Summary

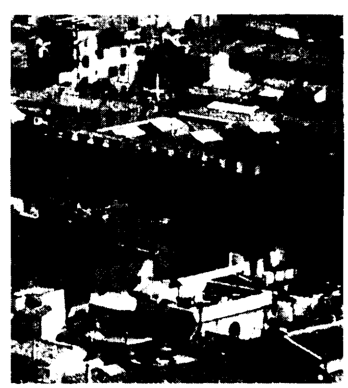
This report assesses an array of transportation policies designed to reduce energy use and describes the intersection of these policies with general transportation problems such as congestion and air pollution. The report:

- describes the U.S. transportation system and its energy use;
- presents and evaluates forecasts of energy use to 2010;
- compares and contrasts U.S. and European travel and energy use patterns;
- discusses reasons governments may choose to intervene in transportation markets; and
- describes and evaluates a range of policy options to reduce U.S. transport energy use, from gasoline taxes to urban planning.

Its objective is to provide a balanced, qualitative perspective of issues and problems rather than a highly quantified analysis.

INTRODUCTION

A primary characteristic of transportation in the United States is its high per capita energy consumption. *The average U. S. citizen consumes nearly five times as much energy for transportation as the average Japanese and nearly three times as much as the average citizen of France, Britain, or West Germany.*[1] The energy efficiency of U.S. transportation has improved substantially over the past two decades (both absolutely and in comparison to Europe) and U.S. travel volume has grown more slowly than in most of the developed world. However, the United States still consumes



[1] L. Schipper et al., "Energy Use in Passenger Transport in OECD Countries: Changes Between 1970 and 1987," *Transportation, The International Journal*, April 1992.

ENVIRONMENTAL PROTECTION AGENCY

Washington, DC, on a smoggy day **About 100** *U.S. cities still violate national ambient air quality standards for ozone.*

more than one-third of the world's transport energy.[2] Also, 96 percent of U.S. transport energy is in the form of oil products.[3] This is more oil than the United States produces,[4] despite its position as one of the world's largest oil producers.

In 1990, the U.S. transportation sector accounted for nearly 65 percent of all U.S. oil consumption.[5] The oil consumed by U.S. transportation creates problems in terms of: 1) air pollution— about 100 urban areas violate the ozone air quality standard, and emissions from transportation sources, primarily highway vehicles, contribute 30 percent of the volatile organic compound and 39 percent of the nitrogen oxide precursors of ozone; 2) national security and balance of trade, because so much of our oil is imported; and 3) greenhouse warming, because large quantities of carbon dioxide (the primary greenhouse gas) are emitted with oil combustion.

The intensity and magnitude of U.S. travel create other problems as well. Growing congestion, especially in urban areas, leads to expensive delays in passenger and freight transport, and increases fuel use and pollution. U.S. reliance on automobiles has resulted in a high percentage of land being devoted to highways, parking facilities, and other auto uses; the loss of wetlands and other ecologically sensitive lands to highways and the diffuse land use that highways support; and a range of other environmental impacts.

Energy use in U.S. transportation is expected to increase despite continued improvements in efficiency. The Energy Information Administration's (EIA) *Annual Energy Outlook 1993* projects steady but moderate growth in transportation energy use across all scenarios. EIA projects a 19- to 38-percent increase over the 20-year period of the forecast. Thus, by 2010, transport energy use would be 26.8 to 31.0 quadrillion British thermal units (10^{15} Btus = 1 quad[6]), about 12.9 to 14.9 million barrels of oil per day (mmbd), compared with its 1990 level of 22.5 quads, or 10.5 mmbd. And, as discussed later, the Office of Technology Assessment (OTA) believes these forecasted levels are likely to underestimate future transportation energy use, because they rely on optimistic assumptions about improvement in vehicle efficiency and growth in personal travel.

With current problems and expectations of continued growth in travel and energy use, Congress has increasingly turned to transportation energy

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[2] U.S. Congress, Office of Technology Assessment, *Changing by Degrees: Steps To Reduce Greenhouse Gases,* OTA-O-482 (Washington, DC: U.S. Government Printing Office, February 1991), table 5-1.

[3] S.C. Davis and S.G. Strang, *Transportation Energy Data Book,* ed. 13, ORNL-6743 (Oak Ridge, TN: Oak Ridge National Laboratory, March 1993), table 2.8.

[4] Total 1990 transportation oil products consumption was 21.81 quadrillion British thermal units (Btus), versus domestic liquid production (crude oil, lease condensate, and natural gas plant liquids) of 17.91 quadrillion Btus. Energy Information Administration, *Annual Energy Outlook 1993,* DOE/EIA- *1383(93)* (Washington, DC: January 1993), tables G1 and G2.

[5] Ibid., table A-8.

[6] A "quad" of energy, aside from being one quadrillion (10^{15}, Btus, is equivalent to about one trillion cubic feet of natural gas, or about one-twentieth of current annual U.S. natural gas consumption; about 170 million barrels of oil, or a bit more than (me-thirtieth of current U.S. yearly oil consumption; about 40 million short tons of coal (coal energy content is variable, so this is a rough approximation), or about one-twentieth of U.S. yearly coal consumption. In 1990, U.S. energy consumption was about 85 quads.

conservation—in the form of improvements in the technical efficiency of travel, increases in load factors, reductions in travel demand, shifting to alternative fuels, and shifts to more efficient travel modes—as an important policy goal. For example, the Clean Air Amendments of 1990 incorporate transportation demand management as a critical tool in reducing urban air pollution. ISTEA—the Intermodal Surface Transportation Efficiency Act of 1991—allows States to shift highway funds to transit, promotes new high-speed ground transportation systems, and generally establishes energy efficiency as a major goal of new transportation investment. EPACT—the Energy Policy Act of 1992-establishes fleet requirements and a series of economic incentives to promote the use of nonpetroleum alternative fuels. Legislation proposed (but not passed) in the 102d Congress sought rigorous new automobile and light truck fuel economy standards. With continued increases in U.S. oil imports, urban traffic congestion, and greenhouse gas emissions, and the failure of many urban areas to meet air quality standards, strong congressional interest in new energy conservation initiatives is likely to continue.

Varying Perspectives on the Nature of the Problem and on Potential Solutions

Although policy makers and the transportation community may agree that transportation energy conservation is a worthwhile goal *in the abstract,* severe disagreements exist about the urgency of the problems that conservation measures can serve to address and the efficacy of conservation alternatives.

Disagreement begins with two very different perspectives about transportation itself:

1. *Transportation, and especially automobile-dominated transport, is a primary source of social and environmental ills such as air pollution, loss of ecosystems, greenhouse emissions, loss of life and limb, and noise pollution.*
2. *Transportation is a key to economic progress and to social, cultural, and recreational opportunity.*

Since both perspectives are valid, both should be considered in seeking a balanced approach to policymaking. Many transportation stakeholders, however, lean heavily toward one perspective or the other. Those leaning toward the first tend to focus on the need to reduce and restrict travel, shift travelers to less harmful modes, and enact strong environmental safeguards; those leaning toward the second focus on the need to increase access to travel and to make traveling easier and more efficient. Thus, in terms of these two perspectives, some of the key features of U.S. transportation—the highest level of personal travel in the world (13,500 miles per person per year) and the most vehicles per person in the world (nearly six autos or light trucks for every 10 persons, and two vehicles per household)—appear as signs either of the profligacy of the U.S. system or of its superiority. Such varying perspectives about the success of the American system in turn lead to very different perspectives about the need for changing that system, with one tending toward substantive change and the other toward fine-tuning.

That transportation is not an end in itself, but a means to attain access to economic and personal opportunity, may aggravate the differences in perspective. The concept of access to a variety of opportunities is easy to grasp but difficult to measure, so transportation services are generally measured simply in miles traveled or trips made. Thus, there is a danger that a traveler who must commute several hours to work will be judged in some analyses to have obtained more value from transportation services than another who walks 20 minutes to work. Also, those judging proposed changes in transportation policy must distinguish

[7] Transportation demand management (TDM) measures seek to reduce traffic volumes (or shift some traffic to less congested times or routes), especially during peak travel hours, by increasing vehicle occupancy, encouraging modal shifts, and other means.

carefully between changes that reduce travel *and* access to opportunity, and those that reduce travel but bring opportunity closer.

Three major problems are driving most transportation energy conservation initiatives—air pollution (especially urban), energy security, and greenhouse warming. Different views about the urgency of these problems in turn lead to different perspectives about the types of tradeoffs worth making to achieve lower energy use. There appears to be a consensus that urban air pollution is a critical national problem, and clear support exists for strong corrective measures. There is a modest level of agreement about the importance of rising oil imports as a national security and balance-of-trade problem, with levels of concern ranging from moderate to substantial and limited support for corrective measures. Agreement is lacking about the urgency of reducing greenhouse emissions to slow down potential warming: environmental groups urge strong action, whereas much of the business community urges that no action be taken until more is known.

Another potential disagreement about the nature of problems facing the transportation system could further polarize policymaking. The Federal Highway Administration (FHWA) projects large increases in urban and suburban traffic congestion, which implies that strong policy measures—including severe demand management and large shifts to alternate modes—will be needed to maintain acceptable levels of urban mobility. A small group of critics, however, claims that the FHWA projections are grossly in error, and that growth in congestion will be kept in check by changes in travel behavior and land use. These views, of course, yield a very different set of transportation policy priorities.

Another disagreement about the need for changes in transportation policy focuses on the extent to which prices for U.S. travel accurately reflect the true marginal costs to society of such travel. Many analysts believe that a combination of "externalities" (consequences such as air pollution that travelers do not pay for or take into account in their decisions) and inefficiently priced inputs (services such as parking, with hidden, subsidized, or inaccurate prices) yields an overall cost of travel that is too low and thus results in excessive travel. Other analysts conclude that the value of externalities and unpriced inputs is small compared with the prices paid openly by travelers, so that "correcting" prices would not result in large changes in travel behavior. These analysts hold that there is not much excess travel in the United States.

Finally, not surprisingly, there are major disagreements about the efficacy of virtually all conservation measures. For example:

- Proponents of *increased mass transit* foresee it as playing a major role in energy conservation and the revitalization of U.S. cities. Skeptics view it as basically irrelevant to most travel, having only a small role to play (mobility for disadvantaged populations, a major general role in a few of America's older, high-density urban cores) given the auto-oriented U.S. land use patterns and offering little if any benefits in energy efficiency.
- Proponents of *stronger fuel economy standards* believe that there are inexpensive ways to achieve large improvements in auto fuel economy, and view standard setting as a proven success in forcing these improvements. Opponents see little opportunity for more than slow, incremental growth in fuel economy, and view standards as an antimarket, inefficient method of achieving the small improvements that are available.
- Proponents of *higher gasoline taxes* view them as proven revenue raisers, which offer improved economic efficiency by capturing "externalities" and inefficiently priced transportation inputs, and allow significant energy savings. Opponents view them as harmful to the U.S. economy, and as offering no economic efficiency benefits and limited energy savings benefits, given the unresponsiveness of travel demand and technical efficiency to gasoline price.

A unifying feature of these policy arguments is a difference of views about the importance of policy-dependent factors versus policy-independent factors in shaping travel patterns. If history (including the history of technology), geography, income, and demographics are the primary determinants of travel patterns, policy may play only a minor role in changing energy use; but if fuel taxes, urban planning, parking policies, and other instruments of public policy are primary travel determinants, there is a large potential for policy to reduce U.S. energy use.

Although much of the disagreement about transportation policy stems from differences in values and philosophy, including different views about the role of government in markets, a significant portion stems from the lack of adequate research and data in several crucial areas.[8] These include:

- the relationship among travel behavior and demographics, urban design, and transportation system characteristics (e.g., the extent to which new transportation facilities can be used as part of an integrated effort to shift land use patterns and travel behavior);
- the magnitude of transportation ● 'externalities," or costs that are not accounted for or borne by transport users;
- identification and quantification of transport benefits; and
- the measurement of "accessibility," which is the primary goal that personal transportation attempts to satisfy.

A SNAPSHOT OF THE U.S. TRANSPORTATION SYSTEM AND ITS ENERGY USE

Passenger Travel

The transportation system in the United States provides U.S. residents with the highest level of personal mobility—in terms of trips made and miles traveled—in the world. The United States has the greatest number of automobiles per capita--0.575 in 1989—in the world,[9] 1.07 vehicles *per licensed driver and 1.92 vehicles per household.* The average adult with a driver's license travels 30 miles per day of local, personal travel, and even adults without licenses manage to travel 10 miles per day.[11] In 1990, the average U.S. resident traveled well over 13,000 miles.[12]

U.S. passenger travel is dominated by the automobile and the highway system. In 1990, about 86 percent of passenger-miles were auto (and personal light truck) miles, and over 10 of the remaining 14 percent were air miles; buses and trains provided only 4 percent of passenger-miles.[13]

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[8] A recent report by the Transportation Research Board (TRB) identifies critical research needs in transportation, land use, and air quality; TRB, *Transportation Research Circular 389: Environmental Research Needs in Transportation* (Washington, DC: National Research Council, March 1992).

9 S.C. Davis and M.D. Morris, *Transportation Energy Data Book*, ed. 12, ORNL-6710 (Oak Ridge, TN: Oak Ridge National Laboratory, March 1992), table I-3.

10 Ibid., table 4-1. Note that "vehicles" includes trucks and buses.

11 A.T. Reno, "Personal Mobility in the United States, " *A Look Ahead-Year 2020,* Transportation Research Board Special Report 220 (Washington, DC. Transportation Research Board, 1988).

12 Data obtained from L Schipper and N. Kiang, International Energy Studies, Lawrence Berkeley Laboratory, in advance of Publication in the *Transportation Energy Data Book,* ed. 14 (Oak Ridge, TN: Oak Ridge National Laboratory, forthcoming).

13 Ibid.

The U.S. highway system consists of about 3.8 million miles of roadway, including 44,000 miles in the Interstate System.[14][15] The system also includes nearly 577,000 bridges.[16] Much of this infrastructure—more than 10 percent of the Nation's roads and nearly 42 percent of its bridges—is considered deficient.[17]

The U.S. mass transit system consists of a wide array of regional and municipal systems, including buses, light rail, commuter rail, trolleys, and subways, as well as an array of vehicles providing "paratransit" services--dial-a-ride, van pools, subsidized taxis, and shared rides in minibuses or vans. Most cities of 20,000 or higher population have bus systems, and buses on established routes with set schedules account for more than half of all public transit passenger trips. However, about 70 percent of all such trips were in the 10 cities with rapid rail systems, with 35 percent of transit passengers and 41 percent of transit passenger-miles in New York City and its suburbs.[18]

Low-density suburban development creates travel patterns that are not easily served by transit.

The highway and public transportation systems in U.S. cities are shaped largely by the need to offer capacity to satisfy peak traffic periods. These peaks now are no longer dominated by worktrips, although these trips still account for 37 percent of peak person-trips.[19] And although the pattern of workers living in surrounding areas and commuting to the central business district (CBD) may once have been dominant, in 1980 the CBDs employed only 9 percent of the workers in their total urban areas and only 3 percent of workers living outside the central city.[20] In other words, peak trips in general, and work trips in particular, are now quite diffuse in origin and destination and thus not easily served by transit. One reason for this travel pattern is that urban development in the United States is characterized by an "undifferentiated mixture of land uses and a broad plateau of population density. . other central places scattered over the urban landscape challenge the primacy of the historic CBD."[21]

Although the automobile continues to dominate U.S. travel, autos face strong competition from commercial aircraft for trips of a few hundred miles or longer. As noted above, air transportation has now captured about 10 percent of the

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14 U.S. Congress, Office Of Technology" Assessment, *Delivering the Goods: Public Works Technologies, Management, and Finance,* OTA-SET-477 (Washington, DC: U.S. Government Printing Office, April 1991), based on Department of Transportation data.

15 Routes that connect principal metropoli(an areas, serve (he national defense, or connect with routes of continental importance in Mexico or Canada.

16 Office of Technology Assessment, op. cit., footnote 14.

17 Ibid.

18 Ibid

19 H W Richardson and P. Gordon, University of Southern California, "New Data and Old Models in Urban Economics," preliminary draft, December 1992, table 3. Peak periods are from 6 to 9 a.m. and 4 to 7 p.m. The precise character of changes in trip purposes is made uncertain by the manner in which trip purpose data are collected, A worktrip interrupted by a stop to run an errand would be counted as a shorter worktrip and another trip. Because trip "chaining" of this sort has increased, some of the shift away from worktrips may be an artifact of the data rather than an actual shift.

20 I.S. Lowry, "Planning for Urban Sprawl, " in *A Look Ahead-Year 2020,* op. cit., footnote 11.

21 Ibid.

total passenger-miles traveled and is the most rapidly growing segment of the U.S. transportation system, with passenger-miles growing more than 7 percent a year in the 1980s.[22]

The U.S. air travel system is quite centralized: There are more than 17,000 airports in the United States, but the top 100 handle 95 percent of all passenger trips, and the 10 largest serve 40 percent of all passenger trips. This is due primarily to widespread use by the major air carriers of "hub-and-spoke" routes.[23] The major airports experience substantial capacity problems and resulting delays--conditions that waste significant amounts of fuel by idling aircraft on runways and keeping arriving planes in holding patterns. Of the 25 airports with the most delays, Chicago's O'Hare ranks first, with total delays exceeding 100,000 airplane-hours per year; two airports have annual delays between 75,000 and 100,000 hours; two more have annual delays between 50,000 and 75,000 hours; and the remainder are between 20,000 and 50,000 hours.[24]

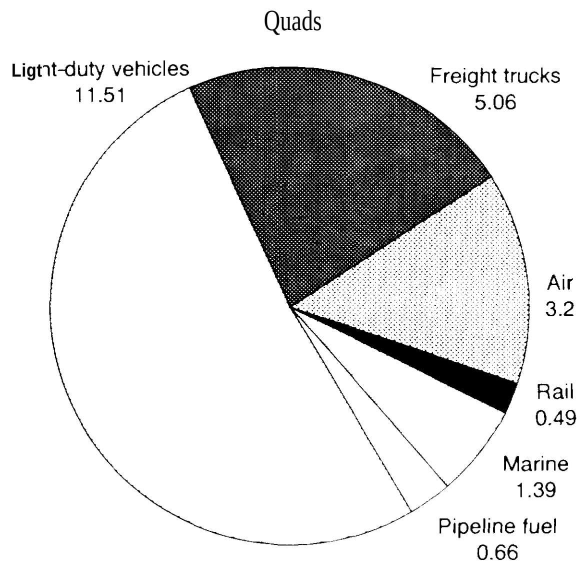
Freight Movement

The U.S. freight system moves about 3.2 trillion ton-miles of freight per year.[25] Trains and trucks each carry about 30 percent of this, barges about 25 percent, oil pipelines 16 percent, and air less than 1 percent. Trucks are the dominant transport mode for nonbulk cargo, such as mail, processed foods, and consumer goods. Truck types and cargo are extremely varied, with light trucks used primarily for short-distance urban and suburban delivery and for carrying craftsman's equipment, and heavy trucks hauling mixed cargo, processed foods, and building materials. Trains, on the other hand, carry primarily bulk products, which the United States ships in large quantities over very long distances. Key products moved by train include coal, farm products, and chemicals. An increasing fraction of train movement-now more than one-quarter—is in the form of trailers or containers (i.e., intermodal shipments involving both train and another freight mode, e.g., truck or barge), typically carrying manufactured or intermediate goods.

TRANSPORTATION ENERGY USE AND POTENTIAL FOR CONSERVATION

Figure 1 provides a broad overview of where energy is being used in the U.S. transport system. The figure illustrates that light-duty vehicles—automobiles, pickup trucks, utility vehicles. and vans—account for more than half of all U.S. transportation energy consumption. These vehicles are used predominantly for passenger travel. Airplanes, also used predominantly for passenger

FIGURE 1: Transportation Energy Use in 1990



SOURCE Energy Information Administration data

[22] Ibid.

[23] J.F. Hornbeck, *Transportation Infrastructure: Economic and Policy Issues*, 92-158E (Washington, DC: Congressional Research Service, Feb. 11, 1992).

[24] Office of Technology Assessment, op. cit., footnote 14.

[25] Davis and Strang, op. cit., footnote 3, p. 2-25.

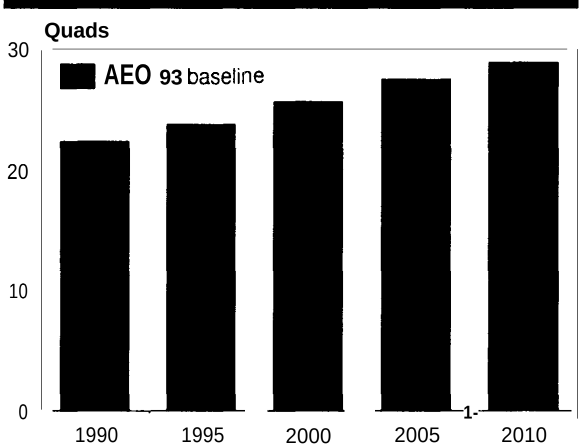
travel, account for 14 percent of U.S. transportation energy use. These two components of passenger travel thus represent a tempting target for energy conservation measures.

Freight trucks are the second largest consumer of transportation energy, accounting for nearly 23 percent of the total U.S. use. Freight truck energy use is expected to grow substantially during the next two decades and thus should also be an important focus for energy conservation. Other freight modes-pipelines, shipping, and rail (most rail energy is freight energy)—are all important, and rail may represent an opportunity to attract freight from trucking, with subsequent energy savings, but they are clearly of lesser significance than trucks for national energy savings.

U.S. TRANSPORTATION ENERGY CONSUMPTION: WHERE IS IT HEADING?

EIA's *Annual Energy Outlook 1993 (AEO93)* provides a detailed picture of future U.S. energy supply and demand, and transportation energy consumption in particular. The forecasts of transportation energy consumption depend on a number of critical factors and assumptions, including:

FIGURE 2: Expected Growth in U.S. Transport Energy



SOURCE U S Department of Energy *Annual Energy Outlook* 1993

- assumptions about future oil prices;
- assumptions about important demographic and socioeconomic trends, for example, the nature of women's evolving role in the workplace and how this will affect their driving patterns, and future rates of immigration;
- future progress in automobile and light-truck fuel economy;
- the market success of alternative fuels; and
- overall and sectoral growth rate of the economy.

EIA's baseline forecast accepts mainstream ideas about oil prices and economic growth: that a combination of plentiful oil supply, gradually increasing world demand, and Saudi restraint will maintain prices in the $20 per barrel (bbl) range for a few years and then gradually push prices upward, to $29/bbl (1991 dollars) by 201 O; and that slower growth in the U.S. labor force for the next few decades (a projected rate of about 1 percent per year versus 2.1 percent annually in 1970-90) will restrain the growth in real output of goods and services, but that the U.S. economy will remain sufficiently competitive in world markets to keep growing at the moderate rate of 2.0 percent per year.[26]

The forecast projects steady but moderate growth in transportation energy use: 1.26 percent per year, yielding a 28.5-percent increase from 1990 to 2010—the 1990 level of 22.50 quads (10.8 mmbd) increases to 28.93 quads (13.9 mmbd) by 2010 (figure 2).

EIA has formulated alternative forecasts based primarily on different economic assumptions: Alternative price scenarios reflect, on the low side, a combination of more conservation than expected, significant competition among Organization of Petroleum Exporting Countries (OPEC) members to expand production capacity, and high non-OPEC production and on the high side, more global economic growth and less conservation than expected, which boosts world oil demand, as well as a decreasing supply. Alternative economic growth scenarios reflect differing assumptions

[26] Energy Information Administration, 1991, op. cit., footnote 4.

about the rate of labor force growth and product i v-ity. As noted earlier, these scenarios introduce a range of transportation energy projections for year 2010 of 26.86to31.00 quads (12.9 to 14.9 mmbd) versus the 28.93 quads/ 13.9 mmbd base] inc.

The uneven history of energy forecasting demands that EIA forecasts, and all others, be viewed with some skepticism. Over the past few decades, sharp changes in both energy demand and supply characteristics-especially the former—have caused actual national energy trends to diverge sharply from widely accepted forecasts. For example, during the 1970s, forecasts of future electricity demand were revised downward so often that a simultaneous plotting of forecasts made in consecutive years described a wide fan, with the top of the fan representing the earliest forecast and the bottom, the latest.

Absent important new Federal policy measures—many of which are the province of Congress—several factors may increase the likelihood that actual transportation energy use in2010 will diverge substantially from EIA forecasts. *Potential* sources of divergence include: sharp changes in urban travel behavior (e. g.. more car-pooling and telecommuting), initiated by Transportation Control Measures under the Clean Air Act; major success of alternative fuels spurred by fleet purchases mandated by the Energy Policy Act, California's low-emission and zero-emission vehicle requirements, and technological breakthroughs; large increases in mass transit usage courtesy of State initiatives supported by ISTEA: breakthroughs in automotive technology, together with large shifts in market conditions: and continuation of recent trends in vehicle-miles traveled (i.e., high rates of grow(h) and energy efficiency (i.e., stagnation), in contrast to EIA's more optimistic assumptions.

Some potential sources of divergence (e.g., unforeseen success of Transportation Control Measures) imply that the EIA forecasts of transportation energy growth could be too high. The most likely sources, however, imply the opposite. *The most likely sources of forecasting error are assumptions about growth rates of travel and efficiency.* EIA has consistently chosen growth rates of travel that are lower, and efficiency increases that are higher, than recent historic rates. For example:

- Light-duty vehicle-miles traveled (vmt) grew at rates well over 3 percent per year during the 1980s, compared with EIA's assumed 1990-2010 rate of 1.7 percent annually. The history of light-duty vmt growth during the past four or five decades has been one of seemingly inexorable growth, despite expectations to the contrary.
- New car fuel economy has fallen since 1987. compared with EIA's assumed 1990-2010 increase of 1.1 percent per year. Low oil prices and consumer preferences for luxury, performance, and size are pushing the market away from fuel economy gains.
- Air travel grew at a better than 7 percent per year pace in the 1980s, compared with EIA's assumed 1990-2010 pace of 3.9 percent per year.
- All categories of freight trucks had mileage increases well above 3 percent per year (combination trucks' mileage grew at 4.7 percent per year from 1982 to 1990), compared with EIA's assumed 1990-2010 annual rate of 1.9 percent per year.

In OTA's view, without substantial policy intervention (excluded in the projections), *future rates of travel are quite likely to be higher and efficiency lower than EIA projects, with a resulting greater increase in transportation energy use than the projected levels.* There is room for technological breakthroughs in engines and other aspects of vehicle design to make some difference (e.g., in energy savings) in the 2010 time frame, but this is less probable than the potential for significant diversions from the forecasts in travel and efficiency growth rates, toward higher energy use. There ap-

[27] OTA agrees, however, that growth rates for light-duty vmt will fall somewhat below recent rates, primarily because of the likely slower growth in the number of adults of driving age.

pears little likelihood (again, without substantial policy intervention) that shifts to mass transit, other important changes in travel behavior, or market breakthroughs in alternative fuels will cause major changes (beyond those already included in the forecasts) in transportation energy use by **2010.**

IS THE U.S. TRANSPORTATION SYSTEM ENERGY-EFFICIENT? A COMPARISON WITH EUROPE

Decisions to initiate pro-conservation policies would be served by a determinant ion about whether the current U.S. transportation system is particularly inefficient in terms of energy use, as suggested by some, or whether it is relatively efficient. Some analysts and policy makers have compared U.S. energy use in general, and that used for transportation, with energy use in other developed nations, particular y Japan and Western Europe. Typically, these comparisons are described as demonstrations of U.S. energy inefficiency, because Japan and Western Europe use considerably less energy per capita in most sectors. As noted above, the average U.S. citizen uses about five times as much transportation energy as the average Japanese, and about three times as much as citizens of Great Britain, West Germany, and France. An examination of comparative energy use in the United States and Western Europe demonstrates that the disparity in per capita consumption is caused by a variety of factors, some of which clearly are related to differences in efficiency, but some of which have little to do with efficiency or are only vaguely connected to it. The discussion here does not address the critical question of comparative access to recreational, social, cultural, and employment opportunities, nor can the relative roles of government policies and other influences in shaping transportation energy use be separated definitively.

The major reason for the difference between U.S. and European transportation energy use is a difference in travel volume: on average, Europeans travel only about half as much (in miles per capita per year) as Americans.** This one factor accounts for half of the total difference in energy use. The causes of the difference are multiple and difficult to unscramble: higher cost of travel; *much* denser land use in Europe—in urban areas, in suburbs, and overall (which may be due in part to higher travel costs, but also is the result of different cultural histories, lower availability of land, stricter land use controls); differences in socioeconomic factors affecting travel (e.g., women participation in the workforce, household size, willingness of workers to relocate far from their families); differences in lifestyle; and so forth. Another reason may be timing: Europe began its shift to "automobility" later than the United States and, despite now having per capita incomes equal to or greater than U.S. levels, is still catching up in auto ownership. Part of the difference in travel volume may translate into greater accessibility to economic, cultural, and recreational opportunities for U.S. citizens, but OTA is not aware of any evidence to support this; the existence of such a difference in accessibility, especially in urban areas, is debatable because European population densities and prevalence of mixed-use development make access to work, recreation, and other destinations closer at hand; because much European urban travel is by walking and bicycling (which tend to be overlooked in statistical analyses); and because accessibility is a subjective, culture-laden term. European land use patterns will be described as "more efficient" than U.S. patterns by some, but this too is highly subjective.

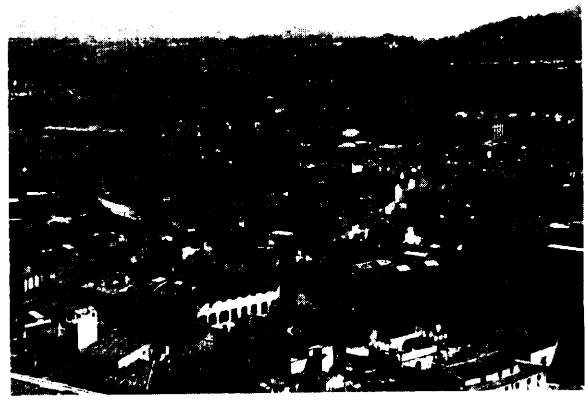
The other half of the energy difference is accounted for by differences in the proportions of various travel modes used (modal shares), load factors, and vehicle efficiency. As a fraction of their total travel, Americans travel somewhat more in private autos, and far more in energy-intensive airplanes, than do Europeans, who make far greater use of buses and trains. Mass transit has

[28] Schipper and Kiang, op. cit., footnote 12.

about a 15 percent modal share—measured as a percentage of passenger-miles—in Europe versus about 3 percent in the United States.[29] And European automobile fleets are more efficient than the U.S. fleet, partly because Americans purchase large numbers of light trucks for personal travel use, and partly because American automobiles are larger than their European counterparts. These differences are lessening, however, as are the differences in per capita travel: the rates of growth of travel and auto ownership are much higher in Europe than in the United States; U.S. auto fleet efficiency is catching up to most European fleets; and mass transit modal shares—although not absolute levels of ridership--are shrinking in most of Europe.

Unlike personal travel, European freight transportation is not more energy-efficient than its U.S. counterpart, though its volume in ton-miles in proportion to total economic activity is much lower than in the United States. The types of goods transported and the physical conditions differ sufficiently from those in the United States that there seem to be few lessons easily extracted from a comparison of the two systems.

The available statistical comparisons between Europe and the United States allow only tentative conclusions. They do demonstrate clear] y that *the substantial differ ence.s between European and U.S. transportation energy use patterns are associated largely with different levels of travel; about half of the difference in per capita energy use is due to differences in energy efficiency, at least in terms of common perceptions of what efficiency is.* On the other hand, Europe's faster rates of growth in travel demand should not be interpreted as meaning that European transportation is simply at an earlier stage of automobile dominance than the United States and destined to "catch up" to U.S. energy consumption levels. Although there will be some continued convergence between the two, *European levels of per capita*



MICHAEL GLUCK

High European population densities and prevalence of mixed-use development reduce the need for long trips to access work, recreation, and cultural opportunities

travel and energy consumption should continue significantly below those of the United States because of a combination of different geography and urban histories; European gasoline prices that are three to four times higher than prices in the United States; different policies regarding land use controls, parking availability, automobile restrictions, and other factors that affect travel; Europe's reasonably robust mass transit systems; and cultural and socioeconomic differences.

Could the United States, if it chose, match European levels of transportation energy use? Fuel price and other policy differences between the United States and Europe can be made to disappear by legislative will, and future U.S. moves to raise fuel prices, enact land use controls that increase urban densities, restrict parking, and so forth *would* move U.S. transportation energy use in the direction of European levels. However, some or all of these policy changes may not be politically acceptable: they would not affect all of the factors that make European energy use lower than U.S. levels; and some resulting changes in energy use, especially those associated with land use, would come quite slowly, over many de-

[29] L. Schipper et al., *Energy Efficiency and Human Activity: Past Trends, Future Prospects* (Cambridge, England: Cambridge University Press, 1992).

cades. The remainder of this discussion examines the incentives for and potential of U.S. government intervention in transportation.

WHY INTERVENE IN THE TRANSPORTATION SYSTEM?

As noted above, a variety of problems and issues are driving U.S. transportation policymaking, and perceptions of the importance of these problems and issues will be a key determinant of future policy decisions.

Economic Efficiency, Externalities, and Unpriced Inputs

To the extent that travelers do not pay for, or do not account for, the full costs of their travel, they will overuse it. Travelers do not pay the full price of the air pollution and congestion they cause, the impacts on national security of the oil they consume, (a portion of) the costs of the injuries and fatalities they cause in auto accidents, and so forth. They indirectly pay for, but do not account for in their travel decisions, the costs of parking in the shopping malls they patronize (these costs are embedded in the price of the goods being sold). Similarly, they may indirectly pay (in the form of lower salaries) but not account for most parking costs at workplaces. They pay and/or take into account only a portion of the costs of building and maintaining roads, because some of this cost is met from general funds, not user fees. And they pay and account for some services inefficiently: gasoline taxes that pay for roadbuilding are only indirectly related to actual road requirements.

In this study, OTA asked Mark DeLuchi of the University of California at Davis to prepare estimates of the social costs of motor vehicle travel, separating private, efficiently paid costs from external costs, hidden private costs, and inefficiently priced costs.[30] **These estimates indicate that approximately two-thirds to four-fifths of the total monetary costs of motor vehicle use[31] are efficiently priced, that is, paid for entirely by motor vehicle users, considered in their travel decisions, and priced at marginal costs to society. Based on some preliminary estimates of the dollar value of external costs, motor vehicle users efficiently paid for about one-half to two-thirds of the social (public plus private) costs of motor vehicle use, both monetary and nonmonetary, excluding the value of time.**

These estimates represent a long-term view of costs and their effects on behavior; that is, they make no distinction between costs that must be paid only occasionally (e.g., vehicle purchase price, insurance premiums) and those that are incurred frequently (e.g., fuel costs, air pollution damages). Some analysts prefer to focus on frequently incurred costs because they believe that these have a more powerful impact on travel behavior. Because many of the private, efficiently paid costs are paid infrequently, and most externalities and hidden or inefficiently priced costs are incurred daily or at least frequently, an analysis of frequently incurred costs would yield a lower ratio of efficiently priced costs to total societal costs. Which perspective—a focus on total costs or only on those costs incurred frequently—is more "correct," however, is not a settled issue.

These conclusions imply that there is some significant opportunity for improving the economic efficiency of motor vehicle travel by incorporating external costs, hidden private costs, and inefficiently priced private costs into the price paid by travelers. However, there are four important caveats:

[30] M.A. DeLuchi, University of California at Davis, "The Annualized Social Costs of Motor Vehicle Use Based on 1990-1991 Data," OTA contractor report, April 1994. Other studies of motor vehicle use are discussed in M.E. Hanson, *Results of Literature Survey and Summary of Findings: The Nature and Magnitude of Social Costs of Urban Roadway Use*, for Federal Highway Administration, U.S. Department of Transportation, 1992. OTA will soon publish a study reviewing different estimates of the environmental externalities of electricity generation.

[31] Including the cost of free parking and the monopsony cost of importing oil (the portion of oil consumption costs attributable to the effect that U.S. oil imports have on world oil prices), but excluding the costs of air pollution, travel time, and other nonmonetary costs.

1. Considerable uncertainty remains about both the magnitude and the appropriate monetary value of several external costs.
2. Measures to incorporate these costs must carefully match the pricing mechanism (gas tax, road pricing, etc.) to the patterns with which the costs are incurred and should avoid high implementation costs. If this cannot be done, it may sometimes be better to leave the costs unpaid by users.
3. Attempting to charge full social costs *only* in the motor vehicle sector ignores the reality that all economic activities have hidden, inefficiently priced, and external costs. Although there are reasons to believe that these represent a higher percentage of motor vehicle costs than of the costs for other activities, failure to apply full social cost accounting to other activities may reduce the economic efficiency benefits that would otherwise result from correcting transport pricing.
4. There may be external benefits as well as costs associated with motor vehicle travel that, ideally, would be incorporated in a "full social cost" accounting. Little research has been done on external benefits, but this does not mean that they are negligible.

Congestion

As noted, FHWA and others have projected large increases in traffic congestion for the coming decades, with delay costs soaring to tens of billions of dollars and average vehicle speeds dropping calamitously in many urban areas. For example, FHWA has projected a 450 percent increase in annual delay times from 1984 to 2005, from slightly more than 1 billion hours to nearly 7 billion hours. And local studies project that Los Angeles freeway speeds will drop to 11 miles per hour (mph) by 2010, from their present 31 mph. Skeptics of these estimates have attacked them at least in part on the basis of survey results showing that average U.S. commuting times remained essentially unchanged during the 1980s, a seemingly odd result if congestion has grown as much as estimated. Increases in reported average freeway speeds also appear at odds with estimated increases in congestion.


FEDERAL HIGHWAY ADMINISTRATION

Rush-hour traffic in the Virginia suburbs of Washington, DC, represents a familiar pattern that is spreading geographically to more cities and suburbs, and, temporally to a greater number of hours per day

OTA's evaluation of the available data indicates that it is possible that both the estimates of growing congestion and some of the apparently contradictory travel and highway speed data may both be right.[32] However, there is another reason to be concerned about the accuracy of the congestion estimates—they are based on traffic counts rather than on measurements of actual speed declines and travel delays, an indirect method that invites inaccuracy. And the dire projections of future congestion costs also invite skepticism because they take no account of shifts in job and residential locations or of changes in travel behavior (although these have been important factors in the past), and they assume that rising travel time costs will have no negative effect on the growth in traffic volume. In other words, these projections ap-

[32] This is primarily because congestion delays still represent a relatively small portion of total highway travel. Consequently, adverse effects of congestion on highway speeds and travel times could be offset by factors such as increased highway speeds during uncongested periods and shifts in commuting patterns.

pear to be worst-case extrapolations rather than "most likely case" estimates.

OPTIONS FOR REDUCING TRANSPORTATION ENERGY USE

The options available to policy makers to pursue transportation energy conservation activities include:

1. *economic incentives--direct taxes,* granting or eliminating tax breaks, subsidies, granting of regulatory exemptions, making pricing more efficient;
2. *public investment--in* new infrastructure (including new types of systems and services, e.g., mass transit), maintenance and rehabilitation of old transportation infrastructure, expansion of service, urban development, research and development; and
3. regulatoryincentives-efficiency standards, zoning, fuel use requirements, speed limits, inspection and maintenance requirements, and travel restrictions.

Some of the main thrusts of transportation energy conservation policy are discussed here, from raising gasoline taxes to increasing the use of mass transit.

■ Gasoline Taxes

Raising taxes on gasoline is often viewed as both a means to raise revenue and an energy conservation measure. Higher gasoline prices serve as an incentive to purchase more efficient cars and light trucks and to change travel behavior-toward carpooling, transit, and reduced tripmaking.

For every 1 percent increase in the price of gasoline, the number of vehicle-miles traveled is expected to decline by 0.1 to 0.25 percent;[33] new car fuel economy may also respond by increasing a small amount,[34] unless fuel economy standards are already forcing fleet miles per gallon (mpg) higher than the market would drive it. Current corporate average fuel economy (CAFE) standards do seem to be propping up fuel economy against a market-induced drop. Consequently, small increases in gasoline taxes maybe more likely to allow some automakers to stop subsidizing sales of small cars (which they do to comply with the standards) than to actually raise their CAFE levels.

Although there is a substantial range of views about the effect of gasoline taxes on gasoline demand and vehicle efficiency, the primary source of controversy about such taxes is disagreement about their impact on the deficit and on the economy. This disagreement stems from three major sources: failure to account for differences in the actual scenarios being analyzed; analytical uncertainty introduced by the use of different models, parameter choices, and baseline assumptions; and differences in beliefs about the extent to which gasoline is "underpriced" because of externalities and unpriced economic inputs associated with driving.

Any discussion of the impacts of a gasoline tax must recognize that such a tax, *like any tax,* acting alone, will in the short term depress the overall economy, increase unemployment, and reduce gross national product (GNP); after several years, these effects die out. Although there are multiple pathways for these effects, the primary paths include the reduction in gasoline demand and demand for new cars, which cuts jobs and income, and the reduction in aftertax income for people who must buy gasoline, which reduces their demand for most goods and services. These impacts then reverberate throughout the economy.

Gasoline taxes provide revenue, however, and the use to which this revenue is put makes a criti-

33 See C.A. Dahl, "Gasoline Demand Survey," *The Energy Journal,* vol. 7, No. 1, 1986, pp. 67-82.

34 The elasticity of fuel economy with respect to gasoline Price is highly uncertain, h'cause the large changes in fuel economy during the 1970s and early 1980s, which provide the best opportunity to obtain data for computing elasticities, occurred during a period when factors other than current gasoline price probably played an important role in boosting fuel economy. In particular, CAFE standards had been passed and available forecasts predicted astronomical oil prices. Al so, U.S. new car fuel economy had declined to wry low levels, so that the initial improvements were easy to achieve.

cal difference in the overall economic impacts of the taxes. This is why evaluation of gasoline tax impacts must be linked to scenarios of how tax revenues are used (e.g., reductions in other taxes, additional expenditures, or deficit reduction; in addition, the Federal Reserve System may accommodate tax changes with changes in monetary policy, and these changes will strongly influence overall economic impacts). For example, if revenues from an increase in gasoline taxes were used to reduce the tax rate on capital investments, the net macroeconomic effect would likely be positive because taxes on investment are particularly distorting to the economy. On the other hand, coupling the tax to a reduction in personal income taxes would likely yield a net negative impact because income taxes do not have large distortionary effects on the economy.

Analytical uncertainty is introduced to estimates of gasoline tax impacts by the use of alternative models. The Energy Modeling Forum at Stanford University has conducted carefully controlled evaluations of alternative model runs that examine the same tax scenario. These evaluations have uncovered large differences in predicted outcomes among the alternative models.

The above factors influence evaluations of the effects of a gasoline tax on quantifiable measures of the health of the U.S. economy. Another indicator of the health of the economy, one that cannot be directly measured, is economic efficiency, which is a theoretical concept of the "goodness" of resource allocation in the economy. As discussed earlier, the presence of externalities and unpriced economic inputs associated with driving leads to an underpricing of driving costs, and thus to more driving and more gasoline use than would be economical 1 y efficient. To the extent that a new gasoline tax reduces this underpricing, it will add to the efficiency of the economy; any further increase beyond the point at which gasoline price matches the marginal cost to society would reduce economic efficiency.

A gasoline tax is limited in its ability to compensate efficiently for externalities and unpriced inputs. It tracks well only with greenhouse warming and energy security costs. but quantification of monetary equivalents for these two externalities is extremely uncertain. Other externalities and unpriced inputs, such as congestion delays and unpriced road services, can be addressed more efficiently by means other than fuel taxes, for example, variable congestion charges on roads. According to the social cost estimates prepared for this study, inclusion of greenhouse warming[35] and energy security costs into the cost of gasoline would add approximately $0.15 to $0.80 per gallon to current prices. Thus, if these estimates are correct, additional gasoline taxes of up to $.15/gallon and perhaps higher would improve overall economic efficiency.

Full Cost Accounting

Although gasoline taxes should be considered a primary option for transportation energy conservation, they are also one component of a broader option, full cost accounting of all transportation modes. As discussed above, full cost accounting attempts to maximize economic efficiency by repricing transportation services so that travelers

Free parking at suburban malls and "super stores" represents **a** *partially hidden cost of motor vehicle travel Parking* **costs** *must be "paid" in higher prices for goods but shoppers may not account for these costs in their travel decisions*

[35] Global warming cost estimates should be considered particularly speculative.

pay and account for the full marginal costs to society of the transport services they select. Such a system would force travelers to take account of the air pollution (and other environmental effects, and negative impacts on society) that a trip would cause; would force payment for all transport services received (e.g., law enforcement); and would move hidden payments, such as parking costs, into the open so that travelers would account for them.

There is little argument about the clear value of full cost accounting in the abstract, but extensive controversy about the practical aspects of such accounting—the magnitude of externalities and unpriced inputs; the monetary values that should be placed on various externalities; the appropriate methods for implementing required price changes; and the likely impacts of price changes on travel behavior.

As noted, gasoline taxes could serve well to "internalize" the external costs associated with energy security and greenhouse warming because these effects vary with gasoline consumed, and thus with gasoline taxes collected. A variety of options exist to incorporate other externalities, unpriced inputs, and other ignored costs into the transportation price structure. For example, congestion pricing with electronic scanning of vehicles can be used to internalize the externalities associated with highway congestion. Parking costs can be "charged" to commuters by requiring firms to offer a cash option as an alternative to free parking. The costs of currently subsidized services—police and fire protection, for example, and a portion of local roadbuilding--can be translated into travel charges, although matching the nature of the services to an appropriate collection mechanism will be difficult. And the external costs of accidents can be added to driving charges by stricter requirements for insurance coverage or by incorporating a portion of insurance costs into fuel prices, vehicle registration fees, or other charges, thereby decreasing the incidence of uncompensated accident victims.

Automobile and Light-Truck Fuel Economy Standards[36]

Because light-duty vehicles—automobiles and light trucks---consume more than 50 percent of all transportation energy and 70 percent of energy from all motor vehicles, raising fuel economy standards for new light-duty vehicles is an obvious candidate for part of a national conservation strategy. The earlier legislative debate on new standards focused on a number of critical issues: the effectiveness of a regulatory approach to increasing fuel economy; achievable fuel economy levels; the most effective format for a new standard; timing of implementation; potential adverse effects on auto safety; effects on employment; and the likely fuel use reductions that would occur if standards are implemented. Each of these issues has generated substantial controversy.

Arguments about the effectiveness of new standards tend to revolve around perceptions about the actual impact of the 27.5-mpg standard (for automobiles only) set in 1975. Claims and counterclaims have been made about whether the large gains in U.S. fleet fuel economy in the 1970s and early 1980s37 were a response to the standard or to changed market conditions. '*Proof" of either side of the argument is elusive, but the sharply different fuel economy trends of companies that were either constrained or not constrained by the standards are persuasive that the past standard was a critical factor in the fleet's improvement.

The range of estimates for an "achievable" level of fuel economy over the next decade or so has been very wide, with domestic automakers arguing that future gains will at best be small and incremental, and conservation groups arguing that gains of 40 to 50 percent over current levels are readily achievable soon after the turn of the centu-

36 For more details, see U.S. Congress, Office of Technology Assessment, *Improving Automobile Fuel Economy: New Standards, New Approaches*, OTA-E-504 (Washington, DC: U.S. Government Printing Office, October 1991).

37 U.S. new car fleet fuel economy rose from 17.2 mpg in 1976 to 27.9 mpg in 1986.

ry. OTA concluded in 1991 that U.S. new car fleet fuel economy levels of about 33 mpg could likely be achieved soon after the turn of the century, with additional vehicle costs balanced by oil savings[38] and few measurable safety consequences (no downsizing would be necessary), but (probably) some limits on performance. Fleet levels of about 35 or 36 mpg were projected to be achievable in the same time frame with little technical risk and no forced early retirement of model lines but with costs that would not be recouped by fuel savings alone. During the nearly 3 years since these estimates were made, U.S. new car fleet fuel economy has not improved, and average vehicle weight has risen. Taking this into account, an updated estimate would likely project potential attainment of 33 mpg (at full cost recovery) or 35 to 36 mpg (cost recovery at $2 per gallon gasoline) by 2004 or 2005.[39]

The potential for- light trucks is somewhat less than for automobiles. Recent analysis of light-truck fuel economy projects that the domestic light-truck fleet could achieve about 23 mpg by 2005 with additional vehicle costs balanced by oil savings, and about 26 mpg by the same date with application of all available fuel economy technologies but no forced early retirements.[40]

Justification for the higher targets for both automobiles and light trucks would presumably be based on a belief that further fuel savings will yield added societal benefits in the form of lower greenhouse emissions. national security benefits from reduced oil imports (for the United States), and environmental benefits from lower oil production that are not incorporated in the price of oil.

The above increases in fleet fuel economy are based on application of well-known technologies and designs. New technologies, not yet introduced commercially into the fleet, could begin to play a significant role within the same time frame, The potential for these technologies is discussed below'.

If more stringent standards are to be imposed on new automobiles and light trucks, lawmakers will have to give serious consideration to the appropriate format for new standards. The current uniform 27.5-mpg standard for automobiles. applied separately to domestic and imported fleets for each company, has created large marketplace distortions by ignoring differences in the mix of vehicles manufactured by each automaker and by allowing gaming between domestic and imported fleets.[41] In particular, the uniform standard offers substantial market advantages to makers who have focused on smaller cars (e.g.. the Japanese automakers), by leaving these makers relatively unconstrained. Lawmakers might consider standards that vary with the average attributes of each automaker's fleet, so that each company's fuel economy target bears some relationship to the true technical potential of the vehicles it manufactures. Attributes such as interior volume, "footprint" (wheelbase x track width). or even combinations of weight, engine torque, and interior volume might be appropriate candidates for such a standard. New standards for light trucks might deal with different categories of trucks individually—for example, basing standards for passenger vans on interior volume and standards for pickup trucks on load carrying capacity. Design of appropriate

[38] If gasoline prices in year 2001 were $1.50 per gallon (1991 dollars). Office of Technology Assessment, op. cit., footnote 6.

[39] Full cost recovery would occur if gasoline prices rose to $2 per gallon by 2001. In comparison, the National Research Council (NRC) projected a "practically achievable level" of 31 to 33 mpg for 2001 using similar assumptions; the most appropriate value for comparison to OTA's projection appears to be the lower value, NRC's "high confidence" level.

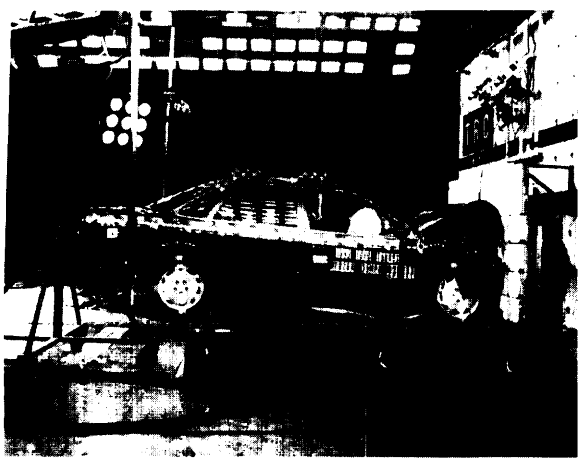
[40] Energy and Environmental Analysis, Inc., "Domestic Manufacturers Light Duty Truck Fuel Economy Potential to 2005," paper prepared for Oak Ridge National Laboratory, July 1993.

[41] For example, by shifting the manufacturing location of a few parts, automakers have changed vehicle designations from "import" to "domestic" or vice versa when this would ease their compliance requirements.

standards for the light-truck fleet will be a special challenge for regulators.

A centerpiece of recent congressional debates about new fuel economy standards has been concern about effects on vehicle safety, with the chief concern being the potential for forced downsizing of vehicles and an accompanying increase in injuries and fatalities from higher incidence of vehicle rollover or other causes. The potential for adverse safety consequences from either downsizing or downweighting is a legitimate concern. Although 10-year fleet fuel economy gains of 30 percent or so are feasible *without* downsizing, and market forces would appear likely to weigh against downsizing, there are no guarantees that automakers would not choose this course; further, moderate reductions in weight (a few hundred pounds would be likely) might have some adverse safety consequences. Also, requiring gains greater than 30 percent in this time frame, or a shorter schedule for required gains, could create severe pressure to downsize the fleet, with likely adverse safety consequences. On the other hand, measures are available to mitigate safety problems, including small increases in track width to reduce rollover risks, universal application of anti lock brakes, and enhancement of interior padding to prevent head injuries.

U.S. DEPARTMENT OF TRANSPORTATION



Barrier tests are an important safeguard in assuring the safety of new car designs, including designs stressing materials changes and other weight reduction measures

Another strong concern of lawmakers has been the potential employment consequences of new standards. Clearly, standards that can be achieved only by severely compromising consumer amenities could adversely affect sales and have an unfavorable impact on industry employment. However, there is no indication that standards at the levels discussed would hurt domestic automakers' competitive position or strongly affect their sales.

Analyses by both the industry and the conservation community have concluded that new standards would have strong employment impacts. However, competing analyses drew sharply different conclusions: the industry's analysis projected large job losses, and the conservation community's analysis projected large job gains. OTA found that both projections were driven more by their starting *assumptions* than by objective analysis.[42] The only defensible conclusion is that oil savings from new standards, like oil savings from any source, will tend to have positive impacts on national employment because the oil backed out of the economy will likely be imported oil, which generates fewer jobs per dollar spent than most other expenditures.[43] However, this is only one of several sources of employment impacts from new standards. Depending on the cost of required changes in auto design and the gasoline savings achieved, consumers may have more or less to spend on other goods and services, which would affect nonindustry employment; and net auto sales as well as auto manufacturing productivity rates might change, which would affect industry employment. These impacts could be negative or positive.

Finally, there has been considerable debate about the likely fuel savings associated with new

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[42] Although the conservation community's analysis, conducted by the American Council for an Energy-Efficient Economy, made much more use of economic analysis in its projection.

[43] In other words a dollar not spent on imported oil costs fewer jobs than are added by spending that dollar elsewhere in the economy.

standards. Most of the debate has been centered around Senate bill S. 279, which required each company fleet to improve by 20 percent for 1996 and 40 percent by 2001. Most differences in estimates occurred because of differences in assumptions about the likely values of fuel economy that would occur *without* new standards; the likely use of alternative fuel credits by automakers; the magnitude of any increase in driving because of reduced "per-mile" fuel costs associated with higher-efficiency autos; and the likely magnitude of future growth of vehicle-miles traveled. Two estimates that can serve as "outliers" are the Department of Energy's estimate of 1 mmbd saved by 2010, and the American Council for an Energy-Efficient Economy's estimate of 2.5 mmbd saved by 2005. OTA estimates that the most likely savings from compliance with S. 279 would be about 1.5 to 2.2 mmbd by 2010, *if compliance does not significantly hurt new car sales.*

"Feebates": An Alternative or Complement to Fuel Economy Standards

"Feebate" plans offer a market substitute for, or supplement to, new fuel economy standards. Feebate plans involve charging fees to purchasers of new cars that have low fuel economy[44] and awarding rebates to purchasers of new cars with high fuel economy. The plans can be designed to be revenue neutral or revenue generating, but their general purpose is to provide an incentive for consumers to purchase efficient vehicles and for manufacturers to produce them. Feebates avoid the danger inherent in CAFE standards: that the estimated costs and fuel economy benefits of available technologies are too optimistic. so that complying with the standards will end up costing much more than expected. Also, unlike CAFE standards, feebates provide continuing incentives to improve fuel economy beyond the level initially desired by rewarding the deployment of new, unforeseen technologies. On the other hand, leaving fuel economy results entirely to the market runs the risk that the actual improvements obtained may be considerably less than hoped for. In OTA's view, the potential for error in projecting the costs and benefits of feebates is quite high. Attempting to predict the actions of auto manufacturers in a free market adds considerable uncertainty to an analysis of fuel economy potential —beyond the important uncertainties in technology costs and benefits inherent in OTA's analysis of CAFE standards.[45]

Recent analyses by Lawrence Berkeley Laboratory (LBL) conclude that feebates large enough to award a $500 differential between a 20-mpg and a 25-mpg car can achieve a significant new car fleet fuel economy increase—15 percent over expected levels by 2010.4b Virtually all of this improvement is expected to come from manufacturer responses to feebates, with changes in consumer behavior contributing little. If this analysis is correct, feebates will have an impact similar to CAFE standards aimed at the same 15 percent improvement, although with more flexibility y for manufacturers but less certainty of attaining the desired improvements in fuel economy. The dominance of the manufacturer response implies, however, that small-scale programs (e.g., programs conducted by one or a few small States) are unlikely to have much effect because they would be unlikely to affect manufacturer decisions.

An important concern of feebates is the possibility that they would provide an advantage to foreign automakers, because foreign companies, especially the Japanese, tend to have higher CAFE levels than U.S. automakers. The LBL analysis concludes that foreign automakers will gain more rebates than U.S. automakers, although this effect would diminish over time. Basing the feebate system on car size would diminish the adverse impact

[44] Measured against the average for all cars, or for cars in that class, or some other value.

[45] Office of Technology Assessment, op. cit., footnote 2.

[46] Using the same estimates of technology costs and fuel economy improvements that OTA used to evaluate CAFE standards.

on U.S. companies, because much of the difference between the U.S. fleets and the Japanese fleets is due to the larger average size of U.S. cars. However, LBL concludes that this type of feebate yields considerably less improvement in fuel economy than a feebate that allocates fees and rebates based only on fuel economy.

Transportation Demand Management Measures

Both the Clean Air Act Amendments of 1990 and ISTEA include requirements for programs that improve transportation efficiency by reducing traffic volume, especially during peak travel times. These transportation demand management measures (TDMs),[47] including parking charges, high-occupancy vehicle (HOV) lanes, and intelligent vehicle-highway systems (IVHS), could play an important role in a national conservation strategy. (In essence, many TDM measures are similar or identical to measures that would form the basis for full cost accounting.) Although few analysts expect any particular TDM to make great inroads in fuel use, especially because of likely political limitations on the severity of incentives considered, fuel savings of several percent may be possible from an intensive program combining a variety of such measures. Unfortunately, the limited number of trials of TDM measures and the diversity and complexity of travelers' reactions to them imply that policymakers must accept considerable uncertainty in gauging their likely impacts. Some promising or prominent measures include:

1. *Pricing parking:* Parking charges would be one of the largest and most visible costs of commuting and other local travel if most travelers paid them, but 90 percent of commuters receive free parking. Asking employers to offer workers a cash alternative to free parking (i.e., either parking or cash, at their choice) or otherwise providing a market incentive not to park appears to have substantial potential to reduce vehicle worktrips.
2. *Congestion pricing:* Placing electronic tolls on heavily traveled roads during peak periods should both reduce total trips and displace trips out of peak periods, when congestion makes them inefficient. Although congestion pricing is economically efficient because it asks travelers to pay for costs they impose on others, the substantial magnitude of the per-mile charges needed to make significant inroads on traffic volumes (estimated to be as high as $0.65 per mile in California's urban areas) represents a powerful roadblock to implementation.
3. *Telecommuting:* The growth of information-oriented service industries and simultaneous radical improvements in telecommunications capabilities may allow growing numbers of workers to "telecommute" from home or satellite offices, thereby avoiding long commutes. Currently, between 2 million and 8 million workers telecommute,[48] and the Department of Transportation projects that as many as 15 million workers could telecommute by 2002. Although all such estimates are highly uncertain, the potential clearly is large, with accompanying energy savings of more than 1 billion gallons of gasoline per year at the upper end.
4. *High-occupancy vehicle lanes:* HOV lanes are freeway lanes restricted during peak hours to vehicles containing two or more passengers. They provide an encouragement to carpooling, as well as providing some potential congestion relief—and increased efficiency-to the remainder of the roadway (unless they are conversions from previously unrestricted lanes, in which case their effects on congestion depend on circumstances). There is controversy about the ability of new HOV lanes to reduce overall vehicle-miles of travel and energy use, because the added roadway capacity and reduced congestion will stimulate additional travel, cancel-

[47] Or transportation control measures (TCMs).

[48] The range reflects the severe lack of data.

ing some of the benefits from increased ride sharing.

5. *Intelligent vehicle-highway systems:* IVHS encompasses a range of systems that can provide services from timely information to drivers about congestion and alternative routes to fully automated control of vehicles on limited access roads. ISTEA authorizes several hundred million dollars for IVHS development. These systems should have substantial potential to relieve congestion in crucial corridors. The ability of IVHS to reduce overall energy use is more problematic, however, because the energy saved by reducing congested (and inefficient) traffic flow must be balanced against any increased energy use from additional travel stimulated by increased road capacity.

Public Transportation

Whether public transportation is a key to revitalizing U.S. central cities and substantially reducing automobile use or has only minor relevance to future transportation policy is an ongoing argument in the transportation community. This is largely an argument between the hoped-for potential of public transportation and the disappointing record of its actual performance in the United States; it is also an argument about unpaid-for costs and unaccounted-for benefits.

There may be many local success stories of U.S. public transportation, and the central business districts of many American cities could not survive in their present forms without mass transit; yet for the past several decades, transit has shown a disturbing trend toward increasing costs and declining market shine despite heavy subsidies. Labor productivity y, for example, fell sharply during 1960-85, although it has rebounded a bit during the past few years. Similarly, per-mile labor costs rose by 80 percent *after inflation* from 1965 to 1983, with relative stability since then. With higher operating costs and reluctance to raise fares because of declining patronage. transit subsidies have risen. Local, State, and Federal governments now pay about 57 percent of transit operating costs and almost 100 percent of capital costs. This means that on capital-intensive systems (e.g., heavy rail systems such as Atlanta, Washington, DC, Buffalo), ticket prices may be paying for only 1() or 20 percent of total costs, with governments picking up the rest.

Heavy rail systems are a transportation mainstay of many U S cities, including New York, Philadelphia, Chicago, Boston, Washington DC (Washington's METRO shown here) and others

Aside from high costs, it also is not clear that most U.S. transit systems *in their present form* are saving much energy. From 1970 to 1989, both bus and rail transit energy intensity (fuel use per passenger-mile) increased substantially: buses by 70 percent, primarily because of lower load factors, growing urban congestion, and greater orientation to suburban services that require more nonrevenue backhauls; and rail systems by 38 percent, at least in part because a number of new systems were added that are faster and tend to operate at lower load factors than earlier ones. Right now, *on average* there is little difference between auto efficiency and public transportation efficiency in Btus per passenger mile.[49] Unfortunately, obtaining a fair comparison between auto and transit energy in ten-

[49] Davis and Strang, op. cit., footnote 3, table 2-13.

sity is quite difficult, requiring an accounting of trip circuity;[50] energy built into capital structures; trips used to access mass transit: appropriate auto load factors, given not only the type of trip but the characteristics of those auto users who are potential transit users; travel conditions (e.g., congestion); and transit system characteristics. Automobiles may in some instances be more energy-efficient than mass transit.[51] This does not imply, of course, that transit systems cannot save considerable amounts of energy under the right circumstances: high load factors for the transit system; private vehicles operating in congested conditions, often with single occupancy; transit operating on its own right of way or lane, or sharing an HOV lane.

Urban Planning

The potential of public transportation cannot be discussed properly without simultaneously discussing the role of urban form in shaping transportation patterns and energy use. It is clear from evaluation of urban areas worldwide and within the United States that residential density, as well as other urban characteristics such as centralization and mix of land uses, plays a crucial role in both the amount of per capita travel and the mode chosen. Cities with high residential densities (greater than 12 persons per acre), a strong central focus, and an intertwining of residential and commercial land uses tend to have both low overall per capita travel and relatively high use of public modes of transportation, as well as walking and bicycling, compared with cities with lower densities, lack of centralization, and separated land uses. Other urban characteristics that are strong indicators of both travel and mode choice are the relative volume of roadway and the volume of parking spaces per 1,000 vehicles. Given these relationships, many in the environmental community wish to consciously reshape American cities to make them more compatible with transit, bicycling, and walking, and to greatly reduce the travel necessary for access to employment, recreational, and cultural opportunities.

The urban characteristics discussed above are the result of both immutable factors—the cities' wealth and its distribution, their history (especially when they experienced their major growth), and their geography-as well as factors that are controlled by governments, such as roadbuilding policies, housing policies (including tax breaks afforded private dwellings), parking requirements, and land use planning controls. The precise role of the various forces is still the subject of considerable debate, with environmental groups stressing the role of policy and pro-development groups stressing the role of factors not controllable by policy. In reality, however, even those factors theoretically controllable by policy have become embedded in the American political system and are difficult to change. A few U.S. cities have made serious attempts to change some of these factors, however—Portland, Oregon being one of the most widely known[52]—but the results are not yet evident, And even these cities can change only some factors; other important matters, such as mortgage interest exemption and a tax policy that treats free employee parking as exempt from taxation, are controlled by the Federal Government. What this implies is that a serious effort to shift land use patterns into forms more compatible with reduced travel and greater use of transit, bicycling, and walking will require strong efforts at all levels of government, that changing the necessary policies will be politically difficult, and that the re-

[50] Trip circuity is the degree to which a trip between origin and destination diverges from the shortest path between the two.

[51] For example, in carpools, or more generally, when transit load factors are low.

[52] Portland has established an Urban Growth Boundary to direct development into the city rather than its suburbs, prohibited automobiles in a key downtown corridor served by bus transit; restricted parking spaces incorporated into new office development; and developed a light rail system. The city has thus far obtained good results regarding traffic volume and transit share for a small downtown area but, as a whole, has seen both a loss in transit share and a large increase in single-occupancy vehicles from 1980 to 1990.

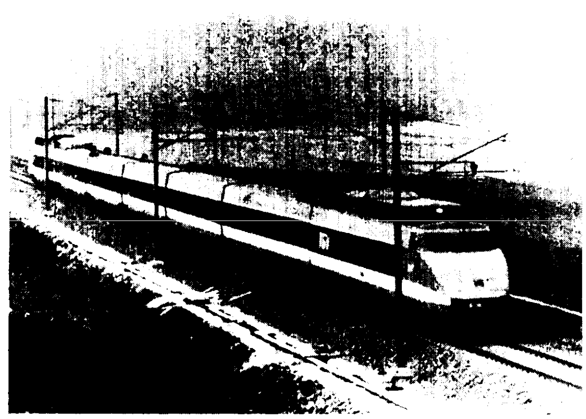
suits, in terms of actual changes in land use, are uncertain. Without a coordinated effort of this sort and a successful shift to denser land use patterns, however, it is difficult to imagine any kind of revitalization of public transportation in this country, regardless of the investment capital poured into new systems.

A corollary to the idea of changing land use to revitalize transit and reduce travel demand is that of installing transit systems to shape land use. Unfortunately, although it is clear that introduction of rapid transit systems can have large effects in the immediate locality around stations, there is little indication that such systems have had much effect on urban structure, at least over the past few decades. This lack of a strong, measurable impact implies that access to a transit system, although certainly a factor in determining locational decisions for new development, is only one of many such factors. Building a transit system can be part of a multifaceted strategy to affect land use, but it is unlikely to do much in relative isolation.

This conclusion is disputed by some environmental organizations, which maintain that comparisons of travel behavior and land use density across areas with different levels of transit service show clearly that such service creates higher densities of land use and reduces per capita levels of travel. Were such an effect to occur, transit evaluations should properly count the induced reductions in travel—and resulting decrease in air pollution, congestion, and other social costs of auto travel—as a direct benefit of transit. OTA's evaluation of the available studies indicates, however, that they are not adequate to demonstrate such an effect: they generally do not show changes over time, do not account sufficiently for demographic differences between areas with differing land use, fail to distinguish among different trip purposes, and cannot prove cause and effect. However, the positive relationship between good transit service and dense land use, on the one hand, and lower levels of travel, on the other, does lend weight to the argument that policies aimed at both increasing transit service and increasing land use density, if successful, would likely reduce travel and should be credited with this reduction in a cost-benefit analysis. Further study is needed to define the likely magnitude of such an effect, however.

High-Speed Intercity Public Transportation

Only 1.2 percent of all person-trips are at least 75 miles in length, but these trips represent more than one-quarter of all person-miles of travel. For trips from 100 miles (below which autos can be expected to continue their dominance) to about 500 miles in length (beyond which air travel should continue dominance), investments in high-speed ground transportation (HSGT) systems capable of speeds around 200 mph or faster—rail or maglev[53]—represent an option to relieve congestion in both auto and air modes and possibly (depending on system characteristics) to save energy (and reduce oil use). In fact, proposals have been made to install such systems in a number of U.S. inter-



The Train a Grand Vitesse (TGV) currently operates at high speeds (185 mph) along more than 1,000 miles of track in France

[53] Maglev systems are trains that operate suspended in air on fixed, dedicated guideways, held up by magnetic forces and propelled by linear electric motors.

city corridors, including Miami-Orlando-Tampa, Cleveland-Columbus, San Diego-Los Angeles-San Francisco-Sacramento-Reno-Las Vegas, Atlanta-Columbus/Macon-Savannah, and the Northeast Corridor (Boston-New York City-Washington, DC). The Transportation Research Board has found that further testing and development are necessary for maglev systems to prove they can operate safely and reliably in revenue service; European high-speed rail systems operating at speeds approaching 200 mph are firmly established.[54]

Although high-speed rail systems have been successful in Europe and Japan, this does not automatically demonstrate their applicability to U.S. conditions. The United States has some key disadvantages—less densely populated intercity corridors, with major cities farther apart; lack of preexisting heavily traveled rail links; lack of well-established intracity trains in most destinations; and availability of competitively priced air shuttle services. Further, much of the current and projected airport congestion is due to airline management decisions favoring hub-and-spoke operations, and is not entirely a function of physical capacity. Thus, the extent of future airport congestion, which is a key argument in favor of intercity high-speed rail, is somewhat in question.

Available analyses indicate that new HSGT systems would likely require strong government capital subsidies to maintain financial viability. With full capital subsidies (which new urban rail transit systems have received), operating and maintenance costs for new systems should be low enough to allow them to compete well with air and low-occupancy auto travel. Without such subsidies, annual ridership levels would have to be at least 2 million, and most likely about 6 million, passengers (high estimate: 17 million passengers per year), for the systems to break even. By 2010, only four city pairs are expected to have total air ridership exceeding this mark—Los Angeles-San Francisco, Boston-New York, Washington, DC-New York, and Los Angeles-Phoenix. Although maglev costs are quite uncertain because full-scale systems have not been built, early analyses imply that they would have a more difficult time breaking even without subsidies; OTA has found that the infrastructure costs of a maglev system for the Northeast Corridor would be approximately double those of a high-speed rail system.[55]

The keys to the future success of HSGT systems, if they are built, will be the extent of congestion growth in both road and air modes (available forecasts for both modes have large uncertainties), the level of subsidies Federal and State governments are willing to extend (which depend, in turn, on the value society places on the oil displacement, congestion relief, and other societal costs reduced by use of the systems), and the response of competing modes.

Improving Auto Fuel Economy: Moving Beyond Current Technology

Recent congressional deliberations about fuel economy standards have focused on relatively evolutionary improvements in automobile design, on moving available fuel efficiency technologies widely into the fleet, and on a short-term (10 to 15 years) time horizon. Another potential direction for fuel economy improvements is a radical shift in technology and design, possibly including a change in basic powerplant. Such a direction is embodied in calls for the introduction of "supercars, " extraordinarily light-weight, electric-hy-

54 Transportation Research Board, *In Pursuit of Speed: New options for Intercity Passenger Transport,* Transportation Research Board Special Report 233 (Washington, DC: National Research Council, 1991).

55 U.S. Congress, Office of Technology Assessment, *New Ways: Tiltrotor Aircraft and Magnetically Levitated Vehicles,* OTA-SET-507 (Washington, IX' U.S. Government Printing office, October 1991).

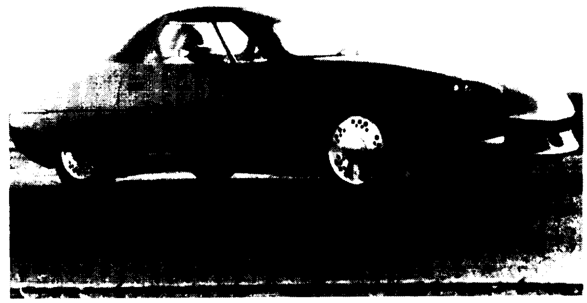
brid-powered vehicles, by the conservation community[56] and in a recent announcement by the Administration and the three domestic automakers of a partnership to develop a new passenger car with up to three times the fuel efficiency of current autos.

The basic features of an advanced automobile, one that went well beyond current technology, might include:

- a shift in body materials, probably to carbon-fiber or other composite materials, with higher materials costs counteracted by greatly reduced assembly costs;
- a total dedication to streamlining, bringing the vehicle drag coefficient down to the range of 0.2 or lower, compared with the current commercial state of the art of about 0.3;
- high-pressure, low-rolling resistance tires, perhaps similar to those in General Motors' Impact electric vehicle;
- an advanced engine, probably either a super-efficient four-stroke design with four or more valves per cylinder, adjustable valve lift and timing, and other low-friction measures or a two-stroke design; and
- extensive use of aluminum and other lightweight materials in suspension and other components (e.g., brake rotors and calipers, sway bars, wheels).

Rather than an advanced internal combustion engine, a radically redesigned automobile might use electric motors powered by batteries or fuel cells. or a hybrid combination including batteries and a motor/generator (or one of a variety of other combinations of power sources, including flywheels).

Recent strong technical advances have placed such an automobile closer to reality, although still a considerable way from commercialization. Some important advances are small, lightweight direct-current inverters that allow use of highly efficient, lightweight alternating current motors:


GENERAL MOTORS

GM's Impact electric vehicle represents a "ground up," innovative design focused on the unique requirements of an electricity based power source

and a 40-fold reduction in the amount of platinum required in proton-exchange membrane fuel cells, moving platinum availability and costs into the "realistic" range. Not surprisingly, there remain a number of crucial technical hurdles: improving the manufacturability and reducing the cost of advanced materials; designing adequate safety systems for a vehicle in the 1,000-pound range; achieving major improvements in fuel cell and battery technology; and so forth.

Thus far, the major "driver" for the development of advanced light-duty vehicles has been California's zero emission vehicle (ZEV) requirements. which require automakers to achieve at least 2 percent of their in-State sales with vehicles emitting no criteria pollutants by 1998, and 10 percent by 2003 (some northeastern States have adopted identical requirements). These vehicles will almost certainly be electric. The ZEV requirements have succeeded in stimulating a major research effort to develop electric cars: the eventual success of the requirements in bringing commercially acceptable electric cars to the marketplace remains an open question. however.

On September 29, 1993, the President announced a "Clean Car Initiative" with the three

[56] See A.B. Lovins et al., Rocky Mountain Institute, "Supercars: The Coming Light-Vehicle Revolution," unpublished report, Mar. 31, 1993.

domestic auto manufacturers. The initiative has as a primary goal the development of a manufacturable prototype automobile within 10 years that achieves a threefold increase in fuel efficiency while maintaining the affordability, safety standards, performance, and comfort of today's cars. This joint government-industry research program may add to the impetus for a large improvement in light-duty vehicle efficiency.

Shifting to Alternative Fuels[57]

The use of alternative, nonpetroleum-based fuels in vehicles, though generally viewed as a fuel substitution measure, also offers opportunities to reduce overall energy use and greenhouse emissions; in other words, alternative fuels can play a role in energy conservation. Energy savings may be gained from changes across the entire fuel cycle, ranging from changes in fuel efficiency at the vehicle[58] to changes in the energy required to find, collect, and transport fuel feedstock materials. Greenhouse gas emission reductions may be obtained directly from the energy savings and also from differences (from gasoline) in the alternative fuels' carbon content and general chemical makeup, which yield different fuel cycle emissions of carbon dioxide and the other greenhouse gases (carbon monoxide, nitrogen oxides, nitrous oxide, methane, etc.).[59]

The primary alternative fuels under consideration for use in light-duty vehicles are the alcohols methanol and ethanol, natural gas, liquefied petroleum gas (LPG), hydrogen, and electricity. Except for electricity, all the fuels can be used in internal combustion engines. Hydrogen also can be used in fuel cells;[60] and methanol and natural gas, which are hydrogen-rich, can act as hydrogen carriers for fuel cells.[61]

Several factors inhibit the introduction of these fuels into the marketplace: the entrenchment of gasoline in the light-duty vehicle market; the lack of supply infrastructures and mature vehicle technologies for most of the alternative fuels; and various cost and range problems.[62] The Energy Information Administration expects, however, that a range of government incentives will help alternatively fueled light-duty vehicles capture from 1.9 to 2.4 percent of the light-duty vehicle fuel market by 2010.[63] These incentives include the 1990 Clean Air Act Amendments (CAAA), which establish a set of clean fuels requirements; the State of California's Low Emission Vehicle Program under the CAAA, which requires minimum sales of vehicles in different emissions cate-

57 For more details, see U.S. Congress, Office of Technology Assessment, *Rep/acing Gasoline: Alternative Fuels for Light-Duty Vehicles*, OTA-E-364 (Washington, DC U.S. Government Printing Office, September 1990).

S8 Because the alternative fuels have di fferent combustion characteristics (e.g., methanol's octane rating is 101.5 and natural gas's is 120 to 130 versus 87 to 93 for typical gasolines; this allows methanol and natural gas engines to use higher compression ratios, raising thermal efficiency) and may require basic shifts in the drive train and fuel storage systems (e.g., electricity demands the use of electric drive motors and battery or ultracapacitor storage).

59 See M.A. DeLuchi, *Emissions of Greenhouse Gases From the Use of Transportation Fuels and Electricity*, ANL/EDS-TM/22 (Argonne, IL: Argonne National Laboratory, 1991). This report presents detailed estimates of the greenhouse emissions for each portion of the fuel cycle for a variety of alternative fuel/vehicle/supply source combinations.

60 Fuel cells are electro-chemical devices that convert hydrogen into electricity without combustion and with water as their only byproduct, acting like batteries that have continual recharge of their chemical electrolyte.

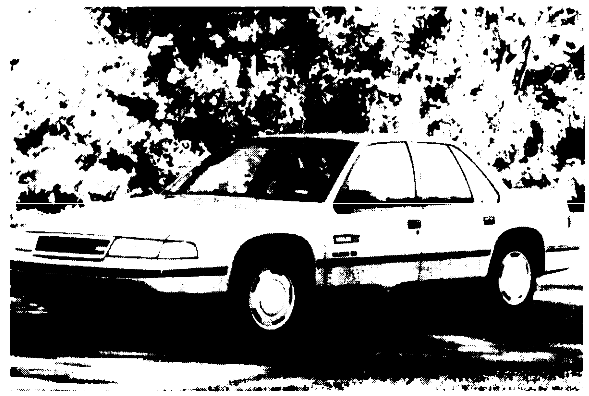
61 However, use in fuel cells of hydrogen carriers rather than pure hydrogen requires the addition of an onboard reformer to first release the hydrogen from these fuels. Although the fuel cell has no air emissions, the reformer does, so a fuel cell vehicle with a hydrogen-carrier fuel will not strictly be a zero emission vehicle.

62 All of the alternative fuels are less energy-dense than gasoline, and thus need a higher volume of fuel to achieve an equivalent range.

63 U.S. Department Of Energy, Energy Information Administration, *Assumptions for the Annual Energy Outlook 199.?*, DOE/EIA-0527(93) (Washington, DC: January 1993).

gories, including the 19982 percent ZEV sales mandate discussed earlier; and alternative fuel fleet requirements and tax incentives under the Energy Policy Act of 1992. Vehicle manufacturers can also get fuel economy credits toward meeting their CAFE requirements by manufacturing alternative fuel vehicles. Because most automakers can comply with current CAFE standards without a great deal of difficulty, the availability of the credits may have little effect unless CAFE requirements are raised.

Government incentives for alternative fuel use hinge on three potential benefits: energy security and economic benefits from reducing oil use and imports; air quality benefits, especially from reduced emissions of ozone precursors; and greenhouse benefits from reduced fuel cycle emissions of CO_2 and other greenhouse gases. The likelihood that these benefits will actually be obtained is mixed and uncertain, however. Take energy security, for example. Although all of the alternative fuels will substitute for oil, some raise their own security concerns because they may be imported (e.g., methanol if U.S. natural gas prices were to rise,[64] LPG in large quantities). These concerns may not be as severe as those associated with oil imports, however; feedstock resources, e.g., natural gas, tend to be less concentrated geographically. Security benefits also will depend on market penetration (which will affect fuel supply sources and costs) and other factors that are uncertain. And the existence of fuel economy credits adds uncertainty to security benefits. Were CAFE standards to be raised, automobile manufacturers might choose to use credits from sales of alternative fuel vehicles to avoid some of the fuel economy improvements otherwise required by the standards; the oil use reduction benefits of the alternative



GENERAL MOTORS CORP

Chevrolet Lumina Flexfuel auto can use straight gasoline, M85 (85 percent methanol, 15 percent gasoline mixture), or any combination in between

fuels might then be at least partially offset by he loss in efficiency gains.

Air quality benefits depend on the nature of emission standards promulgated for alternative fuel vehicles and on the tradeoffs vehicle designers make among factors such as emissions, vehicle performance, and fuel economy. Where regulators try to adjust standards so as to weight emissions according to their potential to impact air quality, as California is doing, the emissions from vehicles using gasoline, methanol, natural gas, and other alternative fuels in internal combustion engine vehicles may be similar; only electricity and hydrogen. and methanol and natural gas in fuel cell vehicles, would then enjoy a clear emissions advantage.[65] Finally, greenhouse benefits depend on a variety of system design details, including choice of feed stocks, tradeoffs in conversion facility energy efficiency between capital and operating cost, and vehicle design decisions, as well as the uncertain progress of immature technologies. In the near term, any greenhouse benefits are likely to be small and easily lost (though early growth

[64] Methanol would likely be produced primarily in the United States and Canada at current gas prices; at higher prices, overseas production would be more likely, though some analysts believe there would still be potential for domestic methanol production as a byproduct of steel production, assuming shifts in steel production technology to allow co-production of pig iron and methanol.

[65] See D.E. Gushee, Congressional Research Service, "Alternative Fuels for Automobiles Are They Cleaner Than Gasoline?" Report for Congress, 92-235 S, Feb. 27, 1992.

of alternative fuels use may lay the groundwork for later benefits); large greenhouse benefits will come when renewable provide the majority of t he feedstocks or when design decisions are controlled by strong incentives to reduce greenhouse emissions from the entire fuel cycle.

Two important issues facing Federal policymakers involve fuel taxation policy and the current Federal policy of fuel neutrality. Currently, Federal taxation of alternative fuels seems at odds with interest in promoting fuels such as methanol and in maintaining a "level playing field" among competing fuels. Electricity, for example, pays no Federal highway tax, and natural gas pays very little, whereas LPG and methanol pay higher taxes than gasoline (on a $/Btu basis). Although it may make sense to tax different fuels at different rates based on their perceived benefits, current rates seem to bear no relation to Federal goals. Congress might consider adjusting tax rates to establish either a uniform tax (per unit energy) among competing fuels or a differential tax weighted according to emissions benefits or other perceived benefits.

Current legislation (especially EPACT) provides large economic incentives (thousands of dollars per vehicle) to alternative fuels with little regard to any differences among the various fuels in their likelihood of satisfying environmental or other Federal goals. Some types of alternatively fueled vehicles likely to enjoy success in the marketplace may, however, provide benefits that are significantly inferior to those provided by other vehicles.[66] At some point, perhaps when the environmental and energy security attributes of various vehicle/fuel combinations become clearer, Congress may want to reconsider the current policy of fuel neutrality (among the competing alternative fuels) in awarding incentives.

FREIGHT POLICY

The future potential for energy conservation in the freight sector lies largely in reducing truck energy use, because trucks consume the major part of U.S. freight energy (more than 80 percent) and because truck mileage is expected to grow rapidly—about 2 percent per year in the EIA forecast, and, in OTA's opinion, probably somewhat faster. The technical measures available include improvement in truck fuel economy-both for new trucks and, with retrofit technology, for the fleet as a whole (including improvement in driver skills); shifting to alternative modes and intermodalism (linking with other modes); and changes in operations to reduce waste.

Tests of the most energy-efficient new trucks under optimal driving conditions for high efficiency have achieved fuel economies 50 to 70 percent above the current fleet average efficiency. Similar tests of prototype trucks have achieved fuel economies over twice the current fleet average. Although real-world operating conditions, including average rather than optimal driving skills, would yield reductions in these efficiency advantages, the test results do suggest that there is a considerable energy savings potential from using commercially available and new technologies. Thus, a key to improving the efficiency of the fleet is both to encourage purchase of the most efficient vehicles and to speed up turnover, which is slow. Policy options to raise new truck fuel economy include fuel taxes, fuel economy standards, feebate programs, and government purchase programs; measures to encourage turnover include fuel taxes, retirement programs, and tax code changes.

Both fuel economy standards and feebate programs will encounter difficult technical problems because the great variety of truck types and cargo confounds efforts to establish fair efficiency goals

[66] For example, a flexibly fueled vehicle, fueled by gasoline, M85 (a mixture of 85 percent methanol and 15 percent gasoline), or any mix of the two will likely yield significantly smaller air quality benefits than a dedicated methanol vehicle.

for trucks and to appropriately group trucks into classes. Combination trucks pose a special problem for regulation because they are sold as separate trailer and engine units, with the design of each being crucial to fuel economy.

It is sometimes argued that mode shifts from trucks to rail or to barges would save significant amounts of energy since rail and barge shipping appears to be much more energy-efficient than trucks. In fact, shippers have found intermodal operations to be very attractive, and this form of shipment has been growing rapid] y, with the common form being containers moving from truck to train to truck. Care must be taken not to exaggerate the energy benefits, however: national data suggest that rail movement is 11.5 times as efficient as truck, but not for the same types of cargo. Limited analysis of alternative modes of moving the same cargo over the same routes suggests that trucks use 1.3 to 5.1 times as much energy as do trains. And incorporating the energy embodied in equipment and in getting freight to and from the rail terminal may reduce rail advantage further, although it still comes out ahead. With the limited portion of freight movement likely to be eligible for shifting to rail, however, total likely savings are in the range of one- or two-tenths of a quad, a few percent of total U.S. freight energy consumption.

POLICY OVERVIEW

Depending on their perception of the urgency of transportation problems and problems associated with urban air pollution, energy security, and greenhouse warming, Federal policy makers have a number of choices to make regarding transportation that can be simplified into three basic options:

1. retention of the status quo, with fine-tuning;
2. an activist approach that focuses primarily on improving technology; and
3. an approach that attempts to move U.S. transportation gradually away from its dependence on the private vehicle.

A status quo approach might use some moderate regulatory and economic policies to ease transportation problems: new CAFE standards set at levels achievable with available technology; modest gasoline taxes, perhaps $0.25 to $0.50 per gallon but likely lower; encouragement of local transportation initiatives taken in response to Clean Air Act requirements; some increased investment in transit with funds shifted from highway allocations (allowed by IS TEA); and so forth. Under such a scenario, congestion would likely increase, but the marketplace would moderate the increase by forcing changes in business and housing locations and in travel behavior. Cars will become more comfortable and will offer more opportunity for entertainment and work. In particularly congested areas, businesses will establish more use of telecommuting, perhaps by establishing satellite work centers. There would likely be a diversity of solutions to local transportation problems, most of them modest, but some drastic as in Portland, Oregon, a city that seeks to remake itself. Given political realities, most jurisdictions will likely try to satisfy both majority auto-oriented drivers and the conservation-environmental community by improving highways and transit services, but the latter is likely to have limited success without more basic changes in the existing incentives for private travel and in urban form.

The "livability" of the results of such an approach is difficult to predict, because analyses that forecast disastrous results invariably ignore society's adjustments to emerging problems. In the absence of technological breakthroughs (e.g., an inexpensive, energy- and power-intensive battery that allows electric vehicles to compete successfully with gasoline cars), urban pollution levels may worsen or not improve, congestion will probably grow worse (but not by as much as current government analyses predict), most urban centers will likely continue to weaken, and transportation energy use is likely to grow and continue to depend primarily on oil. However, there may be some surprises. If local solutions work well and seem transferable to other areas, they will spread. Simple steps that fit well into this overall strategy might make some inroads into auto use. Two measures that could work are requiring employers to "cash out" parking costs to employees and congestion pricing using electronic sensors (although this measure might more comfortably fit into the next approach).

A "technological fix" approach could make some serious inroads into some important transportation problems, while not affecting others. Such an approach might focus on leapfrogging current automotive technology to achieve very high levels of fuel economy, perhaps twice as high as today 's. Government-industry cooperative research programs could also move toward replacing internal combustion engines with electric drives powered by batteries or fuel cells, but strong economic incentives would probably be necessary to make the transition. Investment in IVHS could make moderate inroads in congestion, although probably not in urban centers. It is not clear that the congestion relief offered by such systems would yield better conditions than simply allowing marketplace adjustments, however, because the increased highway capacity such systems create could easily spur travel demand.

In predicting the eventual outcome of this approach, a key unknown is whether travel demand will keep on growing and overwhelm the effects of efficiency or will, instead, reach a plateau or period of very slow growth so that raising efficiency will reduce total energy use.

The third approach is to try to shift the U.S. transportation system substantially away from the private automobile, especially in urban areas and for intercity travel. Such an approach could have a chance of success *only* if it followed a multipronged strategy of drastically reducing highway building and accepting slower highway speeds; practicing '*full societal cost accounting" on automobiles, probably with significant increases in driving costs; redirecting urban structure toward higher density, centralization, and corridor development, with strong limits on parking and limits on suburban/exurban development; and investing massively in existing and new public transportation systems, with high-density mixed-use development focused on station areas.

The goal of such an approach is not only to drastically reduce gasoline use and urban air pollution, but to revitalize America's urban centers, making them places where walking and bicycling to multiple activities are feasible and where urban life is far more vibrant than is possible in most of today's U.S. cities. Whether the measures necessary to follow this approach are politically and socially feasible, and whether the goal is achievable even if such measures are taken, are two critical uncertainties. Many of the measures that would be necessary for this strategy to have a chance for success+ specially the strong controls on development and the increased costs of driving—are likely to draw severe opposition. Also the strategy seeks to reverse a process that appears to be going on worldwide, in a country that has a mature infrastructure designed around inexpensive automobile access. Ultimately, whether the goal is achievable even with successful implementation of the necessary policy measures depends on the answer to the question raised earlier: Has the past and continuing evolution of our city structures and travel behaviors depended primarily on policy or on technological change, rising income, and other immutable factors, and what will be the future relationships among these variables? Only prolonged experimentation with sharp changes in policy can answer this question.