department administrators or will indicate those areas where more comprehensive and vigorous research efforts are needed to define desirable courses of action. To the extent possible, summaries of ongoing efforts to conserve energy will be included.

Detailed discussions and conclusions in each of the indicated subject areas are not yet available. However, some broad observations within each are given in the following overviews.

Highway Construction and Maintenance

In the construction and maintenance area, the primary concept is that of optimizing the expenditures of money and energy to provide the needed transportation at the lowest long-term cost in energy and dollars. While energy considerations are a new dimension, the incentives to save energy are in keeping with the traditional incentives to hold costs to a minimum. It is inevitable that costs for a given type of construction will increase substantially as the cost of energy continues to increase, unless ways to conserve energy are found.

Contractors and materials suppliers can be expected to automatically seek ways to reduce costs by reducing energy consumption. The Department's obligation will be to assure that regulatory procedures or specifications don't prohibit the use of appropriate energy saving techniques. The Department will also be obligated to review all requests for specification changes made with the stated objective of saving energy to be sure that the durability of the final product is not sacrificed. Consideration must be given to not only first costs, but also to total lifetime costs, from the standpoints of maintaining the facility and of energy requirements for those people using it.

In this connection in some cases substantial increases in costs and energy consumption during construction might be justified by the increased energy efficiency of the user of the facility, resulting in long-term energy saving; for example, design and construction of a highway to a flatter grade.

Some of the possibilties to be discussed in more detail in the report for this subject area include the consideration of the use of more "wastes" and in-situ materials for subbases and base courses. For example, the use of fly ash or lime-fly ash stablized layers provides the possibility of disposing of fly ash that otherwise would accumulate as a waste product while at the same time saving energy in transporting conventional material to the job site. Likewise, where the use of in-situ materials is possible, stabilization can result in large savings in energy otherwise needed to carry away unwanted material and bring in new material. A closer look at the materials and energy savings resulting from recycling is already under way. These projects need to be evaluated on a case by case basis, because if the material must be hauled from the job site for processing and then returned, the expected energy saving will not always be realized.

Another consideration for the long-range situation is that the supply of asphalt for paving purposes has a very high probability of decreasing substantially as petroleum sources are depleted. Consequently, it is likely that alternate materials and procedures for construction and maintenance will be needed. Fortunately, there now are certain restraints that prevent all asphalt from being converted to heavy fuels; namely, the limitations of existing refining processes and the high sulfur content of many petroleums. Present refining techniques cannot completely remove sulfur and tend to concentrate this element in the residual during refining. Under present conditions many residuals cannot be burned as fuel because emission standards for sulfur dioxide cannot be met. Consequently, it is advantageous to market such products as paving asphalts. How long this situation will prevail cannot be predicted. Research is under way to develop more efficient sulfur removal techniques. When such techniques become available, the refiners will have more freedom of choice in marketing residuals or using cracking processes that would eliminate the asphalt fraction during refining. While the prospects are that there will be no sudden reduction in the availability of asphalt, ultimately, as petroleum is used up, the supply of paving asphalt will decrease. Inasmuch as considerable time is required to plan and conduct research and field test new materials and concepts, activity towards establishing acceptable alternatives to asphalt should be begun in the near future. Needed activities will be discussed in the subject area report.

Highway Operations and Traffic Control

In this second area, the primary concept is the implementation of various management strategies involving highway operations and traffic control to conserve energy through improved utilization of the existing transportation facilities. These strategies can be categorized as follows:

A. Improved vehicular flow by such techniques as improvements in signalized intersections, fully applied one-way streets, and the relocation of transit stops. Success of these actions can result in decreased congestion, increased average speeds, and reduced travel time, all of which mean energy savings.

B. Preferential treatment of high-occupancy vehicles, such as exclusive bus and/or carpool lanes on freeways or city streets. The decreased travel times and improved efficiency enhance the attractiveness and thus utilization of the high-occupancy modes, with associated energy savings.

C. Reduced peak-period travel by work rescheduling and peak-period truck restrictions. These types of strategies generally improve peak-period traffic flow and save energy by reducing the number of vehicle miles traveled.

D. Parking management, e.g., park-and-ride facilities and parking regulations. Strategies in this category generally tend to improve traffic flow and save energy by decreasing congestion and vehicle miles of travel.

E. Promotion of high-occupancy and nonvehicular travel modes such as ride sharing and human powered travel modes. The reduction in vehicle miles traveled improves the efficiency of the system, thus resulting in energy savings.

F. Transit and paratransit service improvements, such as transit shelters and extension of transit with paratransit operations. The aim of these types of actions is an improved level of service, with a resulting modal shift to high-occupancy modes and thus energy savings.

G. Transit management efficiency measures, through route evaluation, and maintenance policies. These types of measures are aimed at improving the internal operating efficiences of transit systems, with resulting energy savings.

It is apparent that many of the management strategies mentioned here as examples have been utilized for years. It has been only in recent years, however, that these strategies have been formalized by the U. S. Department of Transportation (DOT) into a Transportation Systems Management (TSM) element. As conceived by the U. S. DOT, this short-range element of the required urbanized area plan is designed to address the short-term transportation needs through improving efficiency in the use of existing transportation facilities. Based on the above abbreviated listing of TSM strategies, it is obvious that a primary benefit of implementing TSM strategies is direct energy savings through conservation. Further, many of the strategies have direct application in rural as well as urban areas. Therefore, it is quite logical to limit the discussion of energy and highway operations/traffic control to TSM actions.

From the standpoint of the Virginia Department of Highways and Transportation, the majority of TSM strategies relate to the question of how the Department can best spend its dollars to minimize energy consumption and provide the maximum benefit to the citizens of the Commonwealth and the United States. With some strategies, however, such as van pooling, the Department can achieve direct energy savings through in-house implementation. It must also be recognized that for some strategies – e.g., parking regulations – the Department's only role is to support and encourage action.

Accordingly, in the report on this subject, each TSM strategy will be described and then discussed in terms of the potential energy savings. Where possible, comments will be offered as to the feasibility of implementing the strategy in Virginia. Finally, recommendations will be given as to which strategies offer the best combination of feasibility and savings and which strategies warrant the Department's support (financial or otherwise) and possible in-house implementation, and as to which strategies require possible further research.

Highway Lighting

Efforts in the area of highway lighting will involve promotion and utilization of new technology already available, and will be accomplished in cooperation with the Traffic and Safety Division and other involved divisions of the Virginia Department of Highways and Transportation.

Considerable progress has been made in the development of lighting technology over the last 10 to 15 years, the most notable being improvements of the light sources. The most recent improvements have come in the development of the sodium vapor lamps. These lamps, which are the most efficient light source now available, were not widely used in their early years of production (during the mid 1960's) due to their relatively short life span. Gradual improvements, however, have now brought their life span up to a level that makes them competitive with the mercury vapor lamp, which is the type now most often used. The sodium vapor lamps provide twice the light of a comparable mercury vapor lamp for equal power consumption. Because significantly fewer sodium vapor luminaires (or lower wattage lamps) are required to provide the level of illumination produced by a comparable mercury lighting system, replacement of the mercury lamps with sodium vapor lamps is desirable strictly from the energy viewpoint. However, problems of the proper configuration and light patterns may be encountered. It will also be necessary to determine if the color of sodium light is acceptable in all locations.

Sizeable continuous roadway lighting systems that utilize mercury luminaires are now in operation on sections of interstate highways located in the Northern and Tidewater regions of Virginia. In addition, numerous interchanges and shorter sections of roadway are now illuminated in urban and suburban areas around the state. The conversion of some of the larger sections of mercury vapor lighting, such as those on Rte. 95 (Shirley Highway) in Northern Virginia and on Rte. 64 in the Norfolk area, would result in substantial energy savings and reduced power costs.

The ability to make the conversion to sodium lighting has been greatly enchanced by a recently established FHWA policy [see Federal Aid Highway Program Manual [(5)]] which makes the cost of the replacement of existing mercury luminaires on federal-aid systems eligible for federal-aid participation. Under this policy, preliminary considerations and planning for changeovers at specific locations could be initiated now. To consider the energy conservation and cost savings that might be gained through conversion from mercury to sodium lighting under the new FHWA policy statement, a meeting of the Council's informal lighting research advisory group has been held and action is now in the planning stage.

Additional factors that should be considered under this third subject area include an investigation of the possibility of obtaining off-peak hour energy at low rates and possible strategies for reducing, or turning off, roadway lighting during the seasons having longer daylight hours or during the hours of darkness when traffic volumes are low. There are many practical problems that have to be considered in any of these last mentioned alternatives and in many cases these problems control the decision making process. While all alternatives should be investigated, the most immediate and positive possibility for reducing the energy used in highway lighting is the conversion from mercury to sodium lamps.

Operation of Highway Department Facilities

Activity in the last subject area encompasses an assessment of the energy related factors associated with the operation of Department facilities. Included are buildings, tunnels, and motor vehicles operated by the Department. The objective is to identify major points of energy consumption, evaluate the possibilities of realizing energy savings without undue increases in long-term costs, and to recommend design or operational changes in those areas where progress in energy conservation appears likely. It is anticipated that the major thrust will be concentrated in the areas listed below.

A. Buildings

1. Space Heating
    - a) Insulation and structural and aesthetic design features
    - b) Heating and cooling systems
2. Lighting Systems
3. Hot Water Supplies

B. Tunnels

- a) Ventilation system
- b) Lighting system

C. Motor Vehicles

- a) Alternate fuel sources
- b) Alternate power trains
- c) Fuel economy measures
- d) Optimization of vehicle usage

It is emphasized that there is no intent to carry out extensive research projects in any of the above areas. Rather, information will be gathered and general assessments will be made of the Department's status in each area. More in-depth studies may be proposed in certain areas if a need is indicated.

Recent conversations with operations personnel have provided some insight into the present activities of the Department regarding matters falling within the fourth subject area. A brief summary follows.

All new buildings are now being designed to comply with energy criteria established by the Virginia State Energy Office. Included are minimum insulation requirements, the use of thermopane glass, and the consideration of energy efficient heating systems (primarily heat pumps). Consideration is also being given to the installation of solar heated water systems for high hot water usage facilities and to the use of carpeted floors whenever service conditions permit.

Instructions concerning upgrading the energy efficiency of existing buildings have been issued to field offices. These instructions require the installation of storm doors and windows, the provision of ceiling insulation, the provision of wall insulation where feasible, and the consideration of highly efficient heating systems. Efforts are under way to install carpeting and wall insulation (over cinderblock) in office and high-occupancy areas.

Studies are already under way at the Research Council regarding alternate (higher efficiency) power trains for motor vehicles. Under consideration are diesel engines and electric vehicles. Any action taken by the operating divisions, beyond the general policies of pooling rides and discouraging nonessential trips, has not been identified.

SUMMARY

As is evidenced by the foregoing discussion, energy is everyone's business. Any action taken to reduce energy consumption is likely to have secondary effects on the economy. For example, a significant reduction in the use of gasoline through increased efficiency of the automobile will mean that a smaller number of people will be needed to dispense the gasoline. A drop in gasoline sales will adversely affect the tax base from which most of the highway funds now come. All such interrelationships must be dealt with eventually at state or national policy levels.

In construction and maintenance matters, the state must accept the initiative in conducting studies of needed changes based on the state's needs. The Department of Highways and Transportation must conduct its own research into ways for improving the utilization and operation of its highways, and the Department also needs to be certain that it is operating its facilities in the most energy efficient manner.

In other areas, such as those dealing with increased efficiency of automobiles or the development of alternative liquid fuels for transportation vehicles, the Department must react to developments and, where necessary, evaluate them for their usefulness to the state.

In all these areas it is difficult for the general public to sense the urgency of the energy situation, because the present economy is geared to full production and resources are still available to maintain present levels. However, everything points to increasingly difficult times ahead and there is a need for all governmental bodies to establish policy and programs now to minimize the effects of potential shortages. Such agencies also need to make ambassadors of its employees to convince the general public of the realities facing the country.

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