conditions, with appropriate attention to data collection requirements, strategy feasibility, and local capabilities. Results of this process can then be translated into usable guidelines for local planners and engineers as well as an agenda for continuing research and development activities.

The transition from the traditional approach to TSM may be one of such fundamental proportions that it will not take place quickly but may take a decade or more, with the shift being more evolutionary than revolutionary. The coordination of many small-scale actions toward objectives agreed on in a multi-institutional context poses a far greater challenge than did the implementation of large-scale, capital-intensive projects. During this transition one must, of course, necessarily look for those second best solutions that experience shows will work in the short run. However, capturing the full potential of TSM requires selecting those actions that at the same time will move us another increment toward the more normative process described in this paper.

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PACKAGING TRANSPORTATION ELEMENTS TO MEET ENERGY GOALS

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The need to consider energy in the development of transportation plans and programs is a relatively new development. The relation between the national energy problem and state and local actions is not widely understood. This paper discusses the Federal Energy Administration's program to support the development and implementation of state energy conservation plans and describes the required and optional transportation elements of such plans. It identifies various actions that can be instituted at the state, local, and regional levels. Finally, it discusses the trade-offs that may have to be made in developing the transportation programs to meet energy, air quality, and other objectives.

An effective transportation energy conservation program will require not only expanded efforts to develop and bring on line more energy-efficient technology but also concerted initiatives to bring about the institutional changes needed for the most efficient use of existing technology. A number of programs are under way to develop more energy-efficient transportation technology; nontechnology programs are less numerous. The program of the U.S. Department of Transportation to encourage the development of transportation system management (TSM) plans at the local level is one such program that will be an important test of the ability of governmental institutions to respond to the problems that confront our nation.

THE CASE FOR CONSERVATION

Until the late 1940s, the United States was a net exporter of petroleum. During the next 25 years, we gradually became more and more dependent on foreign petroleum because the use of foreign petroleum, which was cheaper to produce than increasingly scarce domestic oil, enabled the United States to maintain an expanding economy with minimal inflationary impacts.

In the 5-year period ending in 1965, real energy costs in this country decreased by 3 percent. Energy costs, measured in constant dollars per joule, declined by 8 percent between 1965 and 1970 and by 9.5 percent between 1970 and 1973. Small wonder that the warnings of an impending energy crisis fell on deaf ears! During this 13-year period, the United States went from importing less than 0.32 Mm^3 (2 million barrels) of oil per day to importing about 1.03 Mm^3 (6.5 million barrels), 38 percent of domestic consumption. Domestic production peaked in 1970 and has been declining ever since.

In 1973 the rules changed. The oil producers found that our dependency had reached such a level that we had no option but to pay a fourfold price increase. The result was an Arab oil embargo that caused the loss of 500 000 jobs and $10 billion to $20 billion in gross national product. The embargo was followed by the price increase that raised our negative balance of payments for petroleum to $27 billion in 1975 (it was less than $4 billion 4 years earlier), enough money to generate more than a million new jobs and significant industrial expansion had it been spent within the United States.

Our economy has not responded well to these new realities. In the first 7 months of 1973, 39.6 percent of the crude oil used in this country (in the form of refined products) was imported; in the first 7 months of 1976, 45 percent was imported. Domestic production fell 1.48 Mm^3/day (9.3 million barrels) from January through July 1973 to 1.30 Mm^3/day (8.2 million barrels) for the same period in 1976. During the week of March 12, 1976, for the first time in our history, we imported more than half of the petroleum we used. In 1973, less than half of our imports came from the OPEC countries; today about two-thirds of our imports are from OPEC countries. Canada, once considered a dependable supplier, announced a program to cut off all exports during the next few years. We imported 1.03 Mm^3/day (6.5 million barrels) before the embargo; by the end of 1977, if current trends continue, we will probably be importing more than 1.35 Mm^3/day (8.5 million barrels).

Gasoline is the primary fuel used for transportation. An average of 1.05 Mm^3 (6.6 million barrels) of gasoline were used each day during the 7-month period from January to July 1973. The daily average was 1.02 Mm^3 (6.4 million barrels) for the same period in 1974, 105 Mm^3 (6.6 million barrels) for the same period in 1975, and 1.10 Mm^3 (6.9 million barrels) for the same period in 1976. The 1976 amount is 4.1 percent higher than that in 1975 and is equal to the pre-embargo levels of growth in gasoline demand in spite of the fact that the average fuel economy of new cars was 13 percent higher in 1976 than in 1975.

The trends, then, are all in the wrong directions: Consumption (especially gasoline) is growing, domestic

production is declining, and imports are increasing. The vulnerability of our economy to price and supply disruptions is, and will continue to be during the next few years, greater than it was in 1973. At one time, our energy policy was aimed at eliminating imports by 1985. Our current goals are much lower: to reduce our 1985 vulnerability to levels at which we will be able to cope should another supply or price disruption occur.

A 1985 situation can be constructed with the following assumptions: (a) Oil and gas deregulation occurs during the next few years; (b) the world price of oil, in constant 1975 dollars, rises to $82/m^3$ ($13/barrel); (c) moderately optimistic projections of exploitable oil reserves and recovery technology improvements prove to be valid; and (d) present provisions of the federal tax code that affect crude oil economics remain unchanged. The 1985 situation would then be something like this: Petroleum consumption—including natural gas liquids (NGL)—will have increased from the current level of 2.66 to 3.29 Mm^3/day (16.7 million to 20.7 million barrels), domestic production (including NGL) will have increased from the present 1.56 to 2.34 Mm^3/day (9.8 million to 14.7 million barrels), and petroleum imports (including NGL) will have decreased from the current level of 1.11 to 0.95 Mm^3/day (7.0 million to 6.0 million barrels), almost as much as we were importing before the embargo. Obviously, energy will continue to be a major national problem.

Even with the automobile fuel economy standards mandated by the Energy Policy and Conservation Act of 1975, petroleum requirements for transportation will continue to grow from 1.43 Mm^3/day (9 million barrels) in 1974 to approximately 1.83 Mm^3/day (11.5 million barrels) in 1985, still more than half of U.S. demand for petroleum.

Because of its importance as a petroleum consumer, the transportation sector will have an important role in our national energy conservation program. Urban transportation accounts for more than 40 percent of that consumption, and therefore policies and programs developed for urban transportation will have a major impact on whether the United States is able to deal effectively with its energy problem during the next 15 years.

Since the embargo in the fall of 1973, the significant amount of energy legislation enacted has focused primarily on establishing national policies and programs for developing new energy sources and making more efficient use of the existing ones. The Emergency Highway Energy Conservation Act of 1974 made federal-aid highway funds available, at a 90 percent-10 percent matching rate, for funding ride-sharing projects. The Federal Energy Administration (FEA) was established by the Federal Energy Administration Act of 1974. The authorities given to FEA were to advise the president and the Congress on the establishment of a comprehensive national energy policy and to develop and implement programs to promote energy conservation. The Energy Supply and Environmental Coordination Act of 1974 (a) extended the emission standards for 1975 model-year cars through model-year 1976; (b) required the U.S. Department of Transportation and Environmental Protection Agency, in consultation with FEA, the Council on Environmental Quality, and the U.S. Department of Treasury, to study the practicability of a 1980 automobile fuel economy improvement standard of 20 percent; and (c) prohibited EPA from requiring states to impose parking surcharges as part of their transportation control plans.

STATE ENERGY CONSERVATION PLANS

The first relatively comprehensive law regarding energy was the Energy Policy and Conservation Act (EPCA) signed by President Ford on December 22, 1975. Among its various provisions were the establishment of a series of domestic crude oil price controls to be phased out during a 40-month period, a strategic petroleum storage program, new automobile fuel economy standards aimed at doubling the fuel economy of new cars by 1985, and a mandatory appliance efficiency program.

The section most pertinent to transportation system management is Title V, Part C, State Energy Conservation Programs. The law authorizes FEA to establish a program whereby it would fund each eligible state to develop and implement a state energy conservation plan (SECP) aimed at achieving "a reduction... of 5 percent or more in the total amount of energy consumed in such State in the year 1980 from the projected energy consumption for such State in the year 1980" (section 362a1). Section 362c stipulates that each "proposed State energy conservation plan to be eligible for Federal assistance under this part shall include" five separate measures. Three of these minimum requirements relate to public building lighting efficiency standards, state and local government procurement practices, and thermal efficiency standards and insulation requirements for new and renovated buildings. The two transportation measures required for funding approval are (a) "Programs to promote the availability and use of carpools, vanpools and public transportation" (section 362c2) and (b) "A traffic law or regulation which, to the maximum extent practicable consistent with safety, permits the operator of a motor vehicle to turn such vehicle right at a red stop light after stopping" (section 362c5).

In addition to the required measures, section 362d describes five categories of optional actions, two of which relate to public building operations and restrictions on decorative lighting. The remaining three, which have some relevance to the transportation sector, are (a) "Transportation controls," which are defined for the statute as "any plan, procedure, method or arrangement, or any system of incentives, disincentives, restrictions, and requirements, which is designed to reduce energy consumed in transportation, except that the term does not include rationing of gasoline and diesel fuel" (section 362d3); (b) "Programs of public education to promote energy conservation" (section 362d4); and (c) "Any other appropriate method or programs to conserve and to improve efficiency in the use of energy" (section 362d5).

EPCA authorized $50 million/year for fiscal years 1976, 1977, and 1978, of which $5 million was appropriated for 1976 and $25 million for 1977. In determining the amount of federal financial assistance to be provided to any state, FEA was directed to consider the amount of energy to be saved and the number of people affected by the state's SECP. With the exception of not providing financial assistance, EPCA provided no sanctions against states that did not establish an effective plan.

In summary, to be eligible for SECP funds, a state must propose a plan that, at a minimum, includes the five specific measures discussed earlier. An SECP could include any effective additional measure that a state may wish to propose; in fact, by tying the level of federal assistance to be allocated to each state, in part, to the total conservation impact of the state's plan, each state is encouraged to institute additional measures.

The program will be administered through the states, most likely through the energy offices of each state, for the program aims at reducing energy consumption in all end-use sectors. Although the guidelines make clear the need for coordination with the metropolitan planning organizations in the development of program measures to promote the use of ride sharing and transit, the states

are given considerable discretion in determining how this is carried out. In addition, the legislation and the guidelines are clear that all funds go specifically to the states. Although FEA recognizes that an effective state energy conservation plan needs the active participation of the cities, counties, and MPOs, it believes that the distribution of the grant funds within the state should be done by the state. Additional details regarding the administration of this program are in the final guidelines, which were printed in the Federal Register November 3, 1976.

PACKAGING TRANSPORTATION MEASURES TO ACHIEVE ENERGY CONSERVATION

This section discusses various issues that should be considered when the transportation elements of the SECP are developed. Since no state has yet developed a comprehensive SECP, the discussion will be primarily theoretical. As state energy conservation plans are implemented and monitored, the relation among their impacts and the attainment of other social objectives will become clearer.

Identification of Transportation Energy Conservation Measures

Nontechnological, low-capital measures for reducing transportation energy consumption can be grouped into four major categories: increasing load factors, shifting demand to more efficient modes, improving operational efficiency of any or all modes, and reducing the demand for travel and transportation services. Because of the nature of the State Energy Conservation Program as defined by EPCA and the relation of this report to urban passenger transportation, the following categories will be use in this discussion: promoting the use of more efficient modes, improving the efficiency of automobiles in operation, and discouraging the use of private automobiles. For purposes of this classification system, car pools and van pools (whether operated by a public agency, an employer, or a private individual) are considered as paratransit modes. Thus, measures to increase automobile occupancies are subsumed under the category of shifting travel to more efficient modes.

Promoting Use of More Efficient Modes

There are several ways by which the use of more efficient modes can be promoted:

1. Legislative or administrative actions to allow van pools and car pools to operate without official certification as a common carrier;
2. An areawide matching program that provides commuters with an accurate, up-to-date list of others with whom they could share their ride to and from work and that is structured in such a way as to support transit in areas served by fixed-route systems;
3. A ride-sharing and transit education and marketing program, aimed particularly at employers and commuters, to foster commuting by means other than the single-occupant automobile and to generate employer support not only for an areawide ride-sharing campaign but also for active internal car-pool, van-pool, and, where appropriate, subscription bus or transit subsidy programs;
4. Park-and-ride lots where commuters can transfer to high-occupancy vehicles for final stages of their trips to work;
5. Preferential traffic control techniques to give priority to high-occupancy vehicles, including public transportation vehicles;
6. Preferential parking, i.e., more convenient locations or lower rates, for car pools and van pools, especially in lots controlled by a public agency;
7. Low-capital improvements that tailor transit service to better serve identified needs, possibly identified by means of an effective commuter-matching program; and
8. Staggered and flexible working hours to allow better distribution of demand for transit services and the formation of car pools and van pools.

Improving Efficiency of Automobiles in Operation

Ways to improve the efficiency of automobiles include the following:

1. Low registration fees for automobiles having lower fuel consumption, lower power, less weight, or smaller engine displacement to encourage a shift to more efficient automobiles;
2. Vehicle inspection programs that require or encourage engine tune-ups, when appropriate;
3. Traffic flow improvement measures such as elimination of unnecessary control devices, timely changeover of traffic signals to flashing operation, right turn on red, speed limit reductions on selected facilities, designation of reversible lanes, and elimination of on-street parking; and
4. Procurement of more efficient vehicles for state and local government fleets.

Discouraging Use of Private Automobiles

The use of private automobiles can be discouraged by

1. Increasing the marginal costs of vehicle operation through measures such as parking taxes, fee regulation, or surcharges, that can be geographically and temporally selective;
2. Establishing automobile-free or limited-access zones to encourage use of alternative modes or multi-occupant vehicles;
3. Reducing the supply of on-street or off-street parking;
4. Eliminating publicly financed parking subsidies for automobile drivers (this action combined with incentives for ride sharing or transit usage);
5. Establishing tolls for entry into congested areas; and
6. Revising zoning standards to foster reduced reliance on the automobile.

Examples of Transportation Energy Conservation Programs

No state has yet developed or submitted an energy conservation plan. Thus, there is no example of a comprehensive, effective package of transportation measures for conserving energy. However, a number of states and local governments have taken actions that can serve as useful prototypes for adoption by other governmental units. The following is a brief discussion of programs and program measures that have accomplished significant energy savings or that have almost no nonenergy benefits and, therefore, would not be examined in descriptions of measures that focus on environmental or transportation system concerns.

Promoting Use of More Efficient Modes

The most effective areawide program for increasing the use of more efficient commuter modes is probably the commuter ride-sharing program in Knoxville, Tennessee. This program, funded in part by the Urban Mass Transportation Administration, is a coordinated effort by the city of Knoxville, the Knoxville Transit Authority, private bus operators, major employers (including the Tennessee Valley Authority and Levi Strauss), the Tennessee Bureau of Area Mass Transportation, and the University of Tennessee. It is multimodal in scope (encompassing express commuter bus service, van pools, car pools, and social services) and comprehensive in approach (using advanced marketing and matching techniques and legislative changes to "deregulate" van pools and thus facilitate their formation and reduce associated insurance costs).

The success of this program has been incredible. The express bus service, begun in 1973, carries 24 000 passengers/month; the private carriers began operating in the winter of 1975 and carry 12 000 passengers/month. Van-pool operations became legal March 22, 1976, and by August nearly 60 vans were operating (26 leased city vans, 24 TVA employee vans, and 7 identified private vans) and carrying 24 000 passengers/month. TVA, the largest employer in the Knoxville CBD, had 62 percent of its employees commuting by single-occupant vehicles in 1972; in the summer of 1976, this had decreased to 18 percent. During this time, vehicle-kilometer travel by commuters decreased by about 50 percent (3). According to Frank Davis, a member of the Knoxville Transit Authority Board of Directors, the authority and the city are beginning to feel that their primary role is to determine needs, locate potential suppliers, eliminate institutional barriers, and promote all forms of public transportation.

These are the exact functions that FEA hopes will be assumed by various state and local agencies as an element of the state energy conservation plans. No better model for promoting the availability and use of car pooling, van pooling, and transit exists in the United States.

Improving Efficiency of Automobiles in Operation

The Vermont Energy Office conducted a study of the composition of the state's passenger vehicle fleet and the impact of a proposal that would vary the annual registration fees between $20 and $60, depending on weight. This study resulted in a proposed bill that will probably be reintroduced during the 1977 session of the state legislature. A number of other states already have fee structures that vary the charge by vehicle class although energy was not a consideration in developing them.

Vehicle weight, power, and engine size are not completely equitable surrogates for fuel efficiency. Unfortunately, since consistent fuel efficiency ratings are not available for model years earlier than 1974, states are forced to rely on those vehicle characteristics for a few more years. Starting in 1978, EPA mileage ratings will be available for a sufficient proportion of the automobile fleet so that registration fees can be tied directly to the fuel efficiency of each automobile.

Maine has changed its official procurement specifications to provide for energy-conserving characteristics to be considered in the purchase of automobiles for state use (2). Alaska has a State Motor Vehicle Energy Conservation Program that aims for a 10 percent reduction in state vehicle fuel consumption within a 1-year period through instituting and enforcing energy conservation maintenance and operation practices (3). New York State has adopted the policy of purchasing small automobiles with adequate, but smaller engines for state use (1).

Discouraging Use of Private Automobiles

Because the energy problem is not felt in local communities as continually and directly as traffic congestion and air pollution, no areas have adopted automobile-disincentive strategies as a means for conserving energy.

Consistency With Transportation and Environmental Objectives

Energy conservation measures generally contribute to the achievement of the overall goals of reduced traffic congestion and pollution. This is clearest in the case of those measures aimed at shifting travel to more efficient modes and reducing travel demand. It is much less clear for those measures that foster a shift to more efficient automobiles.

Promoting Use of More Efficient Modes

If we could double the use of transit, we could save 7900 to 15 900 m^3 (50 000 to 100 000 barrels) of oil per day (4). If we could increase commuter automobile occupancies from the current level of 1.4 persons/automobile to 2.0 by 1980, we could reduce daily gasoline consumption by 55 500 m^3/day (350 000 barrels). The direct impact on pollution would be proportional to the energy impact, about a 10 percent reduction in daily automobile-related emissions. The reduction in traffic congestion would be even greater since mode shifts of this magnitude would reduce the number of commuter vehicles during peak periods by more than 30 percent.

The subject of pooling as it relates to transit ridership is worth discussing. When the potential of car pooling and van pooling became obvious, FEA did all it could to encourage ride sharing. However, the competition between ride sharing and transit for the same market deserves serious consideration. Obviously, getting someone out of a bus into a car pool saves no energy. The nation's transit systems are and will continue to be an essential element of our national energy program. Unfortunately, there is no way to guarantee that effective car-pool programs will not divert some riders from transit. However, effective ride-sharing programs can benefit existing transit systems if structured with the following thoughts in mind:

1. Few commuters prefer fixed-time, inflexible ride-sharing arrangements over transit if the transit system provides reasonably good service (since "reasonably good service" is a relatively subjective concept, the programmatic value of this finding is not altogether clear);
2. Commuter-matching procedures can be an effective way to pinpoint those areas that have travel demands sufficient to justify fixed-route transit service; and
3. Effective ride-sharing programs in areas not served by transit can help reduce pressure for the introduction of new service that would be underused, further aggravating the financial problems facing metropolitan transit agencies.

Improving Efficiency of Automobiles in Operation

Inproving automobile efficiency has the greatest potential for conflicting with the achievement of transportation

system and environmental objectives. An obvious indicator of such conflicts is the continuing debate regarding the relation between new automobile emission and fuel economy standards. A more basic conflict is that between encouraging the development of more efficient automobiles on one hand and attempting to foster shifts to more efficient modes on the other. Reducing the marginal costs of driving the automobile is not totally in concert with efforts for reducing the demands on the nation's overloaded transportation system and reducing the pollution associated with those demands. Not all measures for increasing operating efficiency are inconsistent with other social objectives. Lower speed limits not only decrease fuel consumption rates but also serve to reduce travel demands and automobile-related pollution.

In any event, it would make little sense from a national viewpoint to impede the development of more efficient automobiles as a means for increasing the cost of automobile travel. Such a strategy would artificially punish those travelers for whom the private automobile is the only transport mode. The use of economic disincentives that can be targeted at those who have other travel options would be a more equitable, effective approach not only for conserving fuel but also for achieving other transportation goals.

Discouraging Use of Private Automobiles

Clearly, discouraging automobile use is the most effective way to reduce traffic congestion, automobile-related air pollution, and energy consumption. However, unless applied with extreme care, this measure conflicts with a basic goal of our society: providing mobility for people and commerce.

A strong case can be made for meaningful disincentives if alternatives to single-occupant automobile travel are available and the public costs of providing for such travel are not prohibitive. Most people are familiar with the concept of marginal cost pricing and recognize that forever building new transportation systems to accommodate peak vehicle demands is a luxury we can no longer afford.

Out-of-pocket marginal costs make up about one-third of the total costs of operating an automobile. Further, the total costs of operating an automobile during peak periods in congested urban areas make up only about one-third of the total economic costs (5). Broader public support for most TSM initiatives should be achievable if the public is given a clear understanding of the three available options: (a) enormous expenditures for expanding the transportation systems, (b) long periods of widespread congestion, or (c) implementation of effective transportation system management measures, including carefully developed and justified disincentives. Transportation analysts must not only design effective, equitable, and appropriate disincentives but also present the costs and benefits of such measures in such a way that decision makers and travelers can fully weigh the advantages and the disadvantages of instituting such measures.

SUMMARY

A wide range of effective actions can be taken to reduce energy consumption in the transportation sector. Many of the important decisions necessary to implement such actions can be made only at the state and local levels. Since nearly all of these actions will contribute to solving other pressing national concerns (such as our reduced ability to build new transportation facilities and unacceptable pollution levels), these actions will have the support, financial or otherwise, of DOT, EPA, and FEA. The real work, however, will have to be done not at the federal level but at the state, regional, and local levels. The energy problem is national in scope and its effects are important to each level of government; dealing with it, therefore, will require the involvement of all levels.

FEA realizes that some of these options have important social and economic implications. Therefore, it supports further study and phased implementation. However, as we study and debate and postpone decisions, we should be aware that we are using up our cheap oil. A cheap, clean, infinite source of energy is not going to be available when we run out or when the next embargo hits. The question is, Do we have the wisdom and the will to act now or will we allow events to act for us?

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PACKAGING TRANSPORTATION ELEMENTS TO MEET ENVIRONMENTAL OBJECTIVES

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Controversy over the relation between air quality requirements and urban transportation planning appears to center around two basic issues. The first is whether the implementation of transportation measures that improve air quality is consistent with the achievement of other transportation objectives. The second concerns the changes in the planning process needed to accommodate air quality requirements. This paper outlines the basic elements of a potential resolution of these issues. The transportation measures that have been proposed to improve air quality are virtually identical to the measures now being proposed to achieve a wide variety of other transportation objectives. However, the various measures are