ENERGY RESEARCH AT THE VIRGINIA HIGHWAY AND TRANSPORTATION RESEARCH COUNCIL

by

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(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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GENERAL OBSERVATIONS

The Virginia Highway and Transportation Research Council has an ongoing program to keep abreast of matters involving the utilization and conservation of energy as they pertain to transportation facilities. As of October 1979, 13 reports have been published and work is under way on 8 studies. Included herein are the titles, report numbers, and summaries of the published reports and a listing of working plans by title and author for the ongoing studies. Copies of the reports and working plans not out of print are available without charge to city and county officials upon request.

While it is not possible to summarize all aspects of such research in a few statements, collectively these reports and the work done to date on incomplete projects have led to the following general observations.

1. Direct transportation energy — the energy required to move people and goods— amounts to about one-fourth of the total energy used in the United States. Indirect transportation energy — that required to build and maintain transportation vehicles and facilities — represents another 17%.

2. At the present time almost all of the direct transportation energy must come from petroleum — gasoline and diesel fuel. This amounts to about 9.5 million barrels of oil a day (about 400 million gallons).

3. Conservation efforts leading to decreased average use of gasoline or diesel fuel per vehicle in the transportation fleet have a significant effect on national energy consumption, since even a very small reduction in the average use per vehicle is multiplied by 100-140 million, the number of vehicles. Decreased consumption can best be attained by increased efficiency (more miles per gallon) in the operation of cars and trucks. A reduction of miles travelled per vehicle through car pooling or the elimination of other unnecessary

trips can also have a significant effect, if practiced by a large number of people.

4. Conservation efforts in highway construction and maintenance have a relatively small effect on total national consumption, but are very important from the standpoint of holding down costs in the face of rapidly increasing prices for energy.

5. Curtailment of highway construction or maintenance of the physical characteristics of streets and highways is not a valid energy conservation technique. Such action is likely to be counterproductive because it will increase the total energy used by decreasing the efficiency of the vehicles using the streets and highways.

6. Gasohol — 10% ethanol blended with gasoline — can be used as fuel in the present automobile fleet. However, without tax reduction incentives, this fuel is more expensive than 100% gasoline at the present time. In addition, the national manufacturing capacity for ethanol is not now sufficient to provide a significant supply of Gasohol in terms of reducing petroleum consumption. The technology is available for developing such capacity, but whether or not a major effort in this direction provides a viable approach to overall conservation of energy remains to be determined.

7. Other potential sources of fuel for transportation vehicles include liquefaction of coal, gasoline from shale oil, hydrogen, and electricity. All of these may eventually provide part of the solution of the problem of replacing gasoline from petroleum, but none of them are likely to be developed sufficiently to provide a significant reduction in the use of gasoline or diesel fuel from petroleum before the next decade — and more probably not until after the year 2000.

8. Solar energy has a potential for providing economical means of charging batteries for traffic counters and signal devices. Its use will be especially advantageous in remote areas not having access to a central power supply. Use of solar devices for heating asphalt emulsion supply tanks and for space and water heating in buildings also shows promise.

9. High pressure sodium vapor lamps for highway lighting are significantly more economical to operate than mercury vapor lights, and eventual replacement of the mercury lamps with

high pressure sodium lamps is recommended for highway lighting. For some locations in urban areas, the yellow color of the sodium lights may be unacceptable.

10. Adequate lighting in congested areas improves safety. However some reduction of lighting intensity may be appropriate to reduce costs.

11. For a state highway department the use of diesel engines in mid-capacity range trucks (e.g. 4-6 yd^2 dump trucks) in lieu of gasoline engines would be more energy-efficient and cost-effective. The saving in fuel costs over the life of the vehicle more than compensates for the initial higher cost of the diesel unit.

12. Significant savings in fuel costs and increased comfort to workers can be attained by proper insulation of buildings. Better regulation of thermostats — principally turning off heat and air conditioning when not needed — provides an opportunity for additional savings.

SUMMARY OF REPORTS RELATING TO ENERGY PUBLISHED BY THE RESEARCH COUNCIL

(1) "The Outlook for Transportation Energy: An Overview and Summary of Conservation Plans in Virginia", Woodrow J. Halstead (VHTRC 78-R17) January 1978

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 a general understanding of the broad aspects of the energy problem and to make the Department's administrators and others aware of the ongoing efforts directed at the problem by the Research Council.

The program outlined includes studies of the energy conservation opportunities in four general areas:

1. Highway construction and maintenance
2. Highway operations (transportation planning and systems management)
3. Highway lighting
4. Operation of highway department facilities

(2) "Some Energy Alternatives", Woodrow J. Halstead (article published in Bulletin of the Virginia Department of Highways and Transportation, Vol. 43, Nos. 1 & 2, November-December 1977)

This article discusses, in general terms, the potential and the major problems in the large-scale production of a number of systems suggested as alternatives to gasoline powered vehicles. Systems discussed include (a) gasoline from coal; (b) gasoline from shale oil; (c) methanol as a fuel for internal combustion engines; (d) electrically powered vehicles; and (e) hydrogen. It was concluded that all of these systems could be developed eventually as substitutes for some petroleum fuel now used but no single one is likely to be adequate as an only alternative. It was also concluded that significant contributions from these sources would not occur prior to the 1990's and possibly not before the year 2000.

(3) "Energy Use and Conservation in Highway Construction and Maintenance", Woodrow J. Halstead (VHTRC 79-R11) September 1978

This report reviews options for the conservation of energy in highway construction and maintenance. The objective of conserving energy was found to relate closely to objectives of conserving high quality materials and reducing costs. For overall energy efficiency, the best possible construction and maintenance procedures consistent with budgetary limitations and availability of materials are considered desirable.

Major conclusions are:

1. No major changes from present-day construction practices are needed.

2. Energy considerations should be a factor in planning and conducting research in all technological areas.

3. The best potentials for conserving energy in construction are increased use of mineral wastes and local materials; increased recycling for both asphalt and concrete pavements; and substitution of emulsions for cutback asphalts.

4. Because of the possibility of a reduced supply of asphalt in the future, long-range studies for minimizing the use of asphalt in highways are recommended.

(4) "Opportunities for Conserving Energy in Asphalt Paving Processes", Woodrow J. Halstead (VHTRC 79-R19) October 1978

This report discusses the potential for energy conservation in a number of activities related to the use of asphalt materials in highway construction. It is pointed out that not only should the total energy be

considered, but also the category of the energy involved. The categories suggested are (1) embodied energy, (2) transport energy, (3) construction energy, and (4) indirect energy. Transport energy and construction energy have a major direct impact on highway contractors, since such energy consists primarily of the fuel to operate hauling and construction equipment. The indirect and embodied energy categories are important from a national viewpoint, but with respect to highway construction are of concern only to the extent that they affect the cost and availability of materials.

Included are discussions of asphalt supply and costs; effects of substituting emulsions for cutbacks; the potential for energy conservation with drum mixing plants; energy saving through the use of asphalt stabilized aggregates; and energy considerations in recycling asphalt pavements.

(5) "Energy Concerns Relating to Highway Construction and Maintenance", Woodrow J. Halstead (VHTRC-RP11) March 1979

This paper presents a broad overview of energy concerns relating to highway construction and maintenance. It combines pertinent information from published Virginia reports (VHTRC 78-R17, VHTRC 79-R11, VHTRC 79-R19) as well as information from a report prepared for the Federal Highway Administration by the Texas Transportation Institute entitled "Ideas for Energy and Materials Conservation in Highway Construction"(FHWA-TS-78-237). The conclusions are summarized as follows:

1. The objective of conserving energy in highway construction and maintenance is closely related to the objectives of conserving the supply of high quality materials and reducing costs. Although the need to minimize the use of energy may alter the priorities of research and development programs, no radical change from present construction practice or existing research programs is likely to occur.

2. The increasing national interest in utilizing industrial wastes is based on conserving supplies of natural aggregates, conserving energy, and economically disposing of materials that might be harmful to the environment. The materials having the best potential for use in highways are mining wastes and fly ash and bottom ash from coal burning plants.

3. In situ base and subbase stabilization and utilization of local aggregates have long been objectives of soils and foundation studies and are already practiced to a considerable extent by a number of states. Traditionally, the concern has been to reduce costs. The cost reduction results primarily from conserving energy by reducing hauling distances. Stabilization with by-products (or waste materials) should be carefully evaluated since the use of these materials is also likely to conserve energy. Their use conserves natural resources by reducing the demand for new materials and may avoid environmentally undesirable accumulations of waste.

4. The energy saved in recycling pavements is usually incidental to the desire to reduce costs and the need to conserve supplies of high quality aggregates or to avoid the accumulation of solid wastes.

5. Because the use of asphalt cutbacks wastes energy and also creates pollution, continuing efforts are needed to minimize and eventually phase out their use in highway construction and maintenance. Efforts to improve emulsions and to develop improved construction techniques with such materials should continue.

(6) "Energy Conservation in Department of Highways and Transportation Buildings", Woodrow J. Halstead and Kenneth H. McGhee (VHTRC 79-R11) September 1978

This report reviews the policy of the Virginia Department of Highways and Transportation toward energy conservation in the operation of its buildings and recommends further measures for conserving energy.

The major conclusions are:

1. The established policy within the Department is to conserve energy whenever possible, and top level administrators support efforts to improve the energy-efficiency of all Department buildings.

2. In the design of new buildings the Department utilizes energy-conserving criteria promulgated by the State Division of Buildings and Engineering. Individual designs are reviewed by that Division only upon the request of the Department.

3. The program for upgrading the energy-efficiency of existing buildings is informal to the extent that, in the case of structures of lesser importance (area headquarters, etc.), the initiation of action is largely left to local field personnel who may not have the time for such planning. In addition, no special funding has been made available statewide to accomplish needed improvements. As a consequence, energy-conserving improvements often are coincidental to general renovation projects.

4. Increased productivity of personnel as a result of increased comfort levels may be a valid consideration when improvements to buildings are contemplated.

Recommendations include specific measures which can be taken by the Department at little or no cost or where payback within a relatively short time (5 years or less) can be expected.

A longer range program to upgrade the energy-efficiency of all existing buildings, which would be based on a study of energy usage for

various types of buildings and heating plants, is also recommended. Also, the savings from the installation of energy-conserving measures in typical buildings would be evaluated and considered in assigning priorities for capital improvements in other buildings of similar types.

(7) "Solar Energy Applications in Transportation Facilities - A Literature Review", Robin Russell (VHTRC 79-R20) October 1978

This report presents the results of a survey of the literature and other sources to determine the types of application that have been made of solar energy in the transportation field. The use of solar energy for powering automatic traffic counters, variable message signs, railroad crossing signals, bridge or pavement deicing, cathodic protection of bridge decks, and heating asphalt, as well as space and water, are all described. A list of references and a bibliography on solar energy are provided.

(8) "Opportunities for Energy Conservation in Transportation Planning and Systems Management", E. D. Arnold, Jr. (VHTRC 79-R24) November 1978

This report is a summary, based primarily on a literature review, of the energy-savings potential of the elements in the transportation planning process and systems management. Within the scope of long-range planning, the energy aspects of land use and mode of transportation were investigated, whereas for the short range the energy potential of the various transportation systems management strategies were considered. The role of the Virginia Department of Highways and Transportation in energy-saving activities was also considered. The report should be of value to transportation planners and traffic engineers as an overview of the energy-use characteristics of activities within transportation planning and systems management and as a resource document for detailed energy analyses.

(9) "Energy Conservation Alternatives in Roadway Lighting", Marvin H. Hilton (VHTRC 80-R8) July 1979

From a review of some of the possible methods of conserving energy in the operation of roadway lighting, with due consideration being given to traffic operations and safety under the current energy scenario, it was concluded that the most favorable conservation measure would be to replace the existing mercury vapor luminaires with the more energy-efficient high pressure sodium (HPS) luminaires. Replacement of the existing mercury vapor lighting systems could lead to a savings of up to 50% of the power currently being consumed. Following a discussion of this conclusion by the Department of Highways and Transportation's Special Roadway Lighting Advisory Committee, it was decided to inventory all of the interstate lighting currently in operation and to estimate the savings that could be achieved through conversion to HPS luminaires. The results of the inventory and analysis indicated that the conversion of 4,752 interstate system luminaires could yield a present

worth savings to the Department of $1.2 million over the average remaining service life of the various installations, assuming the use of the available 90% federal funding. It was further determined that it would take only 7 1/2 months for the Department to recoup its 10% investment and 9.9 years to break even on the total investment. Based on these data, the recommendation to convert all the interstate mercury vapor lighting to the HPS type was approved by management. Currently, approximately 75% of the original inventory is nearing the contract stage for conversion.

Other alternatives for conserving energy in existing roadway lighting systems are discussed and placed in order of preference in the report.

The relative order of the alternatives discussed is as follows:

1. Convert existing mercury vapor lighting to the more energy-efficient HPS lighting.

2. Provide for an efficient field management program that will ensure adequate maintenance and reduce energy waste due to malfunctioning lighting controls.

3. Install automatic energy control equipment to reduce power consumption when full level illumination is not needed.

4. Activate the lighting only during the hours of darkness when the heaviest traffic volumes are on the roadway.

5. Use partial lighting. It should be noted that the reference to partial lighting here pertains to the partial utilization of the lighting on existing systems.

6. Deactivate the lighting on a seasonal basis when the hours of daylight are the longest and where experience indicates that accident rates would be the least affected. This alternative would apply, in most cases, to continous freeway lighting.

7. Turn the roadway lighting off entirely.

(10) "Continuous Illumination and Accidents on a Section of I-95", Marvin H. Hilton (VHTRC 79-R4) August 1978

Beginning with the oil embargo of 1973-74, highway lighting — and particularly continuous lighting on freeways — became one of the first items to be cut back to conserve energy and revenue. During this period of energy shortage, considerable lighting was turned off in Virginia and in particular the 13.8 km (8.57 mi) section of continuous lighting on I-95 between Springfield and Washington, D. C. By comparing the accident rate ratios for the lights turned off with those for the lights turned on it was found, in an earlier study, that the lighting decreased the night accident rate on this section of I-95 during the three-month period studied. Subsequently, the lights were

reactivated. The study reported here extended the data to cover a six-month period and used a more refined approach in the analysis.

For the period including December, January, and February, when heavy traffic volumes are on the I-95 roadway during the early hours of darkness, the lighting was found to be particularly effective in reducing the nighttime accident rate. For the March, April, and May period, when the hours of daylight lengthen, the night accident rate was improved; but the improvement was not found to be significant at the 95% confidence level, due, most likely, to the low number of accidents involved in the test. For the overall six-month period it was concluded that the lighting reduced the night accident rate. This finding was significant at the 95% confidence level. Evaluation of the night-to-day accident rate ratios on an unlit control section of I-95 substantiated this finding.

It was recommended that any plans for reducing energy consumption by turning off entire sections of freeway lighting should be carefully considered for possible adverse effects on the nighttime accident rate.

(11) "The Nebraska Gasohol Experience", Michael A. Perfater (VHTRC 79-R34) February 1979

The political, social, and economic impacts of Nebraska's program promoting the use of an ethanol-gasoline blend as a motor fuel were examined and the literature on research and other activities relating to the use of alcohol as a motor fuel, including records of the deliberations of the National Gasohol Commission, were reviewed.

It was found that the objective of the 1972 Nebraska legislation on the use of Gasohol as a motor fuel was to promote the sale of grain while simultaneously helping reduce the United States' dependence on foreign oil. Since that time much research into all aspects of the use of Gasohol, which is defined as a blend of 10% ethyl alcohol (ethanol) and 90% unleaded gasoline, has been conducted throughout the Midwest. While there appears to be little debate over whether Gasohol will work in a car's engine, there is a great deal of debate concerning the economics and energy balance involved in its production and use. Most of the information now available on both issues is theoretical. There is a widely held feeling that until a full-scale ethanol plant is operating and producing in excess of 20 million gallons per year, answers to the economic and energy balance questions will not be forthcoming. There is widespread agreement that incentives, perhaps in the form of tax reductions, are needed to make Gasohol competitive with unleaded gasoline. The major opponents of Gasohol are the oil companies. Most feel that the United States is several years away from an economic conversion of agricultural products into fuel and are thus concentrating on fuel recovery from fossil sources such as shale oil, liquefied coal, and tar sands.

(12) "Investigation of the Use of Methanol-Gasoline Blends", Michael M. Sprinkel (VHTRC 78-R18) November 1977

An 18-month field test was conducted to determine if the Virginia Department of Highways & Transportation should give serious consideration to the use of methanol as a substitute for gasoline in the operation of its motor vehicles. Five of the eight 1973 and 1974 model vehicles involved in the test were operated for a total of 92,000 miles on a fuel blend containing an average of 10.7% methanol and 89.3% lead-free gasoline. The fuel was dispensed from a commercial type gasoline blending pump by blending at the nozzle and by pumping directly from a storage tank containing a specified blend of methanol and gasoline.

The vehicles operating on the blend averaged 4.0% fewer miles per gallon but were 1.3% more efficient from a miles/Btu standpoint than the vehicles operating on lead-free gasoline. Exhaust emissions data suggested that emissions are more dependent on carburetor adjustments than on the percentage of methanol in the fuel. Driveability was impaired enough in two of the vehicles operating on the blend to warrant carburetor modifications before the vehicles could be operated safely and satisfactorily because the addition of methanol made the fuel-air mixture too lean for good engine performance and because the methanol was incompatible with certain fuel system parts. Since methanol and gasoline are not completely miscibile at all temperatures and moisture conditions, a major effort was required to properly store and dispense the desired blend. From a consideration of economic and supply factors, it was concluded that the use of methanol-gasoline blends in Department vehicles would not be justified at this time. Implementation would require that special attention be directed to vehicular adjustments and to the storage and handling of the blends.

(13) "Recycled Portland Cement Concrete Pavements — State of the Art Summary", Woodrow J. Halstead (VHTRC 80-R12) September 1979

This report constitutes a review of the literature concerning recycling of portland cement concrete pavements by crushing the old pavement and reusing the crushed material as aggregate in a number of applications. A summary of the major projects conducted by state transportation departments is included.

Crushed portland cement concrete is shown to have been successfully used in the following applications.

1. Graded-aggregate bases

2. Cement-treated bases

3. Asphalt base courses and pavements

4. Portland cement concrete bases (econocrete) and pavements

5. Source of supply for independent commercial operations selling aggregate for a variety of applications

In any given circumstances the cost and availability of new aggregate and the cost of disposing of the old concrete play important roles in establishing whether or not recycling is a desirable alternative. Consequently, each project or the general situation for a given area must be examined separately and the decision made on the basis of local conditions. Both dollar and energy costs must be considered.

WORKING PLANS (COMPLETED OR IN PREPARATION)

1) "Demonstration Project — A Solar Powered Traffic Counter", Gerardo G. Clemeña.

2) "Energy Conservation and Money Savings Through the Use of Diesel-Powered Vehicles", Gary L. Roberts.

3) "Energy Conservation in the VDH&T's Large Buildings", Alan C. Pritchard.

4) "Outlook for Vehicular Propulsion Systems", Part I - Diesel (#2 above) Part II - Electric, Marvin H. Hilton.

5) "Evaluation of an Auxiliary Solar Heater", Gerardo G. Clemeña.

6) "Determination of a Relationship Between Pavement Roughness and Fuel Consumption for an Automobile", Kenneth H. McGhee.

7) "Study of VDH&T Vehicles and Equipment Involved in the Use of Gasohol", Michael M. Sprinkel.

8) "Potential for Utilizing Industrial Wastes and By-Products in Construction of Transportation Facilities in Virginia", Woodrow J. Halstead.