NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP Report 377

Alternatives to Motor Fuel Taxes for Financing Surface Transportation Improvements

Transportation Research Board
National Research Council

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Alternatives to Motor Fuel Taxes for Financing Surface Transportation Improvements

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

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The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation officials, or the Federal Highway Administration, U.S. Department of Transportation.

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FOREWORD

By Staff
Transportation Research Board

This report contains recommendations, which are applicable to all levels of government, for evaluating alternatives to the motor fuel tax. An evaluation framework is presented and demonstrated. General assessments and recommendations on future expectations and trends are given. An approach that recommends a contract between transportation agencies and their customers is also suggested as an aid in generating adequate revenues. The research as documented in this report will be of interest to individuals who must deal with the identification of future revenue sources for transportation purposes, principally, highway related. All readers are directed first to the "Summary" for a general description of results; the full report, especially the applications in Chapter 3, is recommended to practitioners.

Petroleum-based motor fuel taxes, the mainstay of the traditional user-charge approach to highway funding in the United State has been a reliable, economical, and comparatively popular method. The federal government and many state governments deposit these revenues in dedicated accounts embracing a user-fee approach to transportation improvements and producing a reliable flow of funds that facilitate long-range planning and programming. However, a number of factors has reduced the effectiveness of motor fuel taxes as primary financing mechanisms for highway and other surface transportation improvements.

Continued improvement in motor-vehicle fuel efficiency and the development of alternatives to petroleum-based fuels diminish the effectiveness of motor fuel taxes as a measure of highway use and have a net effect of reducing expected revenues. Furthermore, motor fuel taxes are used increasingly to implement national policies on energy issues, on environmental concerns, and for budget-deficit reduction. Notwithstanding the importance of other national policies, this practice reduces the amount of motor fuel tax receipts available to transportation and erodes the concept as a dedicated fund comprised of user fees.

Moreover, state and local governments are having to assume increasing responsibilities for funding the surface transportation system. This requires innovative approaches to ensure adequate funding, using new technologies and ideas to provide opportunities for new pricing and financing mechanisms.

Under NCHRP Project 20-24(7), "Alternatives to Motor Fuel Taxes for Financing Surface Transportation Improvements," Cambridge Systematics, Inc., and Sydec, Inc., developed (1) a framework for evaluating revenue sources at all levels of government, (2) several future scenarios, and (3) a concept for a contract approach between transportation agencies and their customers. Application of the framework was demonstrated by evaluating alternative fees and taxes under various future scenarios. These alternatives and their consequences were identified and evaluated to assist public officials in making decisions on the future of the surface transportation system.

Readers should direct their initial attention to the "Summary," which has been identified with shaded page edges. The full research report follows for those interested in the details of the research effort and all of the findings. Of special interest will be Chapter 3, which includes the instructions and demonstration of the evaluation framework.

CONTENTS

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The authors acknowledge the helpful guidance of the advisory panel, chaired very capably by Suzanne Sale. All panel members provided useful suggestions. Carl Williams also provided a wealth of information used in the documentation. Crawford Jencks of TRB provided, when required, strong prodding and kind encouragement to enhance the qualtiy of the products of this research. Arlee Reno and Joe Stowers gratefully acknowledge the valued contributions of Alan Pisarski, Hal Hovey, Herb Weinblatt, and the other research staff and, as always, acknowledge their own responsibility for errors and omissions.

ALTERNATIVES TO MOTOR FUEL TAXES FOR FINANCING SURFACE TRANSPORTATION IMPROVEMENTS

SUMMARY

This research project evaluates alternatives to motor fuel taxation and recommends an innovative approach to financing surface transportation with three major elements:

1. A comprehensive evaluation framework and approach for decision making on revenue sources. This framework provides a means of evaluating alternative revenue sources, including their major attributes, the tradeoffs between the sources, and the sensitivity of the choice of revenue sources to different contingencies or scenarios.
2. A systematic methodology for developing scenarios of critical importance to the choice of revenue sources. These scenarios include consideration of *alternative* types of fuel, levels of development in the technologies for monitoring vehicle miles of travel (VMT), levels of fuel efficiency, levels of travel demand management and VMT, and levels of reliance on fuel taxes to support nontransportation programs.
3. A new "contract" or "compact" approach between transportation agencies and their customers. In the compact, revenue sources are related to achieving benefits for the customers in mobility, environmental, and economic impacts. The new contract approach involves monitoring the performance of programs by using the Intermodal Surface Transportation Efficiency Act (ISTEA) management systems.

Major conclusions of this research project are as follows:

1. Motor fuel taxes will remain important components of state and federal surface transportation revenues for at least the next three decades.
2. Fees or taxes based on VMT (including congestion pricing) have desirable attributes, but their implementation depends on political acceptability and technological developments.
3. Rather than seek to replace motor fuel taxes precipitously, agencies should seek a smooth transition to alternative sources by phasing in promising new sources as elements of revenue programs.
4. The development of monitoring technologies for VMT fees, emissions-based fees or congestion pricing can be fostered by transportation agencies; and Intelligent Vehicle Highway System (IVHS) and research programs should address revenue collection issues.

5. Demonstration of the evaluation framework should be high-priority applied research and can be a key project in helping transportation agencies to achieve the mobility, environmental, and economic goals of the customers they serve.

INTRODUCTION

This research report provides guidance for all levels of government on revenue sources. The guidance takes into account environmental issues, international competitiveness, energy independence, infrastructure deterioration, and the tax revolt. It takes advantage of potential IVHS and other technological advances, evolving institutional structures, and the newly required ISTEA management systems.

This report reviews the status of surface transportation financing in the United States, and proposes a new approach to financing surface transportation involving a new "contract" between transportation agencies and their customers. The approach includes continued updates of agreements on objectives and investment levels. Revenue sources would be chosen to be consistent with the new contract, as well as to meet traditional public finance criteria for adequate, simple, equitable, and efficient revenue sources that will perform well under future contingencies.

This summary report is organized into these major topics:

- Introduction
- Problem Statement and Objective
- Trends Affecting Surface Transportation Finance in the 1980s and 1990s
- Summary of Current Revenue Issues: Is the System "Broken"?
- Evaluation Framework: Criteria and Steps
- Future Scenarios
- Conclusions
- Suggested Research
- The "New Approach"—A New Contract Between Transportation Agencies and Their Customers

PROBLEM STATEMENT AND OBJECTIVE

Current revenue sources for providing, maintaining, and operating an effective surface transportation system may be inadequate to meet present and projected needs. Petroleum-based motor fuel taxes, the mainstay of the traditional user-charge approach to highway funding in the United States, generally have not kept pace with either needs or inflation.

However, until recently, the taxation of motor fuels had been a reliable, economical, and comparatively acceptable method. The federal government and many state governments deposit these revenues in dedicated accounts embracing a user-fee approach to transportation improvements and producing a reliable flow of funds that facilitates long-range planning and programming. However, a number of factors is reducing the effectiveness of motor fuel taxes as the primary financing mechanism for highway and other surface transportation programs.

Continued improvement in motor vehicle fuel efficiency and the development of alternatives to petroleum-based fuels diminish the effectiveness of motor fuel taxes as a measure of highway use and have a net effect of reducing expected revenues. Although the need is recognized, compensating increases in the fuel tax at both the federal and state levels are often difficult to enact.

Furthermore, motor fuel taxes are used increasingly to implement national policies on energy issues, on environmental concerns, and for budget/deficit reduction. Notwithstanding the importance of other national policies, this practice can reduce the amount of motor

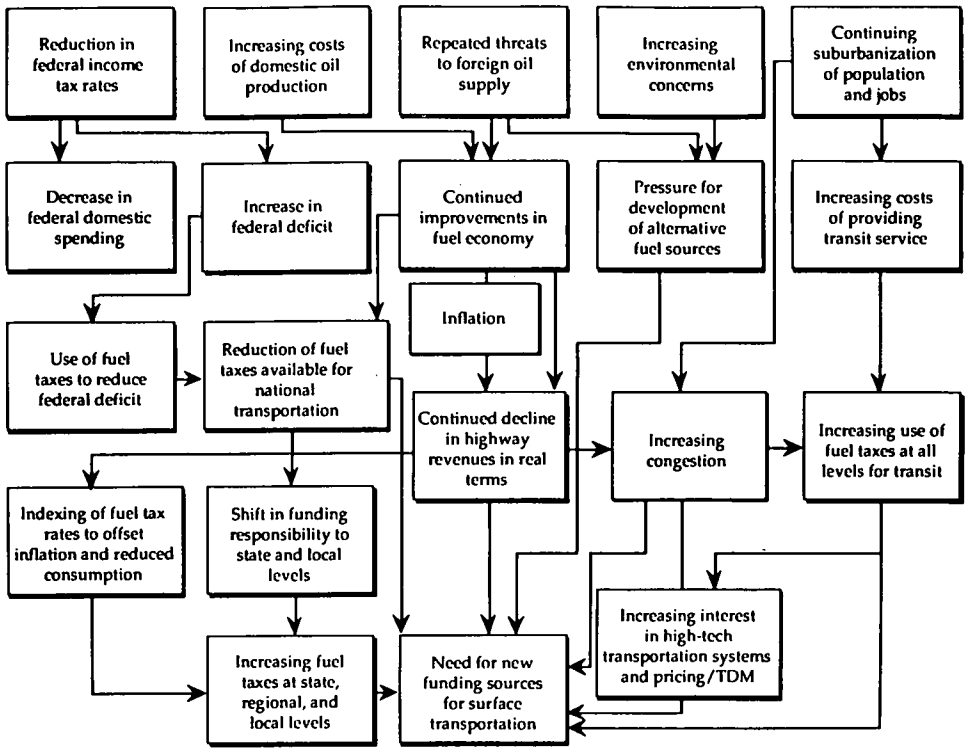


Figure 1. Overview of trends in the 1980s and 1990s relating to surface transportation finance.

fuel tax receipts available to transportation and can erode the concept of dedicated funds composed of user fees.

Moreover, state and local governments are having to assume increasing responsibilities for funding the surface transportation system. This will increasingly require that innovative approaches be taken to ensure adequate funding, using new technologies and ideas to provide opportunities for new pricing and financing mechanisms.

As a result of these emerging trends, existing methods may need to be improved and new methods may need to be developed to finance the surface transportation system. Alternatives and their consequences must be identified and evaluated to assist public officials in deciding the future of the surface transportation finance system.

The objective of this research has been to identify and evaluate alternatives to the traditional motor fuel tax as a principal method for financing the surface transportation system. Alternatives have been evaluated within the context of a range of possible future scenarios. The research has had to reconsider the role of the user-pay principle in financing the surface transportation system in light of current and likely future conditions, and has had to give attention to financing mechanisms at all levels of government.

TRENDS AFFECTING SURFACE TRANSPORTATION FINANCE IN THE 1980s AND 1990s

The 1980s and the 1990s will prove to have been an important transition period for surface transportation finance. Major trends affecting surface transportation finance are related in Figure 1. Particularly important driving forces include those identified in the boxes along the top of the exhibit—reduction in federal income taxes, increasing costs of domestic oil, threats to the supply of foreign oil, increasing environmental concerns,

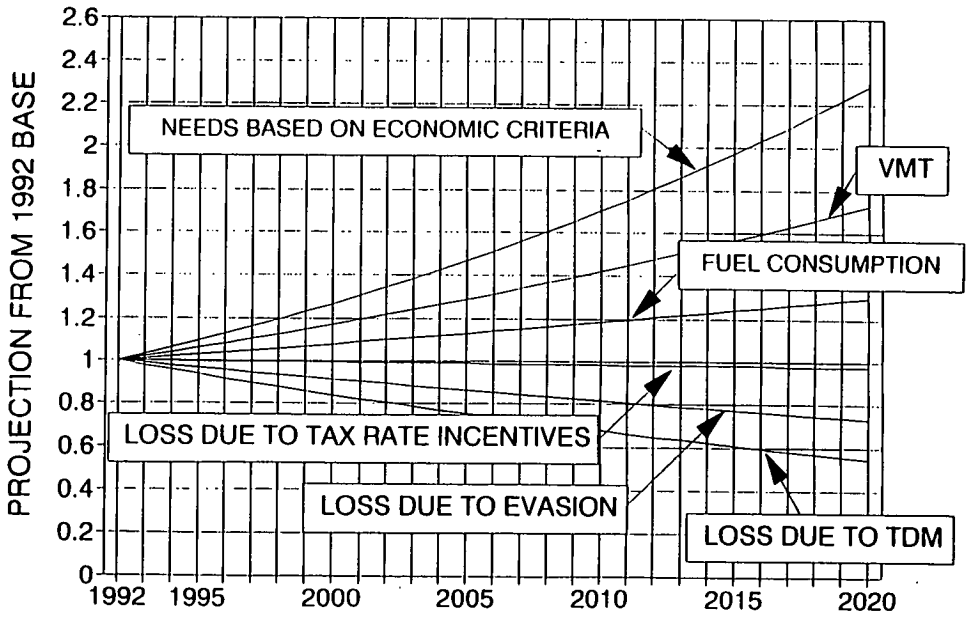


Figure 2. Illustration of revenue loss factors.

and continued suburbanization—along with inflation, shown in the middle of the exhibit. These forces all interrelate, and their confluence results in the need to review the way surface transportation is funded.

The reduction in federal income tax rates and the increases in the federal deficit have been key factors leading to the use of federal highway user fees for deficit reduction and a consequent threat to the likelihood that fuel taxes will be available for transportation. This will continue to be an issue no matter what happens to the current balances in the surface transportation trust fund accounts.

Increasing costs of domestic oil and threats to foreign oil supplies also provide pressures for improved fuel economy and for promoting the use of alternative fuels. These difficulties with petroleum fuels contribute to the decline in revenues for surface transportation by reducing fuel tax collections.

Increased environmental concerns are also playing a role in developing pressures for alternative fuels or cleaner-burning petroleum products and, in some cases, in pressure for transportation demand management (TDM) and resulting reduction of mobility. Continued suburbanization has increased transit costs as well as spread congestion to more links of the surface transportation system. This has led to increased interest in technological solutions such as the IVHS program, and in other measures such as pricing to reduce congestion and fuel consumption.

Figure 2 illustrates the way some of the factors mentioned can combine to cause fuel-tax revenue to fall significantly short of needs. The top line of this exhibit is an illustrative projection through 2020 of surface transportation needs that are warranted based on economic investment criteria—assumed to be a 3 percent annual growth rate in this illustration. These needs are likely to grow more rapidly than base case VMT (2 percent per year in this illustration) because of deferred maintenance and the increasingly high cost of dealing with congestion and providing transit service in suburban areas. Because of increasing fuel efficiency, fuel consumption will grow at a lower rate than VMT (1 percent per year in the illustration). Furthermore, a constant motor fuel tax rate per gallon might yield revenues that would increase at a rate substantially lower than fuel consumption, as illustrated in Figure 2, for the following reasons:

- additional tax rate reductions might be given to alternative fuels;
- the complexities of collecting motor fuel taxes on a range of very different types of alternative fuels could result in continuing increases in tax evasion and collection costs compared with current conditions; and
- there could be a loss of revenue due to TDM measures, and resulting reductions in VMT growth rates.

Note the very large cumulative long-run impact of these individually small percentage impacts. By 2020, revenues from a constant rate per-gallon fuel tax would drop about 25 percent in constant dollars despite a base case increase of over 70 percent in VMT and an even greater increase in needs. In this illustration, the fuel tax rate would have to be tripled to keep pace with the increase in needs.

It is also important to note that, although the longer-term impacts are substantial, there is serious deterioration in revenues even in the short term. Clearly, there is a great need to review and monitor carefully the manner in which surface transportation is funded.

SUMMARY OF CURRENT REVENUE ISSUES: IS THE SYSTEM BROKEN?

A major issue is whether the current system is broken, or will soon be broken. There are pluses and minuses in current revenue approaches and trends, as summarized above, but one of the overriding issues is that the current system does not create a clear relationship between what the customers of transportation agencies want and what they are asked to pay. Establishing that linkage could be the bold stroke that leads to more responsive solutions to the revenue problems of each level of government.

The current and potential future deterioration of "buying power" of existing motor fuel taxes over time has led some transportation leaders to conclude that the system is broken already or will be broken soon. Major difficulties include the following:

- Revenues from fuel taxes will fail to keep pace with inflation if, as is generally the case, fuel tax rates are fixed and are not indexed to the rate of inflation in the costs of the programs the revenues must fund.
- Indexing fuel taxes to the price of fuel can provide a roller-coaster effect, with the revenues increasing or decreasing based on fuel price—a factor well outside the control of transportation agencies. While the situation may seem positive if revenues are increasing, the problem of decreasing revenues during fuel price decreases is significant enough to make this type of indexing of limited value.
- Fuel efficiency increases will reduce the revenue collected per mile of travel and may result in reduced total revenues if fuel efficiency changes more than offset the impacts of VMT changes.
- The combined effects of inflation and increased fuel efficiency will be to lower the real yields of fuel taxes per mile, while costs will not decrease per mile.
- Petroleum-based fuels may become more scarce, or dependence on foreign sources may become too risky, accelerating a switch to nonpetroleum fuels.
- Taxation of alternative fuels can complicate the revenue-raising efforts of all levels of governments by requiring additional collection and enforcement efforts.
- Reliance on fuel taxes leaves the door open to proposals to subsidize alternative fuels by taxing them at a lower rate or not taxing them at all. The tax incentives provided to gasohol have seriously reduced highway revenues. In the electric vehicle program of Calstart, not only is electricity for recharging electric vehicles not taxed, it is provided free at recharging stations.

- The federal government now uses a portion of motor fuel taxes to achieve "deficit reduction," and it is uncertain whether any future adjustments in federal fuel taxes will be devoted to surface transportation, to deficit reduction, or to a mixture of both.
- While the states do not use fuel taxes for deficit reduction, some actions have been taken to augment additional state taxes from highway user fees.
- The opportunity to adopt pricing approaches using automatic vehicle identification (AVI) may eventually render fuel taxes redundant or inefficient as a means of pricing travel.
- The potential for electric or compressed natural gas vehicles raises the challenge of measuring and reporting fuel consumption by these vehicles. The monitoring of VMT would provide a more direct measure of vehicle cost responsibility than attempting to monitor vehicles' fuel consumption.
- Reliance on fuel taxes cannot address all equity concerns among types of vehicles. The variations in fuel consumption per mile among types of vehicles may not correspond to the responsibility of those vehicles for highway costs.
- Lower income households will pay a greater share of a given amount of fuel taxes than they will for many other types of taxes, such as income taxes, taxes on VMT, vehicle sales taxes, or vehicle value taxes (personal property taxes).

On the other hand, it is also possible that the present reliance on fuel taxes for surface transportation finance might continue indefinitely, and perhaps even be strengthened. Reliance on fuel taxes has some important positive attributes:

- Although there have been significant breaches in the "user fee" principle of dedicating highway taxes to surface transportation, the user fee principle may be preventing diversion of user fees to programs with spiraling costs (particularly medical, prisons, and education).
- The gasoline tax can be collected by states and by the federal government at a reasonably high level up the "distribution chain" (e.g., at the refinery) because gasoline is used mostly for taxable highway purposes. The higher up the distribution chain an item can be taxed, the lower will be the compliance costs, administrative costs, and opportunities for evasion.
- Fuel taxes are relatively easy for the final household consumer to comply with; the price is higher because of the tax, but there is no compliance burden of extra time or paperwork. This is significantly different from registration fees, VMT fees, congestion fees, or emissions fees, for each of which forms have to be filled out and payments have to be processed by the individual (or household).
- Fuel taxes are at least generally proportional to highway use and to vehicle emissions, although significant variations do occur.
- Use of dyes or markers may reduce the evasion of taxes on diesel fuels, thus increasing revenues and equity.
- The public is accustomed to taxes on highway motor fuels. All states tax motor fuel, even though all do not levy income taxes or sales taxes (which are the largest sources of direct state revenues).
- Some alternatives to gasoline and diesel might be distributed, sold, and taxed in the same way that gasoline and diesel fuels are today. These alternative fuels include both liquid fuels such as ethanol, methanol, and cleaner-burning distillates of petroleum. If any of these becomes the principal substitute for current fuels, and if the technology of its production and distribution evolves so that taxes can be levied at relatively few points in the wholesale transaction process, then there may be little change in approaches to fuel taxation—even if there are several new alternative fuels.

When we look at the revenue-related issues themselves, continued reliance on motor fuel taxes has some pluses as well as minuses. But the great level of concern now

expressed by many transportation administrators is not motivated by the relative attributes of the different revenue sources themselves. It is a concern that the *overall system* of providing and financing surface transportation is not working in an acceptable manner. Transportation agencies are not achieving the levels of resources they need to provide service levels that best support the economic, environmental, and mobility interests of their customers. Their customers are left with less mobility, less economic development, and less progress on key environmental goals.

A key issue is whether or not there is a desirable and agreed-upon type of contract between the transportation agencies and their customers (the public and its legislative representatives) over what the system should produce for the customers.

What would be a desirable type of contract between the agencies and customers? It would provide for a way through which agencies and their customers could agree on a level of service and performance measures and could understand what they were buying for the fees they pay, or, in the case of legislators, the fees they authorize. It would provide for investments in transportation that achieve the levels of service and meet the economic, environmental, and mobility performance objectives that they desire and for which they are willing to pay.

Agencies must be able to explain to the public and legislators what they are buying in order for this contract to operate. They need to explain how the programs funded by the revenues relate to economic, environmental, and mobility objectives, and to show what can be bought at alternative levels of revenue.

When looked at in this way, the system is broken and the revenue-performance linkage is a key malfunctioning element of the break. Actions necessary to fix the overall system, and its revenue component, are described below. These include the following:

- an evaluation framework for determining future revenue sources;
- a scenario approach for contingency analysis;
- a set of conclusions about alternative revenue sources; and
- a new approach to surface transportation decisions.

EVALUATION FRAMEWORK: CRITERIA AND STEPS

The proposed evaluation framework provides for a comprehensive but readily usable methodology that can be applied at the federal, state, or regional level to evaluate alternative revenue sources and to help to reach agreement on revenue sources to be used to fund surface transportation.

The evaluation framework provides more than just a set of criteria against which all options are to be gauged. It provides a structured process to guide decision making in a real-world environment. Because state or local conditions and judgments are very important, the same revenue source could be found to be very applicable and appropriate in one context but not applicable or appropriate in another. The evaluation framework provides a set of steps that recognize where judgments and well-informed choices, based on values, have to be made by the key decision makers. Information can be developed by staff within the framework to inform those judgments and choices.

The evaluation framework has been applied within the context of scenarios that are described below. In this Summary Report, the procedures for evaluation are described and the outcomes of overall scenarios are illustrated. Examples of evaluations of specific tax alternatives are included in Chapter Three.

The evaluation framework involves eight steps:

1. Identify relevant sources and gather information to use in the evaluation of revenue sources.

2. Screen the suggested revenue sources in terms of whether they could provide adequate revenues and whether the sources could be dedicated to support the specific surface transportation program.

3. Evaluate the promising sources that can provide adequate revenues and that can potentially be dedicated to surface transportation with regard to each of the other criteria.

4. Select the revenue sources that are promising. This is basically a judgment by management about what sources should be considered in the decision process.

5. Define for the most promising revenue sources an overall revenue structure that would result from the phasing in of one or more alternative sources. The overall revenue structure could include current revenue sources continuing or being enhanced or phased out.

6. Perform tradeoff analyses to display to decision makers what the choice of one future revenue structure rather than another gains or loses, including a comparison of new revenue structures to the continuation of the current ones. Specific methods for displaying tradeoffs are illustrated in the applications manual.

7. Perform sensitivity analyses of the tax sources against major scenarios.

8. Prepare recommendations and negotiate a course of action with the responsible decision makers.

The steps are shown and accomplished sequentially, although in an area as complex as revenue structures, there is likely to be feedback or a return to previous steps in response to the dynamics of the decision process. Each step is outlined further below.

Step 1. Gathering Information

Gather the following information from appropriate sources. Where sources are lacking, use judgment or extrapolate from existing information. Information needed for current tax sources includes but may not be limited to

- tax rate and base;
- revenue yield;
- administrative costs and procedures;
- estimated compliance costs;
- estimated evasion;
- forecasts of future revenue; and
- estimated incidence by vehicle class.

For alternative revenue sources, the following information is also needed:

- definitions and list of alternative sources;
- current measurable "units" affecting yields;
- forecasts of "units" over time; and
- previous proposals and studies.

Step 2. Initial Screening

The initial screening is accomplished through a preliminary evaluation of the revenue sources that considers several basic criteria related to adequacy of the revenue sources. Criteria include

- adequacy and tax rate;
- stability and predictability;
- responsiveness (to inflation and to road usage);

- flexibility; and
- appropriateness for dedication.

Initial screening in accord with these criteria provides information about whether the revenue source could provide sufficient, stable, and responsive revenues to be worth considering as a major element of future revenue sources, whether the revenue source could replace or augment motor fuel taxes, and whether or not there is a likelihood that the source or sources could be dedicated to surface transportation. Analytical resources required for these assessments are limited, and thus the screening can be accomplished without expensive analysis. This step allows study resources and policy efforts to be focused on alternatives that can meet these fundamental criteria.

The adequacy criteria are the most important screening criteria because a basic goal of this project is to identify alternatives to motor fuel taxes and evaluate them in comparison to continued reliance on motor fuel taxes. Motor fuel taxes account for 75 percent of federal highway tax revenues and for about 60 percent of all state highway agency revenues. If the alternative revenue source cannot provide comparable — or greater — revenues to federal or state governments, and if the source is not relatively stable and predictable, then it does not represent a reasonable alternative to motor fuel taxes.

If particular revenue sources do not satisfy these criteria, however, this does not imply that those sources should not be used. Even if particular sources are not alternatives to motor fuel taxes, they can still provide useful revenues to accomplish important goals.

The "appropriateness for dedication" criterion provides a practical assessment of whether or not there is any reasonable likelihood that a tax source will be dedicated to surface transportation as a replacement for dedicated motor fuel taxes. This is basically a judgment about our political culture. It is a necessary judgment in order that transportation agencies or advocates not present proposals that in our political culture will embarrass them by being totally unrealistic. For example, a federal income tax or social security tax surcharge could provide dedicated revenues for surface transportation. Revenues could certainly be adequate. But advancing such a proposal could have no other impact than to call into question the credibility of proponents.

The "appropriateness for dedication" criterion is based on the user charge rationale. Other things being equal, user charges are more acceptable than unrelated taxes. The user charge philosophy in highways hinges on the relationship between the service provided and the fee for that service. It has typically implied a direct relationship between the vehicle, the use of a highway, and the tax. This concept has been bent over time, with more or less apparent acceptance for users. For instance, shifts of funds between areas, from urban to rural, from high density to low density states, and from highways to transit have found public support, particularly when such shifts are part of an adopted plan or program. A recent survey of use of earmarking in state government found that motor fuel taxes were earmarked to some extent in every state and that highway programs were the most common function receiving earmarked funding.

Not only is there evidence of taxpayers' greater support for taxes directly linked with specific transportation improvements as noted above, but there is also considerable evidence that highway users will generally support increases in user fees earmarked for transportation programs. However, there is often resistance to the use of tolls as a form of double taxation, particularly if toll receipts are siphoned off for projects in other areas or if toll projects are being built in one part of a state or region but not in others.

Procedures and data sources for applying the adequacy criteria are identified in Table 1. Much of the application of adequacy criteria includes elements of judgment. The example evaluation in Chapter 3 provides a discussion of these factors and example analyses of several potential types of revenue sources, including current fuel taxes, taxes

TABLE 1. Procedures and data sources for adequacy screening

Specific Adequacy Criterion	Data Sources	Recommended Procedures
Adequacy and Tax Rate	Current tax rates and yields for existing sources Units of activity for new sources	Estimate future year yields by multiplying rates by forecast units of activity Adjust for evasion Compare to needed revenues
Stability and Predictability	Compilations of (1) revenue trends for existing sources (2) unit trends for new sources (3) comparisons of forecast versus actual revenues	Stability: Review data and apply judgment of whether source has been or will be monotonically increasing or stable over time. Predictability: assess available forecast procedures and apply judgment of confidence level in forecasts.
Responsiveness - to inflation - to road usage	Compilations of (1) yearly revenue trends for existing sources 2) units of activity for new sources Compare to: (1) inflation trends (2) VMT trends	Compare trends of existing revenue sources graphically and in terms of average annual growth rate to trends in inflation and VMT. For new sources, compare trends in taxable units to trends in inflation and VMT.
Flexibility	Compilations of (1) history of changes in tax rates (2) any special factors which have fostered or hindered changes	For existing sources, compile average number of tax rate changes over ten year period; apply judgment about whether future will reflect past. For new sources, apply judgment.
Appropriateness to Dedication	Compilations of (1) relationship of tax source to vehicles, fuels, vehicle activity (2) dedications of other sources to other functional areas	Apply judgment of whether or not a case can be made that the potential source is a user fee or can otherwise be related to surface transportation program needs.

on alternative fuels, registration fees, vehicle sales taxes, VMT fees, emissions fees, congestion pricing, and pavement-damage fees or weight–distance taxes.

Based on these analyses, taxes that are likely to meet the adequacy criteria include

- taxes on current fuels (gasoline or diesel)—and modifications;
- taxes on alternative fuels;
- state registration fees or federal vehicle use taxes;
- VMT fees;
- sales taxes on vehicles, parts, and accessories;
- congestion pricing;
- tolls;
- emissions fees; and
- value-added taxes on transportation.

Taxes that could provide adequate revenues to replace motor fuel taxes but that are unlikely to be dedicated to replace motor fuel taxes for transportation purposes include

- carbon tax, British Thermal Unit (BTU) tax, or *ad valorem* energy tax;
- general sales taxes;
- income taxes; and
- general property taxes.

Evaluations of these, in less detail than for the first category, also are contained in the final report. Taxes that cannot provide adequate revenue or that are unlikely candidates for dedication to general surface transportation expenditures include all the others, mainly various types of nonuser fees identified in the final report.

Step 3. Application of Evaluation Criteria

Following screening for adequacy, the framework incorporates a comprehensive set of criteria under the categories of adequacy, equity, efficiency, and simplicity. Criteria related to adequacy are discussed in Step 2. The criteria other than adequacy are listed below. The evaluation framework includes a description of how to develop estimates of how each potential revenue source will perform with regard to each criterion.

Simplicity and Effectiveness

Procedures and data sources for evaluating simplicity and effectiveness criteria are described in Table 2. They can be adapted based on experience in the specific local/state context and based on a range of previous and ongoing studies of these factors.

Equity

Equity evaluations are most commonly made concerning

- vehicle class;
- income group; and
- geographic area.

Vehicle class equity is assessed through highway cost allocation studies. Available software can be used to allocate highway costs. However, experience shows that the expenditure data are not quickly compiled or kept by agencies in the format necessary for highway costs allocation. To carry out a highway cost allocation study, detailed information on projected expenditures is necessary in categories for which allocation procedures are applied. Detailed information on the elements making up bridge projects, pavement rehabilitation projects, widening projects, new facilities, right-of-way, safety projects, et cetera, is necessary.

Income group equity should be assessed for all proposed individual sources and overall revenue packages defined in the next step. It is unlikely that specific area data sources will be available in a format that allows evaluation of income group equity for various tax sources. Therefore, the national sources cited in the applications manual should be used for estimates.

Geographic equity among urban and rural users can be determined through a highway cost allocation study or from results of past studies, as illustrated in the applications

TABLE 2. Simplicity and effectiveness criteria

Simplicity and Effectiveness Criteria	Data Sources	Recommended Procedures
Point of Taxation	For existing sources, compile tax code and procedures, and numbers of accounts or filings or other transactions.	For existing sources, summarize taxable activity, and numbers of accounts or filings or other transactions.
Number of Taxpayers	For new sources, estimate point of taxation and numbers of accounts, from activity being taxed and taxable units.	For new sources, estimate activity to be taxed, and numbers of taxable entities (e.g., households and businesses, vehicles, sales establishments, etc.)
	Use examples from the applications manual for default values.	Use examples from the applications manual for guidance on estimates.
Compliance Cost	For existing sources, compile available estimates of time for compliance made by agency or other entities.	Multiply numbers of accounts or transactions by average unit cost of compliance.
	Use sources from examples in the applications manual for default values.	Use sources from examples in the applications manual for default values.
Potential for Tax Evasion	Solicit available studies of evasion of agency revenue sources.	Expert judgment by tax agency auditing and analytical staff.
	Solicit estimates of tax collection administrators and auditors.	Interview participants in FHWA sponsored fuel tax evasion studies for judgments.
	References cited in the applications manual for default or comparative values.	Review against results of studies cited in the applications manual.
Administrative Costs	For existing sources, compile: (1) costs and personnel levels for administration of taxes (2) other costs for audit and enforcement (office and field) (3) estimates of units of taxpayers	Apply expert judgment of administrative managers of tax collection agencies, utilizing existing administrative costs as a guide.
	For new sources, contact outside agencies, if any, which use such sources. Review procedures and assumptions from examples in the applications manual.	For new sources, utilize the referenced estimates from previous studies as included in the applications manual.

manual. Both patterns of expenditure and patterns of use by geographic area can be considered in determining geographic equity.

Economic Efficiency

The relationship of the proposed revenue source to economic efficiency should be considered. Efficiency can be judged by determining whether the revenue source is likely to approximate the marginal cost of travel. Marginal cost is the cost of the trip to all of society including the impact of congestion on other users, not just on the trip maker. Congestion pricing and pavement-damage pricing would charge the marginal cost of travel, or at least move in that direction.

Other

Management must estimate the potential for political support and implementation.

Summary

An overall assessment should be presented for each tax source.

Step 4. Selecting Promising Sources

Based on the evaluation results, some potential sources may no longer seem to be promising and should be deleted from further consideration. This step is based primarily on the results of the previous step and is augmented by the judgment of top management. The remaining steps provide information to aid in the harder choices from among the more promising revenue alternatives and to aid in evaluating how promising sources could fit into an evolving revenue structure.

Step 5. Defining Overall Revenue Structure Alternatives

In this step, analysts will define for the most promising revenue sources an overall revenue structure or alternative structures that would result from phasing in one or more alternative sources. The overall revenue structure could include current revenue sources continuing and/or being enhanced or phased out. For each individual source of revenue, the adequacy and simplicity and effectiveness criteria can be assessed. However, overall revenue structures are the appropriate focus of analyses of equity and efficiency.

The development of packages should be based on the findings of the analyses to date and on the known problems of the current revenue structure (e.g., declining revenues; inequitable, high administrative cost; etc.) The rationale for each package should be identified. The major goal of this step is to pick out what might be promising evolutionary paths for revenue structures (see the discussion of scenarios below).

Step 6. Tradeoff Analysis of Revenue Alternatives

A key part of the framework is the use of tradeoff analysis to illustrate to all decision makers and analysts the critical differences among revenue alternatives. Tradeoff analysis is a means of determining and illustrating what is better or worse about one choice versus other choices. It thus provides focused answers to what is gained and what is lost with one choice versus another. The framework provides an illustration of how to display the critical tradeoffs and how to provide a supporting discussion that will facilitate a decision.

Tradeoff analysis is recommended because it provides decision makers the best summary information on which to base a decision. It is not like scoring functions, which purport to supply "weights" to all variables. Scoring functions hide the critical choices in a mass of calculations and a priori judgments. There is no objective way to weight the different criteria; scoring functions attempt to provide summary evaluations based on subjective judgments of analysts or of persons surveyed and tend to obscure these judgments from top management. The best approach is rather to use tradeoff analysis within the decision-making process itself to determine the weights, rather than to determine the weights outside the real decision process.

The tradeoff analysis proceeds with the following steps:

A. Summarize the comparisons of revenue-structure alternatives.
B. Display the differences between each alternative and continuation of current sources.
C. Display the differences between the alternatives.

A. Summarize the Comparisons of Revenue Structure Alternatives

Table 3 shows how a summary comparison of the revenue alternatives can be displayed, illustrating side-by-side how particular promising tax sources look on each of the principal

TABLE 3. Summary comparison of current fuel taxes and VMT fees

Criterion	Current Fuel Taxes	VMT Fees	Differences
Consistency with a New Approach	Partially	Fully	VMT fees more consistent
Adequacy and Tax Rate	Yes	Yes	No difference
Stability and Predictability	Yes	Yes	No difference
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation, unless indexed; Partially responsive to VMT	Non-responsive to inflation, unless indexed; Fully responsive to VMT	No difference for inflation; VMT, of course, tracks VMT best
Flexibility	Yes; can be adjusted	Yes; can be adjusted	No difference
Appropriateness of Dedication	Yes	Yes	No difference
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes many fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$13 to $22/year per taxpayer	Motor fuel taxes less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% (perhaps greater)	Gasoline taxes lower evasion than VMT fees; diesel and gasohol comparable to VMT fees
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$290 million per year for all states combined	Motor fuel taxes less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	VMT fees more appropriate
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	VMT fees slightly less incident on lower income groups than fuel taxes	No appreciable difference
Equity by Geography	Dependent on highway cost allocation results	Dependent on highway cost allocation results	No appreciable difference
Relationship to Economic Efficiency	Partially promotes economic efficiency	Partially promotes economic efficiency	No appreciable difference
Ease of Implementation	Assumed high	Assumed low	Fuel taxes more implementable

criteria. Note that the criteria are not given any judgmentally different levels of importance in this display. This allows decision makers and others to see the alternatives next to each other and informs them of their comparative importance. Entries in the table are taken from the example evaluation results included in the applications manual. These are generally presented for both state and federal levels in ranges; the entries here are simplified because this is meant as an example of a display rather than results of applying the methods.

The Table 3 example compares current motor fuel taxes versus a complete switch to fees based on VMT, which would be set differently for different vehicle classes.

(Note: Methods, data sources, and procedures for these items are covered extensively in the report, with a focus on the data and procedures used in the example evaluations accomplished for this project.)

B. Comparison of Each Alternative to the Current Revenue Structure

Table 4 illustrates how an alternative can be compared with the current revenue structure

TABLE 4. Summary of the differences between current fuel taxes and VMT fees

Criterion	Current Fuel Taxes	VMT Fees	Differences
Consistency with a New Approach	Partially	Fully	VMT fees more consistent
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation, unless indexed Partially responsive to VMT	Non-responsive to inflation, unless indexed Fully responsive to VMT	No difference for inflation VMT, of course, tracks VMT best
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes many fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$13 to $22/year per taxpayer	Motor fuel taxes less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% (perhaps greater)	Gasoline taxes lower evasion than VMT fees; diesel and gasohol comparable to VMT fees
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$290 million per year for all states combined	Motor fuel taxes less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	VMT fees more appropriate
Ease of Implementation	Assumed high	Assumed low	Fuel taxes more implementable

in what has to change, what is gained, and what is lost. This table is prepared from Table 3 by deleting the rows for which the alternative revenue sources or structures show no appreciable differences.

C. Display and Discussion of the Major Differences Between the Alternatives

A table that illustrates the major differences between the alternatives might look exactly like Table 4 except that a comparison might be made between two new potential revenue sources or structures. In constructing this table, those criteria on which the two alternatives are basically equal have been deleted. Of course, different criteria may be deleted for each two-by-two comparison of this type.

Step 7. Performing Sensitivity Analysis with Regard to Scenarios

In this step, the analyst and top management identify the scenarios, if any, that they want to consider for the future. These could include such items as penetration of alternative fuels, diversions of user fees to other nontransportation programs, and development of vehicle monitoring and VMT measurement technologies. A discussion of scenarios follows.

Step 8. Preparing Recommendations and Negotiating Course of Action

In this step, the study phase is completed and top management decides on a preferred revenue structure and strategy.

■ FUTURE SCENARIOS

The major evaluation activity conducted for this research was the development and

assessment of future scenarios as highlighted in Step 7 that could affect surface transportation finance.

A detailed literature review was conducted of studies over the last 20 years that dealt with the potential for alternative fuels, fuel efficiency changes, technological changes, and other factors that would affect transportation revenues and transportation energy use. About 20 of the most relevant studies and very recent legislative actions are summarized in the final report.

As a result of the literature review of recent forecasts and scenario development studies in this field, several basic dimensions emerged as possible bases for defining scenarios:

- rate of introduction of alternative fuels;
- types of alternative fuels used;
- different environmental strategies;
- tax options to achieve environmental and/or energy goals;
- fuel economy achievements or standards; and
- success of vehicle monitoring technology.

The primary criteria used for choosing among these basic dimensions for scenarios are these: (1) What potential future directions are most likely to affect surface transportation funding? and (2) What potential future directions are likely to present unique challenges to surface transportation funding?

In defining scenarios, no distinctions were made between conditions that result from national policy decisions and those that result from technological advances and economic influences; that is, we treat all these influences as essentially exogenous. Although transportation administrators do have some ability to influence national policy decisions, this ability is relatively limited. Accordingly, transportation administrators must recognize the possibility that national energy and environmental policy may complicate the task of funding the transportation system and they must be prepared to deal with any such possible futures. Further, many of the conditions to be addressed (e.g., improvements in fuel efficiency) may well result from a combination of technological advances, economic influences (increasing real energy costs), and national policy. The focus is on how the conditions that result from these developments can best be addressed, not the extent to which these conditions can be influenced by transportation administrators.

On the basis of the review of related programs, the conclusion was that transportation finance policy must be capable of dealing with alternative futures that may differ from each other in three ways:

- types of fuels used;
- fuel economy and energy conservation; and
- technological capability for measuring VMT.

After consideration of futures in each of these dimensions, five scenarios were selected for formal analysis. These are identified in Table 5, along with a summary description of the evaluations that were performed for each scenario. The five scenarios are described briefly below.

1. High Methanol. This future assumes that the life-cycle costs of methanol vehicles, fuel production and distribution, and support systems come down below all other alternatives including reformulated conventional fuels. Methanol would displace the maximum feasible amount of petroleum fuels, taking into account supply limitations, vehicle turnover, and other constraints. By 2000, methanol would displace about 5 percent of gasoline consumption, and by 2020, about 40 percent. Methanol was selected as an alternative

TABLE 5. Application of evaluation framework to scenarios

Scenarios	Basic Policy Directions		
	Business As Usual	Improve and Adopt Motor Fuel Taxation	Transition to VMT-Based Taxation
1. High Methanol	Limited Evaluation Required	Limited Evaluation Required	
2. High CNG & Electric	Elaborate on Expected Problem	Apply Evaluation Framework	
3. High Fuel Economy	Elaborate on Expected Problem	Apply Evaluation Framework	
4. Tax Diversion/ Subsidy	Elaborate on Expected Problem	Apply Evaluation Framework	
5. Full VMT Measurement Capability	Elaborate on Missed Opportunity		Apply Evaluation Framework
Base Case		Elaborate As Needed for Above Evaluations	Elaborate As Needed for Above Evaluations
Combinations of Above		Discuss in General	Discuss in General

fuel for analysis because it has been seen by some experts in the field as having the best chance of becoming the dominant alternative to petroleum fuels. It is superior to all existing and foreseeable forms of petroleum-based fuels from an environmental perspective, although it is not "clean" enough in comparison with some of the other alternatives to gain the support of many environmentalists.

Methanol production and distribution is likely to evolve into a relatively concentrated industry with fairly small numbers of suppliers, distributors, and production plants and a dedicated pipeline distribution system. If so, tax collection is likely to be similar to that for gasoline. Opportunities for using untaxed methanol as a motor fuel are likely to be fairly limited.

2. High CNG or Electric. This future involves assumptions for these alternative fuels similar to the High Methanol scenario, with about the same level of penetration achieved by the combination of these two types of energy sources. Compressed natural gas (CNG) and electricity are the two very clean fuels that probably have the best chance of high penetration of the market. Because of their superiority to methanol from an environmental perspective, either or both of these fuels could potentially achieve greater governmental support and become dominant instead of methanol.

This future differs substantially from the High Methanol future in difficulties in collecting fuel taxes. Natural gas and electricity currently are used widely as energy sources for purposes other than transportation, and therefore it probably will not be feasible to tax either of them at their production centers or at concentrated points in the distribution system. Neither of the two energy sources is likely to differ in any special way from the form in which it is used for other purposes, except that natural gas is compressed for motor vehicle use. However, this can be done easily in almost any location, such as in private homes or garages. While a natural gas compressor would represent a more significant investment than an electric plug for refueling, CNG also could become fairly widely available. Consumption of CNG or electricity by vehicles may need to be directly monitored if these fuels are to be taxed.

3. High Fuel Economy. A High Fuel Economy scenario is likely to be driven by many of the same concerns as the alternative fuels scenarios—i.e., concerns about air quality, global warming, and dependence on foreign oil imports. Some tradeoffs are involved between the two types of scenarios. To the extent that a high level of penetration of alternative fuels is achieved, there will be less pressure to achieve high fuel economy standards, particularly for conventional fuels. Similarly, to the extent that high fuel economy standards are achieved for conventional fuels, there will be less pressure to achieve a high level of penetration of alternative fuels.

The literature review revealed that a wide range of possible future levels of fuel economy has been considered. After careful review of various forecasts and scenario analyses by others, it was concluded that a target of 39 mpg for new autos by 2015 is a likely upper limit. This is based on a "Moderate Efficiency" scenario by the Office of Technology Assessment and a recent careful review of Corporate Average Fuel Economy (CAFE) standards and related policies by the National Research Council (NRC). NRC defined this level of fuel economy as "technically achievable," stressing that this should *not* be taken to mean the technological limit of what is currently possible. Rather, it is based on autos that are being mass produced somewhere in the world and that pay for themselves at gasoline prices of $5 to $10 per gallon or less (1990 dollars). Higher levels of fuel economy are achievable but are not likely to be achieved because of high production costs and other factors.

4. Tax Diversion/Alternative Fuels Subsidy Scenario. This scenario involves a combination of (1) maximum diversion of motor fuel tax receipts to the achievement of other national and international goals such as deficit reduction, energy independence, air quality improvement, and reduction of global warming impacts; (2) maximum tax subsidies for alternative fuels, alternative fuel vehicles, and fuel-efficient vehicles; and (3) reduction of, and eventual elimination of, the dedication of fuel tax receipts for surface transportation finance.

When such a scenario is coupled with no major improvements in VMT measurement capability, transportation officials would most rapidly lose their dependence on motor fuel taxes and would have to depend more on nonuser revenues than in any other scenario considered. Application of the tax structure evaluation framework in this context involves another type of base case for comparison with the other results. It addresses the question of how the highway user tax structures under the other scenarios compare with reliance on the general tax structure in equity, efficiency, and other considerations.

5. Full VMT Measurement Capability Scenario. The technical capability of measuring the amount of travel by specific vehicles and the difficulty involved in doing it will largely determine whether it is feasible and desirable to substitute taxation of miles traveled for taxation of fuel consumed. This substitution might be partial even in the long term, or eventually a complete replacement for fuel taxes.

The ability to measure travel might also be partial or complete, even in the long term. Partial measurement might be achieved by a series of spot observations of vehicles on main routes or by continuous measurement of miles traveled on freeways or automated guideways. Complete measurement or approximate estimates of total miles traveled might be achieved by tracking of vehicles on either a continuous or a frequent periodic basis, or by periodic or annual readings of "tamper-proof" odometers. All these technical capabilities might vary widely in accuracy and degree of automation.

Basic Policy Directions in Relation to Scenarios

1. It is helpful to distinguish the three basic policy directions available to transportation officials in dealing with the surface transportation finance issues:

TABLE 6. Summary of key factors in transition paths for selected scenarios

Key Factors	High CNG & Electric	High Fuel Economy	Tax Diversion and Fuel Subsidies	Full VMT Measurement Capability
Major Technical Options for Paths	CNG/electric mix Battery technologies Guideway technology options	Engine and vehicle design		Hubodometer, AVI on toll roads, congestion pricing, AVI on Interstates, satellite tracking, guideway technology options
Major Policy Options	Investment in vehicle design, battery development Subsidy of fuel or vehicles	CAFE standards and penalties, including light trucks Taxing fuels Fees and rebates based on mpg of vehicles 55 mph speed limit	Amount of subsidy for alternative fuels Extent of diversion of highway user taxes Source of surface transportation funds	R&D and demos for all technologies Reorientation of IVHS program Assistance to states in implementation
Major Uncertainties and Hurdles	Breakthroughs needed in battery technology Costs to consumers	Safety Industry impacts Costs to consumers	Funding from other sources to offset diversion and subsidy	Invasion of privacy Cost of administration and enforcement for light vehicles

(a) Business as usual, or efforts to "muddle through" with no basic change in policy. This is a base case for policy options.

(b) Improvement and adaptation to motor fuel taxation. This would involve substantially increased efforts to reduce evasion and new efforts to respond to the challenges that would be intensified under each of the scenarios.

(c) Transition to VMT-based taxation. This would involve substantial new commitment to a broad program of studies, research and development (R&D), demonstrations, and development of technologies and systems for measuring VMT.

2. The business-as-usual policy option did not deserve to be treated in the same depth of evaluation as the other basic policy options. It is used as a basis for comparison of the other policy options. The evaluation framework did not need to be applied explicitly under this policy direction. However, when the framework is used under each selected combination of scenario and basic policy option, the business-as-usual option was considered as a basis for comparing the results of each application of the evaluation framework.

3. Similarly, the base case scenario, involving little mix of alternative fuels and trend-based projections of other factors, did not need to be subjected to the same depth of evaluation as the other selected scenarios. It was used as a basis for comparison of the other results of applying the evaluation framework under each of the selected scenarios. It required sufficient elaboration to provide data required for these evaluations.

3. Combinations of the selected scenarios were used as the basis for extending the evaluation results to a wider range of future conditions.

Key Factors in the Transition to Future Scenarios

Table 6 summarizes the key factors involved in the transition between current conditions and each of the four futures defined by the scenarios. They key factors are of three types:

- major technical options for alternative fuels, vehicle design, and ways of measuring VMT;
- major policy options for government investment in R&D, demonstration programs, subsidies for alternative fuels, and regulatory controls; and
- major uncertainties and hurdles that have to be overcome to achieve stated objectives under each scenario.

The scenario subjected to the most careful analysis in each of the critical aspects of the transition period is High Methanol. Daniel Sperling has analyzed all important aspects

of a transition over a period of up to 20 years. His transition scenario is intended to represent "the upper limit of opportunities for introducing methanol fuel to this country"—resulting in the production of 1.5 million barrels per day (MMBD). This would be a higher level of use of any single alternative fuel than any of the other scenarios or forecasts reviewed.

The transition paths for the High CNG and Electric scenario involve somewhat similar policy options regarding government investment in vehicle design and subsidy of fuels and/or vehicles, but have much greater potential impact on surface transportation finance. Because of the fact that these are much cleaner-burning fuels (depending on the fuel source and location of power plants in the case of electric), there is much greater likelihood of tax subsidies, particularly for electric.

Because CNG is more likely to be taxed, the relative mix of the two may be important for surface transportation finance. A larger fleet of electric vehicles (EVs) is projected by 2010, but because CNG would be a dominant alternative fuel for heavy vehicles, it is projected to displace somewhat more petroleum product than electricity.

The High Fuel Economy scenario also involves a variety of technical options for achieving the targets of this future; however, the paths that have been proposed do not involve large-scale government investment in engine and vehicle design, nor in infrastructure, unlike the first two scenarios. Most of this investment is expected to be made by the private sector in response to increased CAFE requirements or increasing price of fuels.

A variety of improvements in CAFE regulations should be considered if further major fuel economy improvements are to be mandated. Consideration should be given to applying CAFE standards to various size classes of vehicles and extending them to light trucks. Other recommendations under this scenario include increased fuel taxes, a tax/rebate schedule for vehicle sales based on mile-per-gallon (mpg) ratings, and reintroduction of the 55 mph speed limit.

The Tax Diversion and Alternative Fuels Subsidy scenario differs from the other scenarios in that no technological development challenges or hurdles are involved, nor is the evolution of related technologies expected to have substantial influence on the likelihood of this scenario's being realized. An end to the dedication of user taxes is a policy decision that is almost completely independent of technological developments. The major policy options for the diversion and subsidy scenario are

- the amount, timing, and duration of tax subsidies for the development and deployment of each type of alternative fuel, alternative fuel distribution system, and alternative fuel vehicle;
- the extent of diversion of highway user taxes from transportation funds to other uses, at both the federal and state levels; and
- the source of funding for surface transportation programs, which could range from continuing reliance primarily on user taxes and fees to almost no reliance on them and almost complete reliance on general revenues and other specific sources.

The critical uncertainty in the diversion and subsidy scenario that is of most importance to surface transportation is the degree of success that transportation administrators might have in obtaining funding from other sources to offset losses due to diversion and subsidy of alternative fuels.

The transition paths for the Full VMT Measurement Capability scenario differ greatly from the others in important ways. There is a variety of possible technological paths. Several technologies might be used throughout the transition period and several mature technologies might remain in use indefinitely. The choice among technological options and the speed of their development will be controlled largely by transportation officials,

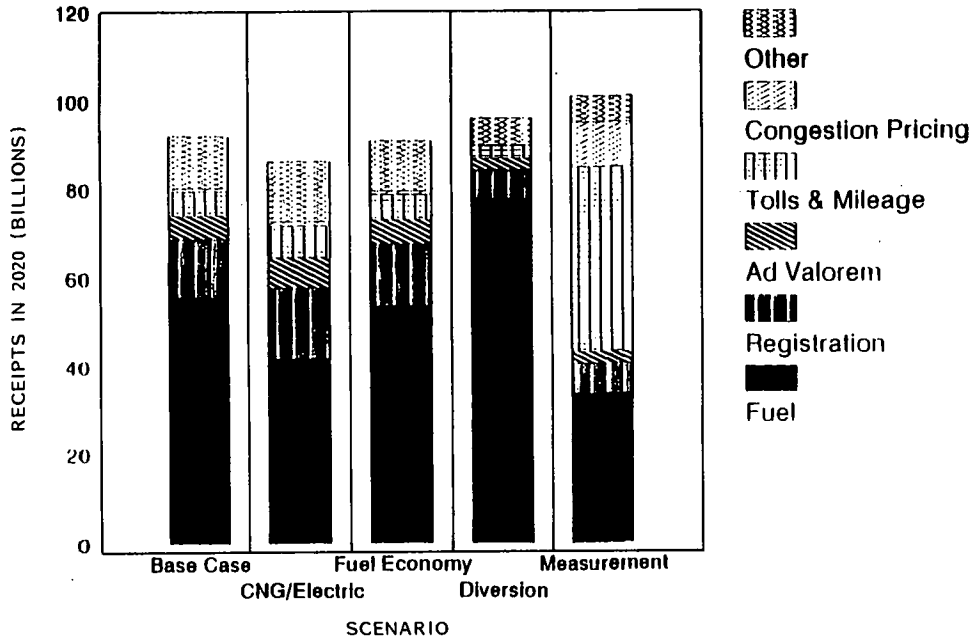


Figure 3. Projected highway user receipts in 2020 for each scenario by type of tax.

unlike the choices in the other scenarios. And, most important, the success of the technological development is positively correlated with improvements to surface transportation finance, as discussed.

Impacts of Scenarios on Revenues

Each of the selected scenarios has been defined in quantitative terms in Figure 3 as to a likely impact on receipts available for surface transportation programs in 2020. The exhibit is intended to portray one example of the impact on revenues of each scenario—one out of a fairly wide range of possible impacts, but one that is fully consistent with the definition of each scenario. All values shown in the exhibit represent total federal plus state receipts available for surface transportation programs.

The base case assumes continuing growth in highway user revenues from 1991 at 2 percent per year, with about the same level of dedication of user revenues as today. All projections are consistent with an assumption of continuing moderate economic growth, and continuation of current growth trends for VMT, with some leveling off of the rate of growth because of increasing congestion, saturation of the vehicle market, and saturation of travelers' time budgets for travel.

The assumptions made for each scenario are intended to reflect the high end of the likely range of change for each factor that defines the scenario. For example, the receipts projected for the High CNG and Electric scenario are consistent with a level of penetration of both CNG and electric vehicles that is about as high as any of the projections that have been made in the literature reviewed. Similarly, the High Fuel Economy scenario projection of receipts is consistent with achievement of the highest "technically achievable" fuel economy for passenger cars according to NRC's conclusions, as described in the definition of that scenario. Comparable statements can be made for the other two scenarios.

The projections shown in Figure 3 result in 6 percent and 1 percent approximate reductions in total receipts available for the High CNG and Electric and High Fuel

Economy scenarios, respectively, and about 5 percent and 10 percent increases in total receipts for the Tax Diversion and Subsidy and Full VMT Measurement scenarios, respectively. Fuel tax receipts as a percent of total receipts change from abut 60 percent in the base case to

- 48 percent for High CNG and Electric;
- 59 percent for High Fuel Economy;
- 80 percent for Tax Diversion and Alternative Fuels Subsidy; and
- 33 percent for Full VMT Measurement Capability.

In the Tax Diversion and Alternative Fuels Subsidy scenario, total fuel tax receipts are assumed to increase by well over the amount of general revenue and other funds made available for surface transportation, but a total of 80 percent of all funds available for surface transportation would come from fuel taxes. The assumption is that surface transportation gets some share of vastly increased fuel taxes under this scenario.

The most dramatic changes occur in the last scenario, which is the only scenario involving large increases in weight-distance tax receipts (from 1% in the base case to 7% of total receipts), VMT taxes and tolls (from 5% to 34%), and congestion pricing (from 1% to 10%).

■ CONCLUSIONS

The most important conclusions derive from the evaluations of the scenarios, because these show the consequences for revenues of various potential developments affecting fuels used, technologies, and deficit reduction actions. The evaluation of tax structures and the individual tax sources under the scenarios leads to the following general conclusions:

- All the scenarios examined in this study have major uncertainties and hurdles to overcome;
- All scenarios involve potentially serious threats to transportation finance;
- Only one scenario offers the potential for major improvements in finance—the Full VMT Measurement Capability scenario;
- Only in the Full VMT Measurement Capability scenario are decisions on major technical and policy options the responsibility of transportation officials; and
- It is not possible now to determine the optimal technological systems for measuring VMT, and therefore several technical paths should be pursued.

In addition to the need to take action to develop VMT measurement or monitoring technologies, other overall conclusions about desirable agency actions include the following:

- Agencies should seek a smooth transition toward a broadening of the revenue sources applied to surface transportation, as opposed to a strategy to implement a sudden replacement of motor fuel taxes.
- Three major tax sources, consisting of taxes on vehicles, fuels, and VMT, will in some combination be the mainstay of revenue approaches.
- Taxation of fuels is now a viable revenue source for supporting surface transportation and will remain an important element under all scenarios for at least the next 20 to 30 years.
- Though taxation of fuels will remain a viable and productive revenue source, other sources have or will have desirable attributes, and transportation agencies should take actions to assure that the alternative sources can be implemented at the lowest administra-

tive and compliance costs — primarily by assuring that technologies are developed for monitoring vehicle activity.

- Fuel taxes should be augmented with promising new approaches on a carefully staged basis, particularly VMT fees or congestion fees.
- Each level of government can choose to alter its current dependence on fuel taxation, as a percentage of all revenues to support transportation, either up or down, without affecting substantially the viability of the fuel tax source itself.
- Alternative fuels (except compressed natural gas and electricity) can be taxed through essentially the same procedures now used for gasoline and diesel fuel.
- As compressed natural gas or electric vehicles can be refueled at businesses and residences, different procedures are necessary to collect fees on CNG or electricity, involving a meter on the vehicle.
- Because miles of travel provides a superior measure of vehicle cost responsibility, miles of travel should be metered for electric or compressed natural gas vehicles.
- Reductions in vehicle use, through travel demand management or other actions, are also major challenges, primarily because they may impose needs for alternative modes while also reducing fuel tax revenues.
- Value-added taxes on transportation present another intriguing option, but a value-added tax for only one area of the economy may be infeasible, and if a general value-added tax is implemented it will be difficult to achieve political acceptability of a dedicated transportation-only component.

Of the three major revenue sources — fuel taxes, vehicle taxes, and mileage-based taxes — the actions necessary for the first two are straightforward. Raising taxes and making them responsive to inflation will improve the sources from the point of view of transportation agencies. For mileage-based taxes, more complex actions are necessary. Major conclusions with regard to mileage-based taxes include the following:

- Mileage-based taxes (including fees based on VMT by vehicle type, and congestion fees) are superior to other types of taxes in their potential equity between and within vehicle classes, no matter what rules are applied to determine equity.
- The feasibility and desirability of mileage-based taxes are dependent on the available technologies to measure miles of travel and to control evasion and minimize administrative and compliance costs.
- At the current time, the implementation of mileage-based taxes will impose higher administrative costs on agencies and will impose higher compliance costs on highway users than fuel taxes.
- In the future, the availability of automatic vehicle identification (AVI) or smartcard technologies on all vehicles could reduce the administrative and compliance costs of mileage-based taxes; it may be feasible to record VMT using electronic interrogators of vehicle smartcards or AVI at refueling stations.
- If technologies are available that minimize administrative and compliance burdens for mileage-based taxes, they may be more attractive than other types of fees.
- Current and proposed IVHS research efforts should be examined continuously to determine whether revenue-related issues are all being addressed in the programs. Transportation agencies should foster research on technologies related to monitoring and measuring VMT.

SUGGESTED RESEARCH

Suggested research falls into several categories, each of which is discussed briefly as follows:

- research to improve, develop, and apply the evaluation framework;
- research on the more specific attributes of motor carrier taxation alternatives and issues;
- research to develop vehicle monitoring and VMT measurement technologies and standards; and
- research into the feasibility of value-added taxes.

Research to Improve, Develop, and Apply the Evaluation Framework

The development of ISTEA management systems offers transportation agencies unique opportunities to use tools that will help to explain and justify program recommendations, by illustrating the long-term consequences of alternative courses of action.

The key to successful demonstration of a proposed new approach (described in the next section) will be the selection of the best context for the demonstration. The most appropriate agency for conducting the demonstration should be selected with due consideration being given to

- operational capability with the several new ISTEA management systems;
- interest in conducting a comprehensive review of the tax structure used for surface transportation finance;
- interest in public/private partnerships or other innovative arrangements;
- feasibility of having the agency's current planning and programming process evolve into the proposed new approach; and
- ability of the agency to commit to developing and using the new approach over a long enough period to demonstrate its success or determine how it should be modified based on the demonstration.

These considerations would be essential in achieving sufficient success to show that this approach could help build increased credibility of transportation agencies in the eyes of the public. The research also should include attention to the potential behavioral responses of users to alternative types and levels of fees and should identify institutional constraints to the development of new or innovative revenue sources. The research should result in a set of fully integrated ISTEA management systems that support a budgeting process.

Research on Motor Carrier Taxation Alternatives and Issues

Although the current project has dealt primarily with tax sources that would be broadly applied, there is no specific a priori reason taxation of heavier vehicles should parallel taxation of lighter vehicles. In fact, because of the different physical and usage characteristics of heavier vehicles, the states and the federal government have found alternative means of taxation to be desirable. Heavier vehicles are uniquely used to a much greater extent for interstate travel, and the limited numbers of heavier vehicles and their higher cost responsibility make them candidates for alternative approaches designed around those attributes.

Research is suggested to evaluate taxation alternatives for heavier vehicles in the context of the findings of this project. The research would specifically address equity, administrative cost, compliance cost, and potential for evasion for tax sources that would be applied only to heavier vehicles.

Research on Technologies

Further investigation is desirable on the application of the most promising technologies that can be used to monitor the use of highways as a basis for collecting user fees. A testing

and demonstration program, perhaps under IVHS, should examine the most promising improvements in technologies for monitoring vehicles' use of the highways. Investigations should include the issues of uniform standards for transponders in vehicles to assure compatibility among states, toll facilities, and others as the number of applications of the technologies grows.

Some research should be conducted on the legal aspects of mandatory requirements for specific types of equipment that might be used for measuring mileage, such as odometers or transponders. Research also should identify strategies for evolving toward such a requirement in a manner that would be most likely to succeed.

Further investigation is desirable on the linkages between technologies, information systems, and the level of evasion of taxes. Alternative strategies to reduce evasion should be examined. Strategies to be examined should include the specifications of the monitoring systems as well as enforcement levels and techniques.

Research on Feasibility of Value-Added Taxes

Value-added taxes are used successfully in other countries, but have not been applied in the United States. Research comparing value-added taxes and other taxes should be comprehensive, considering transport and nontransportation uses.

THE "NEW APPROACH"—A NEW CONTRACT BETWEEN TRANSPORTATION AGENCIES AND THEIR CUSTOMERS

Overview of the Proposed New Approach

A new approach is recommended to create a direct linkage between surface transportation finance and the benefits to be derived from transportation programs. The new approach has several characteristics:

- It recognizes, and builds on, the frequently observed fact that legislators and taxpayers will commonly support increased user taxes and fees if they know that the money is committed to desirable transportation improvements.
- The new approach can be described as a contract or compact between the transportation provider (state department of transportation [DOT], transit agency, etc.) and the customer, in the sense that a binding commitment would be made to achieve a given level of service and other specific objectives in return for the commitment of a specific set of taxes and level of funding. The Texas DOT and state legislature identify outcomes to be achieved from budgeted resources.
- A systematic framework has been developed for evaluating alternative tax structures as a central tool for agencies to use in a variety of decision-making contexts. This framework is a practical, operational tool that encompasses all the criteria used in state-of-the-art tax studies, can be applied at all levels of government and for different time horizons, and is designed to aid in developing the revenue side of the contract with customers.
- The new approach will integrate the revenue options evaluation framework developed in this project with the several new management systems required by the ISTEA. It proposes that these several new management systems all be interrelated in a single comprehensive management system to be developed and demonstrated as part of a high-priority project, following completion of this project.

Nature of the Contract

The new contract approach will tie surface transportation financing to economic growth, environmental preservation, and mobility enhancement by keying financial, investment,

and management strategies to economic, environmental, and mobility goals and performance objectives. The approach allows different agencies and different levels of government to choose their own appropriate emphasis on economic, environmental, and mobility concerns.

In most applications at the state and local levels, the emphasis would be on delivering a specific level of service improvement in specified corridors or areas within a given program period, in return for the commitment of a specified tax package. Periodic monitoring and reporting to the legislature and the public would be part of the contract. In air quality management programs, specific reductions in emissions and improvements in air quality would also be major commitments under the new contract approach.

This new approach to financing transportation can be used to explain to the public, and to administrators and legislators, how their interests as customers and as constituent representatives will be met through proposed surface transportation fees, investments, and management actions. The approach provides a method for agencies to develop programs, revenue sources, and funding levels that can be demonstrated to be in the best interests of their customers.

This new contract between agencies and their customers would assure a greater understanding of their stake in the agencies' programs, finance sources, and overall investment and management actions.

Relationship to ISTEA

This new contract approach linking surface transportation finance to performance objectives and to consumer interests should be integrated with the implementation of ISTEA and its state and metropolitan area management systems. In turn, the management systems called for under the ISTEA will provide the analytical capabilities that will support the integration of decisions on surface transportation finance based on performance objectives integral to each management system. ISTEA management systems for congestion, safety, pavements, bridges, public transportation facilities and equipment, safety, and intermodal transportation will provide the basic information on how program levels will relate to the achievement of objectives.

How It Will Work

Surface transportation financing levels, programs of investment, and management strategies are determined by choosing financing sources consistent with chosen mobility, economic, and environmental objectives, and by setting finance levels necessary to achieve major economic, environmental, and mobility objectives. Agency top management and legislative bodies will target finance sources to each set of objectives—economic, environmental, and mobility—and will set fee levels based on performance objectives.

Fee and tax levels will be indexed and set to achieve these important consumer and societal objectives. The fee levels will be adjusted in the next agency budget or programming cycle if the levels of performance differ from the selected objectives.

The new approach recognizes that surface transportation capital facilities and management strategies exist not for their own sake but for those that enjoy the benefits of transportation, environmental quality, and mobility. Transportation capital facilities and management strategies can leverage enormous consumer benefits in operating costs, economic development opportunities, and environmental and livability benefits.

Economic Objectives

Public investments and management expenditures for surface transportation (on highways and on surface mass transportation) now total about $80 billion per year and largely determine the level of surface transportation operating costs customers will pay. Currently, customers pay about $1 trillion per year nationally in direct costs of operating surface passenger and freight transportation and another $1 trillion per year in travel time and unreimbursed safety costs. Public agency expenditures of $80 billion per year may seem substantial, but in perspective they are 4 percent of the private total surface transportation costs of over $2 trillion per year. The public sector supplies from its modest investment, very important elements of the transportation system that are critical in determining overall user costs and user mobility levels as well as other economic benefits and environmental impacts.

Economic objectives can be defined to set user fees and taxes at levels that achieve specified rates of return on investment to the users of surface transportation. Programs that provide desirable rates of economic returns to surface transportation consumers and to society will be funded. Rates for fees to finance these programs will be set so that programs and projects with the specified highly positive returns can be funded within a given period of years.

For highway programs, states and regions can use procedures such as the ISTEA management systems and the Highway Economic Requirements System (HERS) to identify investment levels and programs with the desired direct user benefits. HERS selects highway improvements based on economic returns, which include private user costs. Illustrative analyses using the HERS have shown that state highway investment programs at higher levels of expenditure than today's can yield very high returns to users—with annual benefits from increased investments at 7 to 10 times the increased annual costs.

For public transportation and transportation demand management, the ISTEA management systems for congestion and public transportation facilities and equipment will provide performance information linked to fee levels, investments, and actions.

Environmental Objectives

Some states or urban regions may wish to integrate surface transportation finance with the achievement of environmental or livability goals and objectives. Environmental-related fees would be designed to achieve clean air objectives by providing that fee levels will be set and adjusted based on the estimated levels necessary to contribute to achieving necessary reductions in emissions. The new approach to using surface transportation finance as an integral part of achieving environmental objectives in particular areas will be to set fees such that they "kick in" or are raised when scheduled reductions in transportation emissions are not being achieved.

Mobility and Safety Objectives

Basic mobility and safety objectives are served by transportation programs. Routine highway and transit maintenance and rehabilitation keep facilities in service and maintain mobility for the users, even if not associated with changes in user costs or changes in emissions. Transit services preserve or improve mobility for many who have no viable alternative means of travel.

Decision Making Under the New Approach

To put together a budget under the new financing approach, the agency determines which programs and projects are necessary to meet economic, environmental, and mobility objectives. It also identifies a level of overall fees that will provide the necessary financial resources for the investment and operating programs. This is not an exercise that most agencies have already undertaken. However, it can be accomplished before the ISTEA management systems are fully operational, and can be readily accomplished when they are implemented, as part of a carefully planned demonstration project.

CHAPTER 1

INTRODUCTION AND RESEARCH APPROACH

This report provides a review of the current status of financing of surface transportation in the United States, and proposes a new approach to financing surface transportation involving a new compact between transportation agencies and their customers. The compact approach includes continued updates of agreements on objectives and investment levels. Revenue sources would be chosen to be consistent with the new compact, as well as to meet traditional public finance criteria for adequate, simple, equitable, and efficient revenue sources that will perform well under future contingencies.

This research project provides practical guidance for all levels of government based on this new approach to surface transportation finance. This guidance takes into account threats and challenges such as environmental issues, international competitiveness, energy independence, infrastructure deterioration, and the tax revolt. It describes how agencies may take advantage of potential Intelligent Vehicle Highway Systems (IVHS) and other technological advances, potential institutional innovations, and the newly required Intermodal Surface Transportation Efficiency Act (ISTEA) management systems. This guidance illustrates how agencies can integrate finance decisions with performance objectives. It seeks to provide agencies with the means to convince their customers that their user fees or other fees will return substantial dividends.

This report defines this new approach, identifies the most promising revenue sources for consistency with the new approach and the other important criteria, summarizes the threats and opportunities, and provides an evaluation of future tax structures under several foreseeable scenarios.

1.1 RESEARCH PROBLEM STATEMENT

Current revenue sources for providing, maintaining, and operating an effective surface transportation system may be inadequate to meet present and projected needs. Petroleum-based motor fuel taxes, the mainstay of the traditional user-charge approach to highway funding in the United States, generally have not kept pace with either needs or inflation. However, until recently, taxation of motor fuels had been a reliable, economical, and comparatively acceptable method. The federal government and many state governments deposit these revenues in dedicated accounts embracing a user-fee approach to transportation improvements, and producing a reliable flow of funds that facilitates long-range planning and programming. However, a number of factors are reducing the effectiveness of motor fuel taxes as the primary financing mechanism for highway and other surface transportation programs.

Continued improvement in motor vehicle fuel efficiency and the development of alternatives to petroleum-based fuels diminish the effectiveness of motor fuel taxes as a measure of highway use and have a net effect of reducing expected revenues. Although the need is recognized, compensating increases in the fuel tax at both the federal and state levels are often difficult to enact.

Further, motor fuel taxes are used increasingly to implement national policies on energy issues, on environmental concerns, and for budget/deficit reduction. This practice can reduce the amount of motor fuel tax receipts available to transportation and can erode the concept of dedicated funds composed of user fees.

State and local governments are assuming increasing responsibilities for funding the surface transportation system. This will increasingly require innovative approaches to ensure adequate funding, including using new technologies and ideas to provide opportunities for new pricing and financing mechanisms.

As a result of these emerging trends, existing methods may need to be improved and new methods may need to be developed for financing the surface transportation system. Alternatives and their consequences must be identified and evaluated to assist public officials in making decisions on the future of the surface transportation finance system.

1.2 OBJECTIVE

The objective of this research has been to identify and evaluate alternatives to the traditional motor fuel tax as a principal method for financing the surface transportation system. Alternatives have had to be evaluated within the context of a range of possible future scenarios. The research has had to reconsider the role of the user-pay principle in financing the surface transportation system in light of current and likely future conditions, and has had to give attention to financing mechanisms at all levels of government.

1.3 SCOPE OF STUDY

The project has involved an intensive review of existing conditions and problems in financing surface transportation with fuel taxes; an analysis of alternative financing methods, including possible new approaches; the development of future scenarios that may have important impacts on finance based on a careful review of all related futures studies by others over the last several years; the development of criteria and a framework for evaluating alternative financing methods; and an application

of this framework to evaluate future financing alternatives under the different scenarios.

The project team has prepared this final report of this research, composed of the document and an executive summary. Included in this report are detailed discussions of application examples written for transportation professionals responsible for conducting revenue studies.

The scope of the project is defined further in the discussion that follows.

Task 1. Identification of Existing Conditions and Problems in Financing Surface Transportation with Motor Fuel Taxes

The project team identified potential problems with the surface transportation revenue system through a literature review, including a TRIS search, brainstorming session of team members and consultants, and selected interviews with knowledgeable experts. Based on this work, they prepared a technical memorandum for inclusion in the interim report analyzing existing conditions and problems in impacts on revenue trends and in effects on the commonly used criteria of adequacy, equity, efficiency, and simplicity, as well as other criteria.

Task 2. Identification of Alternative Financing Methods

The project team prepared an initial comprehensive list of existing and potential alternative financing sources not dependent on motor fuel consumption. These included more effective use of existing methods, user fee alternatives, and nonuser fee alternatives. Sources considered included

- extensions of motor fuel taxes;
- alterations to motor fuel taxes;
- modifications to other existing fees in the absence of motor fuel taxes;
- registration fees;
- vehicle sales taxes;
- weight- and distance-related fees;
- state transaction fees;
- license fees, tolls, and bonds;
- federal heavy-vehicle-user fees;
- federal taxes on heavy trucks sales, parts, and accessories;
- truck tires and tubes;
- transit revenues (farebox revenues, federal aid from general federal revenues, federal aid funded from motor fuel taxes, etc.);
- value-added taxes on automotive and truck products;
- vehicle import fees or import content fees;
- pavement-damage fees;
- congestion pricing fees;
- *ad valorem* fees;
- other forms of externality impact fees (such as noise or disposal);
- benefits-based fees;
- traffic impact fees;
- value capture tax increments;
- state and local aid from a variety of dedicated taxes and general revenue sources (motor fuel taxes, sales taxes, property taxes, general funds, other nonuser sources);
- parking fees;
- emissions fees; and
- vehicle miles of travel (VMT) fees.

This initial list was reviewed, refined, and evaluated based on an initial set of criteria (see Task 4), to determine all financing methods recommended for further study. Revenue alternatives were analyzed by level of government assuming that the taxes or fees were dedicated to surface transportation. The evaluation process included preliminary findings from our assessment of all prior studies of this type and from international experience (see Task 4). A second technical memorandum was prepared for inclusion in the interim report documenting the results of this task.

Task 3. Development of Future Scenarios

A TRIS literature search was conducted, covering transportation energy forecasts, alternative transportation energy sources, alternative motor vehicle power plants, evolving environmental constraints on motor vehicle fuel consumption, and relevant forecasts including transportation futures development for any related type of technological study. TRB staff and several other knowledgeable persons were contacted in the process of conducting the literature search. All the most relevant items were assembled, reviewed, and annotated in the process of preparing the interim report.

Experts were interviewed to obtain up-to-date information on relevant technological developments, market trends, and future expectations for all factors to be considered in defining the scenarios. The list of experts was compiled based on contacts with TRB staff, NCHRP project panel, and the literature review. Interviews were conducted by telephone and in person as appropriate, covering the following topics:

- environmental prospects associated with alternative fuels and power plants;
- technological developments in alternative fuels and power plants;
- market trends and factors including costs for alternative fuels and power plants;
- international developments in technology and markets;
- enforcement, evasion, administration costs, and compliance costs associated with alternatives to current fuel taxation;
- technological developments and market trends in vehicle monitoring systems with potential applications for annual or periodic mileage reporting (such as transponders, "tamper-proof" odometers, on-board computers); and
- political and legal issues surrounding the potential introduction of alternatives to current fuel taxation.

Notes were prepared from each interview emphasizing implications for the definition of scenarios and the evaluation of finance options under the scenarios.

Basic dimensions considered for defining scenarios include the following:

- proportion of fossil fuels replaced by other energy sources;
- improvements in fuel efficiency of motor vehicles;
- improvements in emissions controls for various pollutants;

- developments in understanding the consequences of environmental impacts of fossil fuels on human health, other forms of life, and the ecosphere;
- extent of use of fuel taxes for nontransportation purposes, such as energy conservation, environmental impact reduction, and reduction of budget deficits;
- developments in vehicle monitoring technology, and markets for that technology, related to mileage reporting;
- developments in automated highway systems technology leading to large-scale automated control of motor vehicles on major routes;
- growth rates for the national economy and for VMT; and
- major changes in the degree of concentration of control of surface transportation programs at the national level versus the state, local, and regional levels.

Based on these analyses, the basic dimensions of possible scenarios were narrowed to three (alternative fuels used, growth in VMT, and VMT measurement capability), and eight preliminary scenarios were defined in general terms. The research team then reviewed these, narrowed now to four recommended scenarios, and refined them based on this review. A technical memorandum on the scenarios was prepared summarizing and explaining each of the preliminary scenarios. The memorandum included those scenarios recommended to be used in Phase II, other scenarios considered but not recommended, and explanations of the basis for the recommendations. Each scenario was defined in specific, nonquantitative terms, beginning with the basic dimensions selected, and the importance of the scenario to surface transportation finance.

Task 4. Specification of Criteria and Development of Framework for Evaluating Alternative Financing Methods

The research team developed a set of criteria and a detailed analysis framework to estimate and evaluate impacts of alternative financing programs. The analysis framework considers impacts under existing motor fuel revenue structures and under alternative revenue structures at all levels of government. The criteria include detailed measures that should be assessed under the following general categories:

- adequacy of revenue in relation to highway program requirements;
- the equity of the revenue structure by vehicle class, fuel type within each class, and income group, and, where applicable, by geographic area;
- impacts on economic efficiency and the environment, including whether revenue programs are encouraging uneconomic uses of resources or travel patterns or are creating incentives harmful to the environment; and
- simplicity, including administrative and compliance costs and potential for evasion.

The process of developing the criteria involved an in-depth review of all recent major state tax studies and surface transportation finance studies.

Methods were adapted or developed, and were then applied for estimating the impacts for all quantitative factors.

A technical memorandum was developed for inclusion in the interim report, documenting criteria and methods for evaluating alternative revenue sources and assessing the sensitivity of the evaluation to major uncertainties. The memorandum described both the framework and the methods to be used to evaluate alternative revenue sources.

Task 5. Interim Report

An interim report was prepared and submitted for review summarizing the results of Tasks 1 through 4 and incorporating the technical memoranda for those tasks. An updated working plan for Tasks 6 through 8 was also included in the interim report.

The project's principal investigators met with the advisory panel to brief the panel and to seek input and guidance for the remaining tasks.

The panel played a lead role at this point in shaping the final products of the project. The panel's deliberations over the draft products were intense and extended because of the diversity of perspectives represented and the seriousness of the research topic to the interests of the nation's transportation administrators. The panel required substantial improvements in the evaluation framework and substantial revisions to the criteria and took the initiative in redefining the scenarios. Additional draft products were reviewed by the panel at a second meeting, and additional products were requested and reviewed before completion of the subsequent tasks and the draft final reports.

Task 6. Evaluate Consequences of Alternative Finance Methods Under Scenarios Presented in Task 3

The criteria and methods developed in Task 4 were refined after review by the panel and were then used to evaluate alternative sources identified in Task 2. The appropriateness and the prospects for each alternative source under each scenario were assessed. Each revenue source was evaluated with regard to the levels of government to which it would be most applicable. A technical memorandum was prepared for inclusion in the final report, documenting the results of the evaluations.

Task 7. Identify Issues for Further Research

Issues for further research have been identified based on the results of the research, particularly Tasks 4 and 6. Issues have been structured into those that can or cannot be expected to be resolved through further research. For those issues where research is expected to have a payoff, brief research statements have been drafted and priorities have been recommended.

Potential research projects considered include

- further investigation of the application of the most promising technologies that can be used to monitor the use of highways as a basis for collecting user fees;
- preparation of a testing and demonstration program for the most promising improvements in technology for monitoring vehicles' use of highways;

- further investigation of uniform standards for transponders to assure compatibility among toll facilities, states, and other users as the number of applications grows;
- research on the legal aspects of mandatory requirements for specific types of equipment for measuring mileage (such as odometers or transponders), and investigation of strategies for evolving such a requirement in a manner most likely to succeed; and
- further investigation of evasion of fuel taxes to assess the extent of the problem, factors that influence the amount of evasion, and alternative strategies for reducing the problem, including establishment of improved monitoring systems and enforcement techniques.

Task 8. Final Report, Executive Summary, and Applications Manual

A final report, executive summary, and applications manual have been prepared in NCHRP-specified format. The executive summary is a brief, easy-to-understand document that can be widely distributed to those with a general policy interest in surface transportation finance. The applications manual details and explains methods for evaluating alternative revenue sources and is a guide to strategies for developing revenue sources in the context of the future scenarios.

This document incorporates all information presented in the final report, executive summary, and applications manual produced under Task 8 of the study.

CHAPTER 2

FINDINGS

This chapter includes

- a review of trends and issues affecting surface transportation finance;
- an identification of alternative financing methods;
- a review of current programs that may affect the future of surface transportation finance;
- the development of criteria for evaluating tax alternatives; and
- an analysis of future scenarios of most interest to surface transportation finance.

2.1 TRENDS AFFECTING SURFACE TRANSPORTATION FINANCE IN THE 1980s AND 1990s

The 1980s and the 1990s will prove to have been an important transition period for surface transportation finance. Major trends affecting surface transportation finance are graphically summarized in Table 7. Particularly important driving forces include at least those identified in the boxes along the top of the exhibit along with inflation, shown in the middle of the exhibit. These forces all interrelate, and their confluence results in the need to review the manner in which surface transportation is funded.

The reduction in federal income tax rates and the increases in the federal deficit have led to the use of federal highway user fees for deficit reduction and a consequent threat to the likelihood that future fuel tax increases will be available exclusively for transportation. This will continue to be an issue no matter what happens to the current balances in the surface transportation trust fund accounts.

Increasing costs of domestic oil, increasing reliance on foreign oil, and threats to foreign oil supplies are likely to occur again and will also provide pressures for improved fuel economy and for promoting the use of alternative fuels. These difficulties with petroleum fuels may contribute to a decline in revenues for surface transportation by reducing fuel tax collections.

Increased environmental concerns are also playing a role in developing pressures for alternative fuels or cleaner-burning petroleum products and, in some areas, in calls for management of demand or actual reductions in travel. Continued suburbanization has increased transit costs as well as spread congestion to more links of the surface transportation system. This had led to increased interest in technological solutions such as an Intelligent Vehicle Highway System (IVHS) and in more direct ways of managing demand, such as congestion pricing. IVHS technologies offer opportunities to collect fees in ways that provide for greater equity among vehicle classes, or to increase the efficiency of the transport system by allowing variations in charges by time of day or level of congestion.

Inflation compounds the problems mentioned. Figure 4 compares changes in FHWA's composite index of construction prices for federal-aid highways to general inflation, as measured by the GNP deflator, and to changes in the price of gasoline. Increases in highway construction costs follow a different pattern than does general inflation—primarily because of the significant energy components in asphalt, concrete, and construction activity itself, and because of the influence of changes in the level of construction activity on construction prices. Nonetheless, the cost of highway construction has tended to climb over the years, at a long-term rate that is roughly similar to general inflation, but at a much less predictable rate. This can be expected to continue. Because of the high energy component of construction and diminishing oil reserves, long-term prospects are for somewhat greater inflation in construction prices.

Fuel efficiency changes can alter the revenue generated per mile of travel under fixed per-gallon motor fuel taxes. Table 8 shows comparative forcasts of vehicle stocks, vehicle miles of travel (VMT), and fuel consumption. Because of increased fuel efficiency, fuel consumption per vehicle declined and then leveled off somewhat in the late 1980s. Further declines may occur in the future because of fuel price increases in excess of inflation and fuel tax increases to pay for deficit reduction, environmental programs, and surface transportation.

A range of forecasts of fuel use and fuel efficiency are reported in Appendix D. All forecasts indicate at least some continued decline in fuel consumption per mile of travel through the near term. Fuel efficiency under current policies has been influenced by the Corporate Average Fuel Economy (CAFE) standards. Policy analysts argue that CAFE standards should be changed at least to the point where economic benefits accrue from the increased standards. CAFE standards for autos under these circumstances have been estimated by Difiglio, Duleep, and Greene at 34.3 to 36.4 miles per gallon, depending on how many years are used to recapture costs through fuel savings at close to current market prices for fuel.[1]

Based on these figures, new automobile fuel economy could be increased up to 25 percent over the current standard of 27.5 miles per gallon. A comparable loss in revenue per mile would be realized without fuel tax increases.

Although highway costs respond to inflation, revenues from most highway taxes and fees do not. One exception is taxes based on sales or on value of vehicles. However, other taxes can be, and sometimes are, indexed to construction costs or to other cost indices. More indexing of this type can be expected in the future to offset some of the trends discussed above.

TABLE 7. Overview of trends in the 1980s and 1990s relating to surface transportation finance

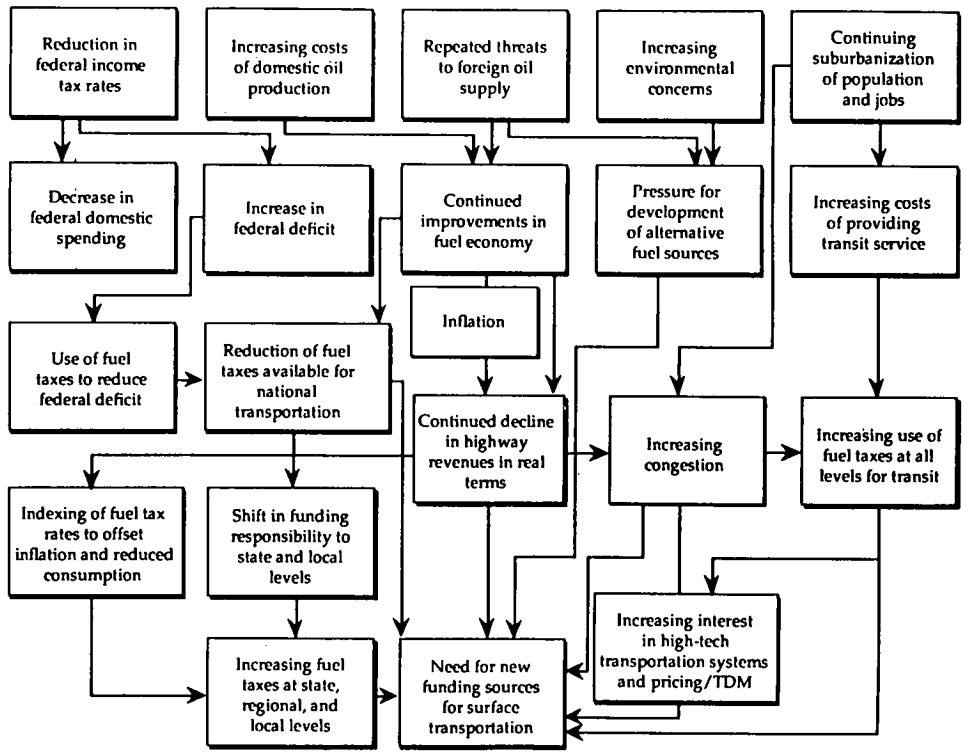


Figure 5 illustrates how some of the above factors can combine to cause fuel tax revenue to fall significantly short of needs. The top line of this exhibit is an illustrative projection through 2020 of surface transportation needs that are presumed for this purpose to be warranted based on economic investment criteria. A 3 percent annual growth rate in required investment is assumed in this illustration. These needs are likely to grow more rapidly than base case VMT (2% per year in this illustration) because of deferred maintenance and the increasingly high cost of dealing with congestion and providing transit services in suburban areas. Because of increasing fuel efficiency, fuel consumption will grow at a lower rate than VMT (1% per year in the illustration).

Furthermore, a constant motor fuel tax rate per gallon might yield revenues that would increase at a rate substantially lower than fuel consumption, as illustrated in Figure 5, for the following reasons:

- additional tax rate reductions are likely to be given to alternative fuels; and
- the complexities of collecting motor fuel taxes from the consumption of very different types of alternative fuels could result in continuing increases in tax evasion and collection costs over today's evasion rates.

In the illustration shown in Figure 5, each of the factors is assumed to decrease revenues by 1 percent per year. Note the very large cumulative long-run impact of these individually small percentage impacts. By 2020, revenues from a constant rate per-gallon fuel tax would drop about 25 percent in constant dollars despite a base case increase of over 70 percent in VMT and an even greater increase in needs. In this illustration the fuel tax rate would have to be tripled to keep pace with the increase in needs. Such an increase would itself have significant effects on VMT, fuel economy, and tax receipts.

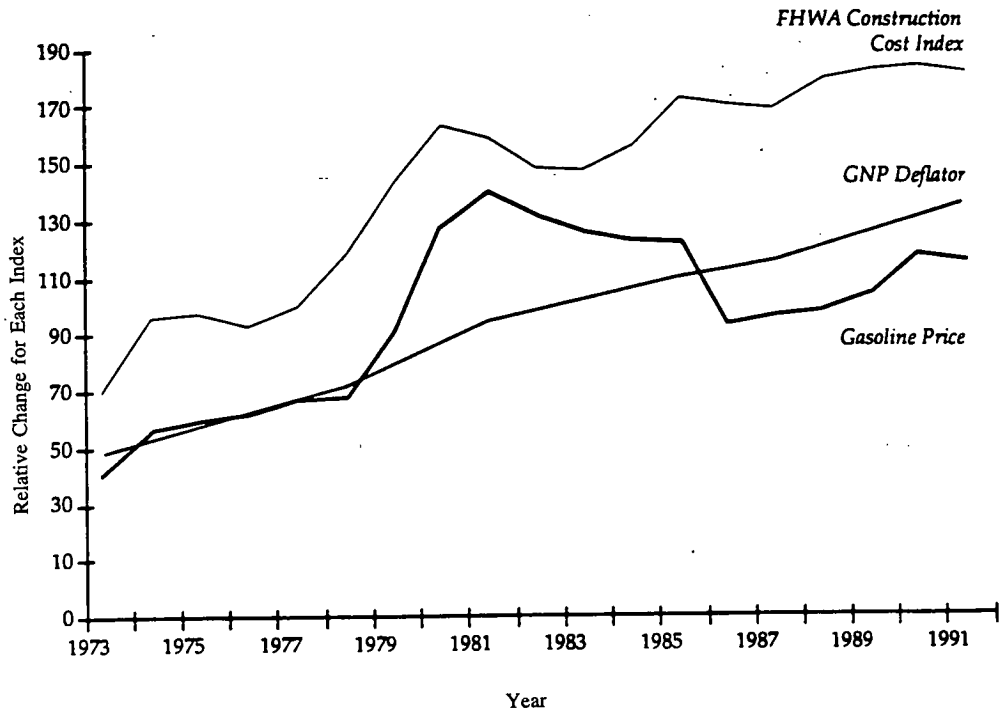
Although the longer-term impacts are greater, there is serious deterioration in revenues in this illustration even in the short term. Clearly, there is a need to review the way surface transportation is funded. The merging of all the forces discussed above results in the need to examine new funding sources for surface transportation that can provide a stable, reliable revenue stream adequately scaled to meet mobility needs, regardless of how the future takes shape.

2.2 CURRENT REVENUE ISSUES: IS THE SYSTEM "BROKEN"?

A major issue is whether the current system is broken, or will soon be broken. There are pluses and minuses in current revenue approaches and trends, as summarized above, but one of the overriding issues is that the current system does not create a correspondence between what the customers of transportation agencies want and what they are asked to pay. Establishing that linkage could be the bold stroke that leads to solutions to the revenue problems of each level of government.

The current and potential future deterioration of the buying power of existing motor fuel taxes over time has led some key transportation leaders to conclude that the system is broken already, or will be broken soon. Major difficulties include the following:

- Revenues will fail to keep pace with inflation because fuel tax rates are fixed per gallon and are not indexed to the rate of inflation in the costs of the programs the revenues must fund.



Sources:

FHWA composite index of construction prices for federal aid highways: Federal Highway Administration, Highway Statistics: 1990, Table PT-1; and Survey of Current Business, August 1992, page S-7.

GNP Deflator: Survey of Current Business, December 1991 and August 1992, Table 1.9 and 1.10; and U.S. Department of Commerce, Statistical Abstract of the United States, Table 779, 1991 and earlier years.

Gasoline Price: U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, June 1992. Prices for 1976-1991 are retail prices of unleaded regular gasoline, including taxes; for 1973-1975, prices are for leaded gasoline, adjusted to be consistent with the price for unleaded 1976.

Figure 4. Measures of inflation.

• Indexing of fuel tax rates to the price of fuel can provide a roller-coaster effect, with the revenues increasing or decreasing based on factors well outside the control of transportation agencies. While the situation may seem positive if revenues are increasing, the problem of decreasing revenues during periods of falling prices is significant enough to make this type of indexing of limited value.

• Fuel efficiency increases will reduce the revenue collected per mile of travel and may result in reduced total revenues if fuel efficiency changes more than offset the impacts of VMT changes.

• Petroleum-based fuels may become more scarce, or dependence on foreign sources may become too risky, accelerating a switch to nonpetroleum fuels.

• Alternative fuels can complicate the revenue-raising efforts of all levels of government by requiring additional collection and enforcement efforts, if alternative fuels are taxed.

• Reliance on fuel taxes leaves the door continuously open to proposals to subsidize alternative fuels by taxing them at a low rate or not taxing them at all. The tax incentives provided to gasohol have seriously reduced highway revenues. In the electric vehicle program of Calstart, not only is electricity for recharging electric vehicles not taxed, it is provided free at recharging locations.

• The opportunity to adopt pricing approaches using automatic vehicle identification (AVI) technology may eventually make fuel taxes a relatively inefficient means of pricing travel.

• Transportation programs cannot afford to provide full subsidies for alternative fuels and also meet infrastructure funding needs with continuing reliance on fuel taxes as the primary source of support.

• The potential for electric or compressed natural gas vehicles raises the issue that fuel consumption by these vehicles may have to be metered on-vehicle. If meters become widespread on vehicles, monitoring VMT rather than fuel consumption would provide a more direct measure of vehicle cost responsibilities.

• Reliance on fuel taxes cannot address all equity concerns among types of vehicles. The variations in fuel consumption per

TABLE 8. Forecast comparisons: Personal vehicle stocks, vehicle miles, fuel consumption, and fuel economy

Source	Value by Year						Growth, 1985-2010 (%/Year)
	1985	1990	1995	2000	2005	2010	
Stocks (10^6)							
Personal vehicles							
ANL	145.2	170.0	186.0	201.2	214.8	229.4	1.85
Automobiles							
ANL	131.2	149.6	161.1	173.4	185.2	197.7	1.65
DRI	145.8[a]	147.1	148.8	150.6	NA	156.6	0.33
GRI	140.7[b]	NA	151.1	158.5	166.6	170.3	0.80
EEA	117.3[b]	125.3	135.0	145.7	155.0	163.1	1.38
Vehicle Miles (10^9)							
Personal vehicles							
ANL	1,267	1,502	1,602	1,732	1,840	1,955	1.75
EIA	1,511[a]	1,553	1,681	1,834	2,017	2,241	1.81
Automobiles							
ANL	1,261	1,460	1,555	1,653	1,756	1,857	1.56
DRI	1,439	1,503	1,631	1,725	NA	1,954	1.40
GRI	1,311[b]	NA	1,609	1,767	1,898	1,975	1.72
EEA	1,377[b]	1,512	1,636	1,768	1,890	1,999	1.56
Fuel Consumption (10^{15} Btu)							
Personal vehicles							
ANL	9.317	10.047	10.589	11.009	10.905	10.803	0.59
EIA	10.314[a]	10.431	10.616	10.962	11.469	12.158	0.75
Automobiles							
ANL	8.666	9.145	9.390	9.635	9.575	9.515	0.16
GRI	8.939[b]	NA	8.714	8.989	9.076	8.851	-0.04
EEA[c]	8.780	8.645	8.514	8.565	8.831	9.211	0.20

mile among types of vehicles does not, in general, correspond to the responsibility of those vehicles for highway costs.

- Lower-income households will pay a greater share of fuel taxes than they will for many other types of taxes, such as income taxes, taxes on VMT, vehicle sales taxes, or other types of *ad valorem* taxes (e.g., personal property taxes). The introduction of alternative fuels will exacerbate this problem, because lower-income households are less likely to benefit from the tax subsidies to alternative fuels, because they own relatively older vehicles.

On the other hand, it is also possible that the present reliance on fuel taxes for surface transportation finance might continue indefinitely and perhaps even be strengthened. This may be true if none of the previously stated possibilities becomes a reality in the foreseeable future, and if motor vehicles continue to evolve along their current path. Reliance on fuel taxes has some important positive attributes:

- The gasoline tax can be collected by states and by the federal government at a reasonably high level up the distribution chain (often at the refinery) because gasoline is used mostly for taxable highway purposes. The higher up the distribution chain an item can be taxed, the lower will be the compliance costs, administrative costs, and opportunities for evasion.

TABLE 8. Forecast comparisons: Personal vehicle stocks, vehicle miles, fuel consumption, and fuel economy (continued)

Source	Value by Year						Growth, 1985-2010 (%/Year)
	1985	1990	1995	2000	2005	2010	
On-Road Fuel Economy (mpg)							
Personal vehicles							
ANL	17.0	18.0	19.1	19.7	21.1	22.6	1.15
EIA	18.2[a]	18.7	19.9	21.0	22.1	23.1	1.10
All automobiles							
ANL	18.2	20.0	20.7	21.3	23.0	24.7	1.23
EIA	19.5[a]	20.2	22.0	23.8	25.5	27.2	1.52
DRI	20.0[a]	21.1	23.1	24.3	NA	27.2	1.41
GRI	18.4[b]	NA	23.1	24.6	26.2	27.9	1.75
EEA	19.3[b]	21.4	23.1	24.3	25.0	25.2	1.12
New automobiles							
EIA[d]	28.3[a]	28.6	30.7	32.8	34.8	36.9	1.21
DRI	24.1	24.3	25.5	27.0	NA	30.1	1.02
GRI	23.1[b]	NA	25.3	27.1	29.0	31.1	1.25
EEA	23.8[b]	24.3	25.1	26.5	26.5	26.5	0.45
Vehicle utilization (VMT/vehicle)							
Personal vehicles							
ANL	8,726	8,835	8,715	8,608	8,566	8,522	-0.09
Automobiles							
ANL	9,611	9,759	9,652	9,533	9,482	9,393	-0.09
DRI	9,870[a]	10,218	10,961	11,454	NA	12,478	1.07
GRI	9,318[b]	NA	10,649	11,148	11,393	12,612	1.27
EEA	11,739[b]	12,067	12,119	12,135	12,194	12,256	1.80

[a] 1988.
[b] 1986.
[c] Excludes oxygenates.
[d] EPA rated.

Source: Argonne National Laboratory (ANL), Forecast of Transportation Energy Demand through the Year 2010, April 1991, pages 67 and 68. EIA is Energy Information Administration. DRI, GRI, and EEA are private forcasters: Data Resources, Inc.; Gas Research Institute; and Energy and Environmental Analysis, respectively.

NA, not available.

- Fuel taxes are relatively easy for the consumer to comply with; the price is higher because of the tax, but there is no compliance burden of extra time or paperwork. This is significantly different from registration fees or income taxes, for each of which forms have to be filled out and payments (often substantial) have to be made by the individual, household, or business.
- Fuel taxes are at least generally proportional to highway use and to vehicle emissions, although in each case, significant variations occur depending on the type and condition of the vehicle and other factors.
- Diesel fuel dyes are likely to reduce evasion of diesel taxes and dyes could possibly also reduce evasion of other liquid fuel taxes, thus increasing revenues and equity.

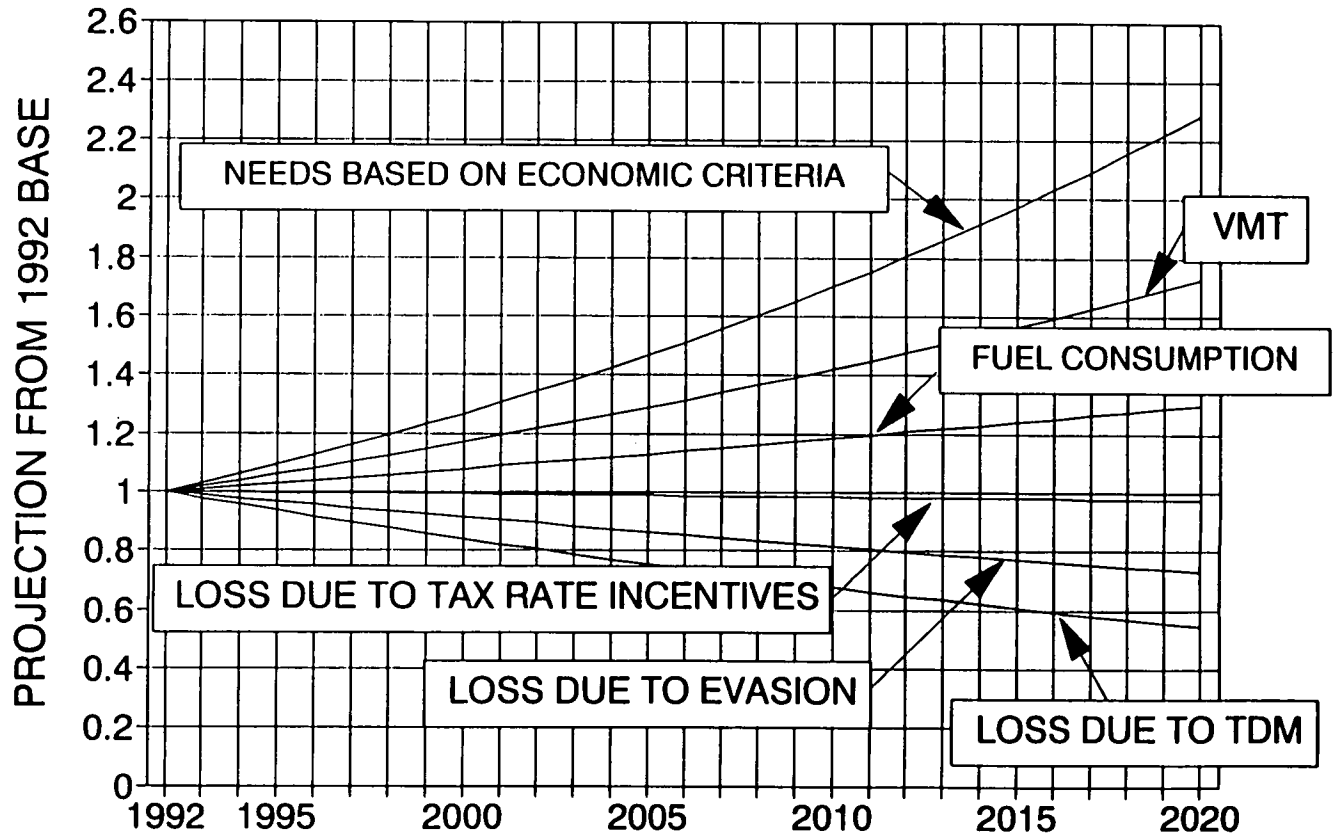


Figure 5. Illustration of revenue loss factors.

• The public also is accustomed to taxes on highway motor fuels. All states tax motor fuel, even though all do not levy income taxes or sales taxes.

As documented in detail in Appendix A, motor fuel taxes have continued to be the primary source of surface transportation finance and have even increased in relative importance over the last decade, despite the problems discussed.

Some alternatives to gasoline and diesel might be distributed, sold, and taxed in the same way that gasoline and diesel fuels are today. These alternative fuels include liquid fuels such as ethanol, methanol, and cleaner-burning distillates of petroleum. If any of these becomes the principal substitute for current fuels, and if the technology of its production and distribution evolves so that taxes can be levied at relatively few points in the wholesale transaction process, then an increased market share for these types of fuel may make little difference compared to continued use of gasoline or diesel fuels. This may be true even if three or four types of fuel capture significant segments of the market.

When the revenue-related issues themselves are looked at, continued reliance on motor fuel taxes has some pluses as well as minuses. But the level of concern now being expressed by many transportation administrators is not brought about by the relative attributes of the different revenue sources themselves. It is a concern that the *overall system* of providing and financing surface transportation is not working acceptably. Transportation agencies are often not achieving the level of resources they need to provide the service levels that best support the economic, environmental, and mobility interests of their consumers. The clients of the agencies—the consumers—are left with less mobility, less economic development, and a poorer environment because of the forgone programs and projects.

The revenue-related concerns and the revenue alternatives must be evaluated in this broader context of whether the entire system of revenue/investments is broken, or will become broken. A key issue is whether or not there is a desirable and agreed-upon type of compact between the transportation agencies and their customers over what the system should produce for the customers.

What would a desirable type of compact between the agencies and consumers do? It would provide for a way through which agencies and consumers (the public, households, businesses) could agree on a level of service and performance measures, and the consumers could understand what they were buying for the fees they paid. It would provide for investments in transportation that achieve the desired levels of service and meet the economic, environmental, and mobility performance objectives the consumers want and for which they are willing to pay.

Agencies must be able to explain to the consumers they serve what they are buying for this contract to operate. They need to explain how the programs funded by the revenues relate to economic, environmental, and mobility objectives, and to show what can be bought at alternative levels of revenue.

When current conditions are contrasted with this definition of

how surface transportation finance should work, the system is broken and the revenue-performance linkage is a key malfunctioning element of the break. Actions necessary to fix the overall system, and its revenue component, are described in Chapter 3.

2.3 ALTERNATIVE FINANCING METHODS

This section contains three major subsections that describe

1. User fees—the various existing and proposed methods for obtaining revenue from users of the transportation system;
2. Nonuser fees — other existing and potential sources of transportation funds; and
3. Debt financing and private ownership.

Figure 6 illustrates the range of revenue sources that have been identified and categorized in a study by Alan Pisarski. A preliminary evaluation of each revenue source is presented below, in terms of whether the source could provide adequate fees to replace all or a major portion of motor fuel taxes, and whether the source is a good candidate for dedication. This is the first "screen" of the framework for evaluation that is presented in Chapter 3.

User Fees

Most existing highway user fees relate to the vehicle, to fuel consumed, to vehicular activity, or to the externalities caused by vehicles and their usage. In addition, the general category of user fees includes transit user fees and various minor types of user-related fees. The first four categories — vehicles, fuel, activity, and externality related fees—are categories of user fees that can provide adequate revenues and could be dedicated to surface transportation.

Taxes and Fees Related to the Vehicle

Registration Fees. For light vehicles, about half the states have flat fees; about one-third of the states base the registration or "tag" fee for light vehicles on weight; and the remainder (about 15%) base the fee on various combinations of weight, age, horsepower, and value.[2] Additional revenue is obtained from the sale of vanity plates.

The choice of a variable on which to base the registration fee is extremely important to revenue yields. States and localities that base registration fees for light vehicles on estimated vehicle value have seen such fees grow substantially over time. The advantage of value-based registration fees over other registration fees is in the automatic responsiveness of these fees to inflation.

Fees based on weight or horsepower may fluctuate up or down based on consumer preferences. With low fuel prices, sales of higher-weight, higher-horsepower vehicles can be expected to increase, because fuel consumption becomes a less important attribute. With higher fuel prices, the average registration fee may decline for fee structures based on weight or horsepower.

For heavier vehicles, registration fees usually increase rapidly with some measure of weight. The measure most commonly used is registered gross vehicle weight (GVW), the declared maximum gross weight of the vehicle and its load. The increase in these registration fees with weight is generally significant, reflecting the greater cost responsibility of heavy vehicles.

As Table 9 indicates, registration and motor carrier fees provide an average of about 17 percent of all state highway revenues,[3] and are the second largest source of funds raised by the states themselves.

Federal Heavy-Vehicle Use Tax. The federal heavy-vehicle use tax is an annual tax on trucks with registered GVWs or gross combination weights (GCWs) above 55,000 pounds. For vehicles weighing between 55,000 and 75,000 pounds, the tax is $100 plus $22 per 1,000 pounds over 55,000; for heavier vehicles, it is $550 per year.[4]

Vehicle Property Taxes. Several states and localities levy personal property taxes on the assessed value of motor vehicles owned by individuals and/or businesses. These are the same as registration fees based on value. Advantages of such taxes are their responsiveness to inflation, and that they currently are deductible for federal income tax purposes.

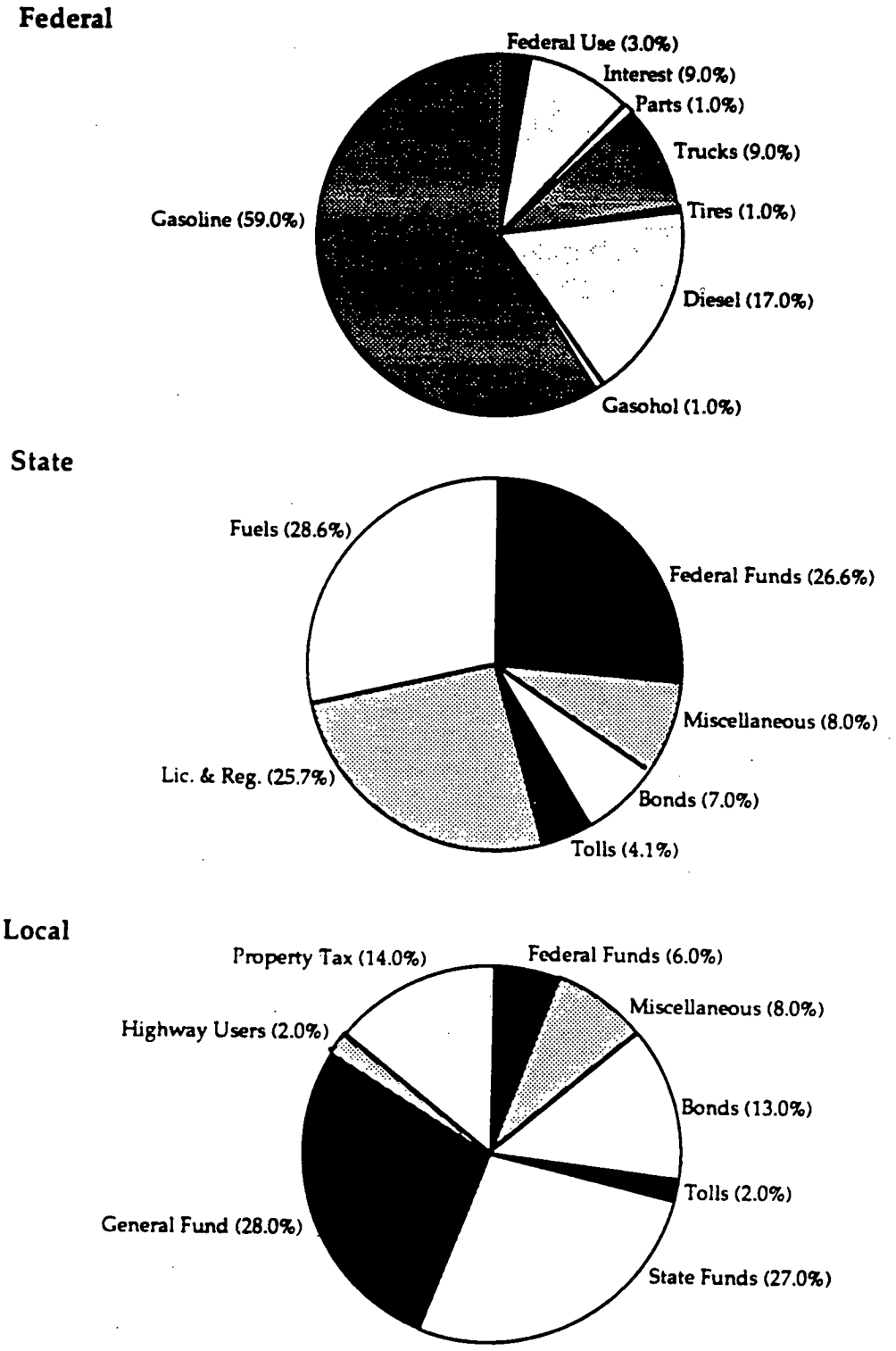
Vehicle Transfer or Sales Taxes. Vehicle transfer or sales taxes are taxes that are levied as a percentage of the sales price of a vehicle when it is purchased or first registered in a state. The sales price may be the gross price or the net price after subtracting the value of any trade-in. These taxes have a variety of names, including "titling tax," "excise tax," "vehicle document fee," and "motor vehicle use tax." These taxes differ from general sales taxes in that revenue derived from these taxes is deposited in the highway fund, while revenue from a general sales tax usually is treated as general revenue. They also differ from titling fees that are charged for changing the title of a vehicle and that are independent of vehicle value.

Because vehicle transfer taxes are levied as a percentage of vehicle sales prices (i.e., they are levied *ad valorem*), revenues from these taxes rise automatically with inflation. As Table 9 indicates, these taxes generate significant revenue in nine states, accounting for 6 to 31 percent of state highway revenues in these states.

Federal Excise Tax on Heavy Trucks and Trailers. The federal government currently levies a 12 percent excise tax on the retail price of trucks and tractors with GVWs or GCWs over 33,000 pounds and trailers with GVWs over 26,000 pounds.[5]

Federal Tax on Tires. The federal government taxes new truck tires weighing over 40 pounds on a sliding scale.[6] The tax is 15 cents per pound for the first 30 pounds of additional weight, 30 cents per pound for the next 20 pounds, and 50 cents per pound for any excess above 90 pounds.

Federal Gas Guzzler Tax. The federal gas guzzler tax applies a graduated fee schedule to vehicles with fuel economy ratings that indicate excessive fuel consumption. The fees amounted to



Source: Alan Pisarski, *Highways, Streets, Roads, and Bridges*, prepared for the National Council on Public Works Improvement, 1987.

Figure 6. Proportion of highway funds by source and by level of government.

TABLE 9. State highway funding sources (percentage by source)—1992

COMPILED FROM REPORTS OF STATE AUTHORITIES

(THOUSANDS OF DOLLARS)

STATE	HIGHWAY-USER REVENUES				MISCELLANEOUS				FEDERAL FUNDS				
	MOTOR-FUEL TAXES	MOTOR-VEHICLE AND MOTOR CARRIER TAXES	STATE HIGHWAY-USER TAX REVENUES	ROAD AND CROSSING TOLLS	OTHER STATE IMPOSTS, GENERAL FUND REVENUES	MISCELLANEOUS INCOME	TOTAL	BOND PROCEEDS	FEDERAL HIGHWAY ADMINISTRATION	OTHER AGENCIES	TOTAL	PAYMENTS FROM LOCAL GOVERNMENTS	TOTAL RECEIPTS
Alabama	48.8%	16.1%	64.9%	-	0.4%	2.5%	2.9%	-	31.8%	0.3%	32.1%	-	100.0%
Alaska	5.4%	5.3%	10.7%	4.4%	26.1%	6.3%	32.4%	-	52.3%	0.2%	52.5%	-	100.0%
Arizona	28.2%	14.5%	42.7%	-	7.8%	3.7%	11.5%	20.9%	13.7%	0.7%	14.4%	10.6%	100.0%
Arkansas	47.0%	21.2%	68.1%	-	0.4%	2.3%	2.6%	-	27.9%	0.4%	28.4%	0.8%	100.0%
California	38.1%	20.5%	58.6%	1.9%	3.2%	5.6%	8.8%	-	28.2%	0.6%	28.8%	1.9%	100.0%
Colorado	49.4%	16.5%	65.9%	-	0.0%	0.9%	0.9%	-	32.7%	0.5%	33.1%	-	100.0%
Connecticut	21.6%	10.3%	32.0%	0.0%	8.9%	7.2%	16.1%	21.8%	29.9%	0.1%	30.0%	0.1%	100.0%
Delaware	12.3%	7.4%	19.7%	12.9%	17.8%	2.8%	20.7%	33.4%	11.1%	2.3%	13.3%	-	100.0%
Dist. Of Col.	11.8%	15.7%	27.6%	-	6.6%	24.6%	31.2%	13.0%	28.0%	0.2%	28.2%	-	100.0%
Florida	32.3%	19.7%	52.0%	10.2%	6.0%	5.0%	11.0%	5.8%	19.5%	0.6%	20.1%	0.9%	100.0%
Georgia	24.0%	4.1%	28.1%	0.1%	30.5%	3.2%	33.7%	12.2%	24.7%	0.2%	24.9%	1.1%	100.0%
Hawaii	15.9%	15.8%	31.7%	-	13.7%	5.5%	19.1%	-	49.0%	0.2%	49.2%	-	100.0%
Idaho	40.2%	24.9%	65.2%	-	-	-	-	-	31.1%	2.8%	34.0%	0.9%	100.0%
Illinois	32.7%	16.1%	48.8%	8.9%	1.2%	1.1%	2.2%	21.1%	18.1%	0.2%	18.3%	0.7%	100.0%
Indiana	40.9%	11.0%	52.0%	4.1%	0.3%	7.6%	7.8%	5.3%	29.4%	0.2%	29.5%	1.3%	100.0%
Iowa	32.2%	24.1%	56.3%	-	13.3%	2.9%	16.2%	-	27.1%	0.2%	27.3%	0.2%	100.0%
Kansas	22.1%	8.7%	30.7%	3.7%	14.9%	3.4%	18.3%	32.7%	13.0%	0.3%	13.4%	1.3%	100.0%
Kentucky	33.6%	35.7%	69.3%	1.3%	3.3%	7.9%	11.2%	-	17.7%	0.2%	17.9%	0.3%	100.0%
Louisiana	43.4%	11.6%	55.0%	2.2%	-	3.1%	3.1%	9.1%	30.2%	0.4%	30.6%	-	100.0%
Maine	36.1%	13.5%	49.6%	9.8%	0.7%	1.1%	1.8%	16.6%	22.0%	0.1%	22.2%	-	100.0%
Maryland	29.4%	29.3%	58.8%	6.1%	3.7%	3.6%	7.3%	2.3%	25.0%	0.2%	25.3%	0.4%	100.0%
Massachusetts	22.0%	14.1%	36.2%	8.1%	-	3.2%	3.2%	15.0%	37.2%	0.2%	37.4%	0.0%	100.0%
Michigan	31.9%	21.4%	53.2%	0.7%	5.0%	3.9%	8.9%	12.1%	22.1%	0.2%	22.4%	2.7%	100.0%
Minnesota	35.8%	32.0%	67.9%	-	0.7%	5.0%	5.7%	0.6%	22.9%	0.3%	23.2%	2.6%	100.0%
Mississippi	45.3%	12.7%	58.1%	-	8.5%	3.1%	11.6%	-	28.8%	1.2%	30.1%	0.3%	100.0%
Missouri	38.0%	17.1%	55.1%	-	10.8%	0.3%	11.1%	-	32.8%	0.2%	33.0%	0.8%	100.0%
Montana	37.6%	12.1%	49.8%	-	0.5%	1.0%	1.5%	-	46.4%	2.3%	48.8%	-	100.0%
Nebraska	41.7%	9.0%	50.7%	-	19.2%	1.4%	20.6%	-	25.8%	0.3%	26.0%	2.7%	100.0%
Nevada	47.4%	15.7%	63.2%	-	4.5%	2.8%	7.3%	9.1%	20.1%	0.3%	20.4%	-	100.0%
New Hampshire	32.1%	20.8%	52.9%	14.7%	1.3%	5.9%	7.2%	0.9%	22.9%	0.2%	23.2%	1.1%	100.0%
New Jersey	10.6%	6.7%	17.3%	17.7%	-	14.7%	14.7%	35.2%	14.9%	0.2%	15.1%	0.1%	100.0%
New Mexico	35.8%	25.5%	61.3%	-	-	2.4%	2.4%	-	35.9%	0.5%	36.3%	-	100.0%
New York	13.6%	5.0%	18.6%	15.2%	-	4.9%	4.9%	41.5%	19.7%	0.2%	19.9%	-	100.0%
North Carolina	52.5%	16.3%	68.8%	0.1%	4.0%	5.8%	9.8%	-	20.1%	0.2%	20.3%	0.9%	100.0%
North Dakota	31.3%	17.2%	48.5%	-	1.9%	0.4%	2.3%	-	44.5%	0.5%	45.0%	4.3%	100.0%
Ohio	47.7%	21.8%	69.6%	3.7%	-	1.5%	1.5%	4.3%	20.2%	0.2%	20.4%	0.5%	100.0%
Oklahoma	42.8%	10.6%	53.4%	9.8%	2.9%	2.7%	5.6%	5.7%	24.6%	0.4%	25.0%	0.6%	100.0%
Oregon	35.5%	23.7%	59.2%	0.3%	3.1%	3.6%	6.7%	-	24.4%	8.5%	32.9%	1.0%	100.0%
Pennsylvania	43.1%	17.2%	60.2%	11.2%	-	3.2%	3.2%	1.2%	23.3%	0.3%	23.6%	0.6%	100.0%
Rhode Island	22.6%	6.8%	29.3%	3.9%	-	0.5%	0.5%	13.4%	52.4%	0.5%	52.8%	-	100.0%
South Carolina	52.4%	11.3%	63.8%	-	-	1.3%	1.3%	-	34.0%	0.8%	34.8%	0.1%	100.0%
South Dakota	32.4%	8.1%	40.5%	-	11.2%	2.4%	13.6%	-	42.7%	1.0%	43.7%	2.2%	100.0%
Tennessee	37.6%	10.3%	47.9%	0.0%	28.2%	0.5%	28.7%	-	22.0%	0.2%	22.2%	1.2%	100.0%
Texas	43.9%	22.0%	65.9%	1.4%	0.6%	2.3%	2.9%	-	28.3%	0.3%	28.6%	1.2%	100.0%
Utah	44.7%	10.3%	55.0%	0.1%	8.2%	0.6%	8.8%	-	29.8%	5.9%	35.6%	0.5%	100.0%
Vermont	23.2%	28.3%	51.5%	-	-	3.9%	3.9%	6.0%	35.4%	1.1%	36.5%	2.0%	100.0%
Virginia	29.5%	19.9%	49.4%	5.0%	19.0%	2.5%	21.5%	6.1%	15.0%	0.2%	15.2%	2.9%	100.0%
Washington	33.5%	25.3%	58.8%	4.6%	0.0%	4.5%	4.5%	2.1%	27.8%	1.7%	29.4%	0.5%	100.0%
West Virginia	33.3%	22.7%	56.0%	5.7%	1.6%	3.4%	4.9%	-	32.8%	0.5%	33.3%	0.0%	100.0%
Wisconsin	39.5%	15.9%	55.4%	-	-	2.6%	2.6%	14.9%	24.3%	0.4%	24.6%	2.5%	100.0%
Wyoming	17.0%	12.4%	29.3%	-	10.1%	2.2%	12.3%	-	35.5%	21.8%	57.3%	1.0%	100.0%
Total	33.4%	16.6%	50.0%	4.8%	4.9%	4.2%	9.0%	9.7%	24.7%	0.6%	25.3%	1.1%	100.0%

a total of $118 million in 1991 and are not allocated to the federal transportation trust funds.

Other Vehicle-Related Fees. Other vehicle-related fees include those for transferring certificates of title, vehicle inspection, temporary operating permits, and oversize and overweight permits. Vehicle taxes related to price or value are responsive to inflation.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication

Registration fees, or at the federal level vehicle use fees, are clearly important alternatives to motor fuel taxes. Registration fees could be raised to the point of replacing all motor fuel taxes. Registration fees based on value for smaller vehicles and on weight for larger vehicles represent a particularly promising set of sources.

Vehicle sales taxes could provide adequate revenues, but are more appropriate as an adjunct to other taxes, because they are incident on only a subset of users in any given year. Taxes on tires, vehicle transfers, gas guzzler taxes, and minor vehicle-related fees cannot provide adequate revenues and will have the disadvantage of being applied only to subsets of vehicles in any year. They should be considered as very useful auxiliary sources.

Fuel Taxes

Sometimes called second structure taxes, because they were the second major source of highway revenues to be introduced, fuel taxes account for about 75 percent of the revenue obtained by the Federal Highway Trust Fund. In most states, as Table 9 indicates, motor fuel taxes are the largest source of state tax revenue from highway users.

Also, in most states, fuel-tax rates are set by law and are increased periodically by state legislatures in response to increasing needs for highway revenue. However, 10 states use a variable tax rate that is automatically adjusted at specified intervals in response to changes in fuel prices or in response to some index of prices or highway costs. Most of these 10 states have a minimum tax rate (or "floor") below which the rate cannot go, and some also have a maximum rate (or "ceiling").

Gasoline Tax. As of December 1993, per-gallon state gasoline taxes averaged 19.1 cents per gallon (weighted average). The federal tax on gasoline was increased from 14.1 to 18.4 cents per gallon effective October 1, 1993. Of the 18.4 cents, 0.1 cent is deposited in the Leaking Underground Storage Tank (L.U.S.T.) Trust Fund, 6.8 cents is committed to deficit reduction, and 11.5 cents is deposited in the Highway Trust Fund (HTF).[7] For all highway fuels, 1.5 cents of the HTF revenue is placed in a separate Mass Transit Account,[8] with the remainder being available for highway needs.

Most gasoline is used as a highway motor fuel. This makes imposition of the tax on highway gasoline relatively straightforward. The tax is collected on virtually all gasoline produced, and refunds are provided for exempt uses. Nonetheless, evasion has been of concern. FHWA and the states are devoting increasing attention to measures designed to curtail fuel tax evasion.

Gasohol. Gasohol is defined to be gasoline with at least a 10 percent ethanol content by volume. Since the mid-1970s, gasohol has received special tax treatment from the federal government and from many states, primarily to promote the use of renewable fuels from domestic sources. Also, because of the oxygen content of ethanol (and of all other alcohols), gasohol produces lower carbon monoxide (CO) emissions than does conventional gasoline. However, because the addition of ethanol to gasoline increases Reid vapor pressure, gasohol produces higher evaporative emissions than gasoline — an undesirable characteristic in areas where ozone levels are high.[9]

At the state level, the trend is away from providing special tax treatment for gasohol. Between 1985 and 1990, 15 states repealed or began a phase-out of their gasohol exemptions. As of 1990, only 11 states exempted gasohol from all or part of the state per-gallon motor fuel taxes, and gasohol was actually consumed in only eight of these states.[10] The Road Information Program (TRIP) reported state revenue lost as a result of gasohol exemptions was only $30 million.[11] Because fuel taxes in states where gasohol is used are relatively high, the average per-gallon state tax applied to gasohol is 18.1 cents per gallon,[12] slightly higher than the corresponding averages for gasoline and diesel fuel.

Diesel Fuel Tax. As of December 1991, per-gallon state taxes on highway diesel fuel averaged 19.1 cents (weighted average). The federal tax was increased from 20.1 to 24.4 cents per gallon effective October 1, 1993. Of this amount, 17.5 cents goes to the Highway Trust Fund, 0.1 cent to the L.U.S.T. Trust Fund, and 6.8 cents to deficit reduction.[13] The federal tax rate on diesel fuel has exceeded the tax rate on gasoline by 6 cents per gallon since 1984, when this "diesel differential" was enacted in return for reducing a then-pending increase in the heavy-vehicle use tax.

Number 2 distillate fuel oil has significant uses as highway diesel fuel, as Number 2 home heating oil, and in various industrial and agricultural applications. The federal diesel fuel tax is paid when this fuel is intended for highway use, but it is not paid on fuel sold for nonhighway uses. It has proven difficult to assure that fuel on which the highway tax has not been paid is not used for highway purposes. One estimate is that tax is not collected on 10 percent to 20 percent of diesel fuel used for highway purposes.[14]

The collection of the diesel fuel tax by individual states is complicated by the number of diesel-fueled trucks that regularly operate between states and the large fuel tanks with which these vehicles are equipped. Operators of these vehicles can easily purchase most or all of their fuel in states where the fuel tax is relatively low and little or none where it is high. To guarantee that a fair share of this tax is paid to all states in which these vehicles operate, a complex system of fuel tax reporting has been developed.

Liquefied Petroleum Gas. The fuels that are now classified as "alternative" highway fuels include one fuel, liquefied petro-

leum gas (LPG), that has long been used for a modest amount of highway travel and several others that have become of interest in recent years. For tax purposes, LPG and most of the other alternative fuels are classified as "special (motor) fuels" by many states, a category that also includes diesel fuel in some states.

LPG contains only about three-quarters as much energy per gallon as does gasoline. Accordingly, some states tax LPG at a lower rate than gasoline. However, the federal government and most states apply the same rate to both fuels. As of December 1991, 44 states and the District of Columbia applied a per-gallon tax on highway LPG, averaging 13.3 cents (weighted average), and 13 states charged an annual fee on LPG-powered vehicles.[15] The federal tax on LPG used by highway vehicles is 18.4 cents per gallon.

LPG has significant nonhighway uses. Accordingly, collection of the tax on LPG is difficult, though the relatively small amount of LPG currently used results in this problem being of less immediate concern than collection of the diesel fuel tax.

Methanol and Ethanol. Other liquid alternative fuels include methanol and ethanol, usually mixed with gasoline in an 85:15 ratio (and called M85 and E85, respectively). These fuels contain appreciably less energy per gallon than gasoline (nearly 30 percent less for ethanol, more than 40 percent less for methanol), and so it would be appropriate to tax them at a lower rate. The federal tax on these fuels is slightly lower than the tax on gasohol. For methanol, the tax is 7.1 or 8.1 cents per gallon, depending on whether or not the alcohol is obtained from natural gas; and for ethanol, it is 7.1 or 8.7 cents per gallon, again depending on whether or not the alcohol is obtained from natural gas (though ethanol is almost never obtained from natural gas).[16] These liquid alternative fuels are or would be produced primarily for use in motor vehicles and so could be taxed in much the same way as gasoline.

The federal tax code also applies a tax reduction of 6 cents per gallon to gasoline when it contains 10 percent methanol,[17] and to diesel fuel when it contains 10 percent alcohol derived from biomass.[18] The mixtures of methanol and gasoline and of alcohol and diesel fuel are not currently being used, but could be fuels of concern in the future.

Natural Gas and Electricity. Natural gas and electricity are nonliquid alternative fuels that are of substantial interest both as clean fuels and because they can substitute for significant quantities of imported petroleum. Because of the many existing uses of these fuels, collection of a separate tax on these fuels when they are used for highway purposes is complicated. Several states charge in-state vehicles that use natural gas an optional or mandatory annual fee instead of a fuel tax, while others levy a per-gallon fuel tax on compressed natural gas (CNG).[19]

The tax complications caused by CNG and electrically powered vehicles are due to the widespread distribution of natural gas and electricity. A natural gas compressor could very easily be available to households, and electric outlets are already available to households. Metering on the vehicle itself might be required to monitor consumption of these fuels for highway purposes and to collect the taxes based on consumption. The individual vehicle owner, rather than the major fuel distributor, would become the party remitting the tax due. This might result in a need to monitor use of fuel by a meter on the vehicle, and perhaps in a need to tie the CNG or electric fuel tax to the registration transaction. Alternately, a mileage meter could be the primary basis for taxation of these vehicles.

Sales and Gross Receipts Taxes. The application of sales taxes levied on an *ad valorem* basis to motor fuels varies widely. The sales tax may be applied to the retail price of fuel including the state and federal per-gallon fuel taxes, excluding the per-gallon taxes, or including the federal tax but excluding the state tax. In some states, the sales tax is applied only to fuel that is exempt from the per-gallon tax; and in some states, the sales tax applies only to certain types of motor fuel.

Liquid-Fuels Inspection Fees. Seventeen states charge fees for inspecting liquid fuels. These fees are usually nominal. In only two states are they higher than 0.25 cents per gallon: 1 cent in Tennessee and 2 cents in Alabama.

Petroleum Release Fees. As of the end of 1990, seven states imposed fees of 0.2 to 1.0 cents per gallon on motor fuel sales to cover the costs of remedial actions required as a result of petroleum releases.[20] These fees are likely to become an increasingly popular source of funds for such remedial actions.

Fees for Retailer and Wholesaler Licenses. Most states require wholesale distributors and retail dealers of motor fuel to be licensed or otherwise registered. Most charge a relatively nominal license fee, and some deposit the proceeds into the state's highway or transportation fund.[21]

Fees for Fuel-Use Licenses. As discussed previously, most states subject heavy trucks that operate in more than one state to fuel-use reporting. Most states require fuel-use licenses for such vehicles and many charge a fee for these licenses.[22] The fees are generally nominal but, along with a fuel-use bonding requirement imposed by several states, they have been a source of irritation to motor carriers that operate in multiple states.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication.

All motor fuel taxes together should be considered as adequate sources and as appropriate for dedication.

Taxes and Fees Related to Vehicle Activity

Mileage Taxes. Several states levy taxes on the number of miles traveled by heavy vehicles within the state. These taxes are sometimes called "third structure" taxes, in comparison to first structure taxes (registration fees) and second structure taxes (fuel taxes).

The most common form of current mileage taxes is the weight-distance tax (also called a weight-mile or ton-mile tax).

The rate at which this tax is levied is based on registered gross vehicle weight (GVW). Weight-distance taxes have been designed to reflect the effect of distance traveled on cost responsibility and (somewhat imperfectly) that of weight on cost responsibility per mile. The administrative and compliance costs of weight-distance taxes can be modest as a proportion of revenue when applied only to vehicles on which the tax rate is reasonably high. The costs become more significant for taxes applied at lower rates. Evasion rates for existing weight-distance taxes have been estimated by one source to average about 10 percent.[23]

A variant on the weight-distance tax is the axle-weight-distance tax. In 1989, Oregon adopted an axle-weight-distance tax into its fee schedule for divisible-load permits for vehicles regularly operating at GVWs above 80,000 pounds. Under the Oregon "axle-weight-mile" system, the permit fee depends on both registered GVW and number of axles. For a given GVW, adding axles results in reducing the tax rate. As pavement costs are extremely sensitive to axle loadings, the Oregon fee structure or other axle-weight-distance tax allows a better matching of tax rates to actual cost responsibility than does a conventional weight-distance tax, with a corresponding increase in equity and economic efficiency. The determination of the tax rate to be applied to a given vehicle (required only in Oregon when a permit is requested) is more complex than for the Oregon weight-distance tax, but administration and enforcement are otherwise essentially the same.

Tolls. Toll facilities are now operated in 35 states.[24] Forty-two toll bridges are privately operated, and private toll roads are being built in Virginia and California.[25] As Table 9 indicates, tolls provide less than 5 percent of state highway revenues. Tolls are commonly based on the number of axles and distance traveled. Passenger car tolls now average about 4.4 cents per mile,[26] but there are substantial variations based on local conditions and policies.[27]

Bond indenture agreements dedicate the tolls or other revenues to the payment of principal and interest on the revenue bonds. In some cases, tolls yield substantial excess revenue after paying the principal and interest and the costs of operating and maintaining the toll facility. The excess toll revenues are used by some agencies as a source to fund other programs. Significant excess toll revenues now accrue to many agencies in northeastern states. However, it is considered unlikely that there will be many new toll projects around the United States that would generate substantial excess revenues.

The advantage of using tolls is that additional revenue can be raised for other priority projects and that the financing of toll roads through bonds allows additional projects to be implemented sooner than with pay-as-you-go financing. Potentially, tolls can be used for congestion pricing. The feasibility of doing so can probably be increased with widespread use of AVI systems for toll collection.

The disadvantages of toll roads are the high cost of borrowing capital; lost time, increased fuel consumption, and emissions at toll barriers; restricted availability because of the distance between access points; the high cost of collecting tolls (an average of 22% of gross revenue); and the fact that because users also pay federal and state motor fuel taxes, they are subject to a form of double taxation.[28] The toll collection costs and the user's lost time and increased operating costs at toll barriers can be reduced substantially by use of AVI technologies for toll collection.

Oversize and Overweight Permit Fees. All states have special rules that apply to the movement of loads that are oversize and/or overweight. These include both safety requirements and rules for spreading the load over extra axles to minimize the damage to pavement and bridges. Routes to be used may have to be approved in advance, particularly in the case of very heavy loads and those that will not fit under some bridges and other structures with limited clearance.

Several states issue permits for the routine operation of vehicles carrying divisible loads at weights that exceed the state's normal weight limits. These permits generally are issued for periods of time up to one year. Fees for these permits usually consist of an administrative fee plus a fee based in part on the maximum GVW at which the vehicle will operate. In states with a weight-distance tax, the latter fee takes the form of a weight-distance tax or, in Oregon, an axle-weight-distance tax. In other states, the fee is similar to a registration fee and does not reflect cost responsibility.[29] In such states, revenues could be increased by adopting a fee structure that reflects cost responsibility.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication

Mileage-related fees are potentially adequate and appropriate for dedication. VMT fees should be set by vehicle type based on cost responsibility. Consideration of pavement-damage fees and other highway-related costs should be incorporated into the establishment of any type of VMT fee.

Externality and Related Fees

Emissions Fees. Emissions fees, also called smog fees, have been proposed in California as a way of internalizing the cost of vehicle emissions and thus providing economic incentives for reducing these emissions. These fees are currently being studied by a multiagency group set up by the California Air Resources Board (CARB).

In its most general form, an emissions fee might be a monthly, quarterly, or annual tax on VMT charged at a rate determined by a vehicle's emissions of nitrogen oxides, hydrocarbons, carbon monoxide, and carbon dioxide. An emissions fee collected in proportion to VMT is of course a variation on a VMT fee, with rates based on emissions characteristics and mileage. Emissions fees might provide economic incentives for reducing VMT, for purchasing low-emissions vehicles, and for proper maintenance of the emissions-control system. One estimate suggests that, if fees are set on the basis of health and damage costs per unit of emissions, the annual fee per vehicle might range from $5 to $1,000 with an average of about $125.[30]

Most California proposals presume the use of odometer readings taken at the time of emissions inspections — a procedure that could permit evasion by means of odometer tampering. The means of reducing opportunities for tampering would include sealing odometers or using additional measuring devices, such as hubodometers or emissions meters, which were also sealed

or nonremovable by the owner. Alternative proposals that do not require the use of VMT data include environmentally indexed registration fees and sales taxes based on the vehicles' emissions characteristics.

Under the California proposals, increases in net revenues due to emissions fees would be applied to mitigate impacts on low-income drivers, to subsidize transit or ridesharing programs, and to support other environmental programs. However, there is no intrinsic reason why a significant share of any increase in net revenues should not also be used for highway programs.

Energy Taxes. Various forms of energy taxes have been proposed to provide an economic incentive to reduce energy consumption, to reduce dependence on imported oil, and/or to reduce the deficit. The Energy Information Administration (EIA) recently completed a study of the effects of four versions of the most frequently proposed types of energy taxes:[31]

- Motor Fuel Tax—An increase in the federal tax on gasoline and highway diesel fuel of up to 50 cents per gallon.
- BTU Tax—A tax of up to $1 per million British Thermal Units (BTU) on all energy sources applied at the point of production or import.
- Carbon Tax—A tax on all fossil fuel applied at rates that are (at least roughly) proportional to their carbon content. The rates would be designed to yield the same revenue as would a corresponding BTU tax. The tax would be applied at the point of production.
- Ad Valorem Tax—A tax of up to 15 percent on all energy products imposed at the point of final sale.

Although the basic purpose of the four taxes is to reduce energy consumption by increasing energy prices, only the BTU tax would apply to all energy sources in proportion to their energy content. The *ad valorem* would be greatest for high cost energy, such as electricity. The carbon tax would apply only to fossil fuels and would be based on the carbon content of the fuel. The purpose of making tax rates proportional to carbon content is to reduce production of carbon dioxide—the most common of the so-called "greenhouse gases" that are believed to be causing global warming. A motor fuel tax could apply only to highway fuels, or to all transportation uses of gasoline or diesel fuel.

All four of these taxes would result in an increase in motor fuel tax rates. If none of the revenue is used for highway or transit purposes, these taxes would reduce the productivity of existing dedicated motor fuel taxes by both reducing vehicle use and promoting fuel efficiency, while reducing highway needs to a lesser extent because of the reduction of vehicle use.

Congestion Pricing. Congestion pricing, in its purest form, would provide for fees to be levied on highway travel based on the costs imposed on all travelers, including other users, as a result of the particular trip being made. Congestion pricing is advocated to promote economic efficiency, because with proper application those trips imposing more costs than they are worth to the traveler would not be made, thus reducing the overall costs of travel to the society.

A previous estimate of the revenue impacts of congestion pricing, applied to all highways in the United States, was that congestion pricing could yield revenues of $210 billion per year, at pricing levels ranging up to 50 cents per mile for travel on the most congested facilities.[32]

Congestion pricing could be approximated by peak period toll surcharges, parking taxes, or pricing of entry into downtown areas. Area pricing is currently applied to a small part of the city-state of Singapore. Payment of a fee is necessary to allow entry to (and now, also exit from) the Singapore central business district at peak level periods.

Concerns about congestion pricing center around the perceived inequity of taxing lower-income people off the streets, high administrative and enforcement costs, and the unfamiliarity of the concept in the United States. Congestion pricing is now being seriously considered in several cities, including the urban areas of San Francisco, Los Angeles, and Portland (Oregon).

Pavement-Damage Fees. Pavement-damage fees have been advocated as a means of charging for heavier axle loads and their impacts on pavement costs. Pavement-damage fees would be based on the estimated impact of axle loads on pavements. They would encourage the use of additional axles to spread the loads and thereby to reduce pavement damage, and would also act to shift loads to configurations that cause less pavement damage. Oregon's "axle-weight-mile" system of permit fees discussed above is a limited form of payment-damage fee.

Other Externality Fees. Fees for other externalities could also be assessed. These could include fees to cover costs due to noise; the disposal of consumed items, such as autos, batteries, tires, and petroleum wastes; or visual pollution. Examples of such fees cited under the discussion of fuel taxes include the federal leaking underground storage tank fee and similar petroleum release fees imposed by several states. Fees for these types of externalities usually would be set to cover costs to correct for the externalities, and not to provide general transportation revenues. However, in some cases, they might provide revenue for activities (such as the construction of noise barriers) that now are being undertaken with transportation funds.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication

Congestion fees, emissions fees, and pavement-damage fees might be adequate and appropriate for dedication, if applied on a widespread basis. Carbon taxes, BTU taxes, and *ad valorem* energy taxes can provide adequate revenues, but might not be dedicated to surface transportation, at least not as they generally have been proposed in the past.

Transit Charges

The average share of transit operating costs paid for by users through fare revenues has stabilized recently at about 40 percent, although there are very substantial variations among transit systems. States and localities use a variety of other revenue sources

to support transit, with general revenues and dedicated sales taxes being the most important. Until recently, federal aid provided a large portion of the capital expenditures made on transit systems. However, larger shares of transit capital expenditures are now coming from state and local sources than from federal assistance. These expenditures are supported by a variety of state and local funding sources.

Federal revenue used for transit was derived entirely from general revenues until passage of the Surface Transportation Assistance Act of 1982. That Act established a Mass Transit Account within the HTF. The account received 1 cent per gallon from the federal tax on motor fuel until 1990, when it was increased to 1.5 cents.

Transit user fees are likely to remain fairly close to today's levels, in dollars adjusted for inflation. Most transit agencies periodically adjust fares in response to inflation and general cost increases. Transit user fees will probably continue to support between 30 and 50 percent of transit operating expenses and, under any likely scenario, these fees will not be made available for other uses.

Transit agencies that have established dedicated revenue sources have achieved greater stability of revenues than those without dedicated funding. Sales taxes have been the dedicated source of funds that has provided the most revenue from regional and local sources. States have provided funds from a range of fuel taxes, other sources, and substantial amounts of general revenue for aid to transit systems.

Efficient road pricing could have implications for transit pricing, which could be changed along with road pricing as part of overall efficient pricing programs. Peak period pricing of transit fares has been used in some urban areas. Some proposals have been made to link road pricing revenues with expenditures for transit to assure mobility for those "priced off" the highways.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication

Transit fares are clearly appropriate for dedication but cannot replace motor fuel taxes. They should be considered as an important source for supporting portions of surface transportation programs.

Other Highway User Fees

Other taxes and fees paid by highway users include fees for drivers' licenses, motor-carrier gross receipts taxes, and fees for record checks and other miscellaneous transactions. These are not candidates to replace major portions of motor fuel tax receipts, although they are useful as revenues to cover the costs of providing the services involved.

Nonuser Fees

Funding of transportation systems from nonusers can come from two types of sources: (a) fees or assessments on landowners and other nonusers who benefit from the transportation system, and (b) general revenue sources.

Nonuser Fees and Assessments Tied to Benefits

Transportation investments generate substantial benefits that may be associated with nonusers. The construction and maintenance of highway and transit systems, as well as waterways, airports, and rail systems, often provide major benefits to landowners. Improved access (e.g., transit stations, airports, freeway interchanges, new bridges, and arterials) enhances desirability for such diverse uses as warehouses, office buildings, factories, shopping centers, theme parks, and residential developments.

Market forces will tend to create incremental benefits from major transportation improvements that can be capitalized in the increased value of land. This increase in land values can be considered a "windfall" to be reaped by those owning land with improved access. Such access is often eagerly sought by developers who lobby for transit stations, interchanges, or improvements to arterials.

Also, substantial investments in local roads are made to permit their occasional use by heavy vehicles such as fire trucks, sanitation trucks, utility trucks, school buses, and construction vehicles. These vehicles impose costly requirements for pavement strength and geometry (e.g., road widths and turning radii) over and above those necessary for use by personal vehicles. Because such vehicle types may be exempt from most or all user charges, it is impractical to recover such costs from these vehicles. The benefits of providing access to such types of vehicles also accrue to the property owners.

In recognition of these types of benefits, various transportation agencies have required landowners, developers, and/or future users to share in the costs of new transportation investments through various fees and other devices. These devices generally are most appropriate for funding individual transportation projects whose nonuser beneficiaries are readily identifiable rather than being a general source of funds for a transportation system. Projects to be financed in this way are local in nature and therefore are likely to be used by a local government rather than a state.

There is no limit to the ingenuity of government officials, landowners, and developers in structuring creative arrangements. The following are some of the most common arrangements.[33]

Concessions. In many circumstances, state and local officials seek a variety of concessions from landowners and developers, and the developers seek a variety of concessions from the governments involved. Developers seek commitments of public sector infrastructure, including parks and schools, as well as transportation investments, tax concessions, and procedural commitments, such as speed in approving required permits. State and local officials seek concessions such as contributing land for public improvements, financing transportation or other infrastructure, hiring local residents, and using developer or employer programs to encourage transit or high-occupancy vehicle use.

The resulting arrangements are typically tailored to individual situations. In some cases, the developer may make extraordinary commitments to transportation finance but may in return be excused from normally required contributions elsewhere (e.g., water and sewer connector charges). But the balance can involve the reverse set of concessions, with governments providing transportation capacity at no charge while developers provide

concessions in other areas, such as building schools. There is thus no certainty in relying on negotiations over concessions.

Impact Fees and Exactions. In most states, local governments have the authority to require that subdividers and developers provide some or all of the public infrastructure needed to support their activities. In several states, local governments collect impact fees to cover part or all of government's cost of providing this infrastructure. They frequently are based on the size of the development (number of square feet, number of units, etc.), but they have also been based, in part, on the developer's profits.[34]

In areas experiencing strong growth, impact fees and exactions are an effective means of requiring developers and subdividers (and ultimately their clients) to pay for the costs of providing required roads and other infrastructure. By causing the internalization of these costs, these fees and exactions promote economic efficiency by inhibiting developments that cannot pay for the public costs they create.

Special Assessments. Special assessments are charges imposed on owners of property to pay for government programs designed primarily to benefit the owners of that property, such as the construction of roads serving previously underdeveloped areas, or the expansion of the road system serving rapidly growing areas.

Special assessments are used to pay for infrastructure development and other governmental activities that are designed to benefit a class of property owners, whereas impact fees are used to enable government to provide infrastructure required by the planned activity of some property owner. Special assessments thus can be applied to a somewhat broader range of situations than impact fees. Also, impact fees depend on government's regulatory power, while special assessments depend on its power to tax.

In concept, individual assessments should be distributed across property owners in proportion to benefits from the program. However, to avoid subjective evaluation of benefits, a simple formula is usually used (e.g., a specified percentage of assessed value).

Value Capture Tax Increment. Value capture tax increments have been used as a means of enabling the public sector to share in the increased property values created by a public project such as a new road or transit line. Sales of property are subject to a special tax designed to capture a significant portion of the appreciation attributable to the project. An accepted formula must be specified in advance for calculating the portion of appreciation due to the transportation project.

In concept, this form of tax can be viewed as a type of special assessment in which the assessment does not become due until property changes hands. In the case of a project that has a very large effect on property values, it is possible for total tax revenue to exceed the full cost of the project including interest costs. The disadvantage is that revenues are realized only on the sale of the property in question.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication

These are highly appropriate fees to dedicate to transportation at local and regional levels. It would be difficult for the states or the federal government to substitute such sources for fuel taxes, however, as they are most appropriate to the solution of particular problems of local or smaller areas, and funds from these sources could not be spread flexibly across state or federal programs. Although all these sources taken together can be extremely important to transportation finance, it is at the state and federal levels that substitutes for fuel taxes are being examined.

General Revenue Sources

User charges are the predominant source of highway funds at the federal level and in most states. However, local governments, transit agencies, and some states rely on many general revenue sources to support road and public transportation programs.

There is no inherent reason why government revenues generated from particular general taxes (e.g., sales, income, or property), special excises (liquor, hotels, insurance), or other revenues (e.g., interest earnings, lottery profits) cannot be used as a transportation revenue source. Advocates of particular programs (e.g., libraries, transit, highways, health, public schools) periodically seek earmarking or appropriation of general fund resources or specific tax sources. Where the rationale exists for general purpose tax revenues to be devoted to transportation or other functions, there is, by definition, little appropriate interest in the precise form the revenue raising should take on the part of those interested in the particular function.

In transportation, as in other fields, there has been nearly endless discussion and debate of the extent to which general fund resources should be used to supplement user charges. In transportation, this discussion often focuses on "nonuser benefits." The same concept is used as a framework for discussing general fund support of other programs, but the vocabulary differs.

Arguments are periodically made that particular chunks of general revenue fund sources should be earmarked for transportation (or other functions). In those circumstances, the transportation interest is in the adequacy of the amounts claimed using the same criteria discussed elsewhere in this report (e.g., stability of revenues, responsiveness to inflation, growth over time). The relative attributes of one revenue source over another (e.g., cigarette tax vs. income tax) can be evaluated in these terms. However, as a practical matter, earmarking of revenue sources totally unrelated to transportation use (e.g., a general personal income tax or an alcoholic beverage tax) is more a matter of the politics of competing claimants than the economics of appropriate financing.

A case is sometimes made that a particular revenue's being used for general purposes is an appropriate source of transportation finance because it has some aspect of a user-charge or benefit assessment. The primary cases are these:

- *Selective Excises.* Distinct from general sales taxes, excise taxes are often levied on particular goods and services. Some, like the federal excises on tires and the state vehicle transfer

taxes, are already earmarked for transportation and were discussed above. State excises have been used to defray tire disposal costs and might arguably be imposed for transportation programs, as might excise taxes on a variety of industries involved in transportation.

- *Sales Taxes.* General sales taxes can be, and sometimes are, assessed on purchases of transportation: fuels, vehicles, repair parts, consumables like oil, and repair services. However, except for the special sales or transfer tax imposed on vehicles by some states or localities, revenues from these taxes generally are considered to be general revenues. Making sales taxes more selective can strengthen the potential to earmark them for transportation purposes. The one dedication of general local or regional sales taxes that has become very useful for surface transportation is the dedication of some portions of sales taxes (1 cent, 0.5 cent, 0.25 cent) to public transportation.

- *Severance Taxes.* A number of states levy severance taxes on producers of coal and other specified minerals and, in some cases, timber as compensation for removing ("severing") the states' natural resources. Several states dedicate a portion of the proceeds of these taxes to highway finance. Frequently, this revenue is for use only in the county of origin and/or for maintaining the roads used by the mineral and timber haulers. However, Montana and Wyoming deposit significant amounts of revenue from these taxes into their state highway funds.[35]

- *Personal Property Taxes.* Some states and local jurisdictions levy personal property taxes on highway vehicles, boats, and other items. The proceeds from these taxes usually are treated as general revenue. While phrased in general terms as applicable to personal property taxes other than real estate, in practice many personal property taxes are incident predominantly on highway vehicles. A case thus exists for dedicating or allocating the proceeds to transportation purposes.

- *Real Property Taxes.* Local governments rely on real property taxes for a large proportion of their revenues, including revenues to support highway and mass transportation programs. Normally, general real property taxes are not dedicated to transportation, although there are jurisdictions that dedicate some portion (a millage rate) to transit or highways. Highway finance studies often have made the argument that the provision of access to property is a nonuser benefit justifying the dedication of such funds for a portion of highway programs.

- *Income Taxes.* Income taxes are virtually always general revenues for all levels of government imposing them. Opportunities to dedicate income taxes to surface transportation should be considered limited, although the case might be made that income taxes from transportation industries should be used for transportation purposes.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication

These general tax sources available to local jurisdictions can provide adequate revenues for meeting local and regional transit and highway program needs, but are generally not applicable to broader state or federal transportation programs.

Debt Financing and Private Ownership

Unlike the funding sources discussed above, debt financing and private ownership are means of financing transportation investments but are not revenue sources. These finance tools can be used only in conjunction with other sources of funds discussed above. The primary advantage of these tools is that they allow transportation facilities to be paid for by revenues that are not obtained until after completion of the facility and that (in the case of tolls) can be generated partly or entirely by the facility itself. These two types of finance mechanisms are discussed below.

Debt Financing

Debt financing commonly is used to finance major capital development programs, particularly for projects expected to generate revenue that can be used to retire the debt. Revenue bonds are the most common form of financing for toll roads.

The other major category of debt financing consists of general obligation bonds. These bonds become a general obligation of the government that issues them. Funds used to repay these bonds may come from any combination of tolls, dedicated taxes and fees, and general revenues.

Another type of debt financing that has attracted some interest consists of tax increment bonds. These are bonds that are issued to support a public development that is expected to increase property assessments and so to increase tax revenue. These bonds are supported by a pledge of the increased revenue resulting from the project. A primary advantage of this form of financing is that it enables local jurisdictions to issue bonds without the approval of referendum that may be required for general obligation bonds.

As Table 9 shows, bonds provided about 10 percent of state highway funds in 1992. Slightly over one-quarter of this money was used for toll facilities, with the remainder used for constructing other state and local roads.[36] For the toll-road bonds, in 1990, 89 percent of the funds required for debt service (excluding funds from newly issued bonds and investment revenue) came from tolls, 10 percent from highway user revenue, and 1 percent from other sources (primarily general revenue). For other bonds, 89 percent of these funds came from highway user fees and the remainder came from other tax sources.[37]

Private Ownership

Private development of a transportation facility is feasible when the facility has the potential to generate enough revenue to provide a competitive financial return to investors in the

development or when a public agency is willing to provide a sufficient subsidy to make the investment attractive.

In the case of highways, the primary potential private sources of revenue are tolls, appreciation in the value of surrounding property, or both. If these sources of revenue are not sufficient, and there is a clear public purpose in the project, public funds could pay a portion of the cost, either up front or over a period of years. An alternative to a privately operated toll road is the lease of a privately built facility by a public agency.[38] Situations in which private development of a road may be appropriate are

- if a private company could build a facility more quickly and less expensively; or
- if a developer is willing to pay the cost of the improvement because of the effect it will have on the value of the property he or she owns.

It should be noted that, even in the second case, there is no necessity that the road be constructed privately—a government agency can build a road with the assistance of impact fees from or special assessments on the private developer. Even if a road is financed entirely with private funds, public participation may be needed in the planning process and/or in the use of eminent domain for right-of-way acquisition.

Preliminary Evaluation of Adequacy and Appropriateness for Dedication

Debt financing and private ownership can be useful adjuncts to major user charges but do not promise to provide adequate revenues or to be appropriate for dedication by the states and the federal government. They are very appropriate at local and regional levels as alternatives to local or regional fuel taxes.

2.4 CRITERIA FOR EVALUATING TAX ALTERNATIVES

This section provides a description of the criteria applied in this research to evaluate alternative revenue sources. The criteria provide the basis for evaluating alternative tax sources in the structured framework in Chapter 3.

The criteria have been developed through a comprehensive review of general studies of taxation and a review of experience with transportation taxes. Appendix B describes how each of the criteria has been applied in most of the general studies of state taxation over the last two decades.

The perspective of this chapter is comprehensive in that it is based on the best of current practice in the general field of taxation and public finance. Transportation finance studies have normally been more limited in the criteria used in evaluating tax alternatives. However, there are important reasons for beginning with a comprehensive approach in this chapter. Transportation program decision making is increasingly being integrated with comprehensive state and national economic program decision making. Greater attention is being paid in transportation program administration to economic development, environmental, livability, and economic efficiency goals. We anticipate that trends will continue in this direction.

Nonetheless, many transportation finance studies may continue to emphasize the criteria that have been in most common use—i.e., the adequacy of the revenue generated and the equity of the tax structure in relation to the costs occasioned by different classes of highway users. For this reason, the framework presented in Chapter 3 and applied in evaluating tax alternatives emphasizes these criteria while giving appropriate attention to other factors.

Criteria are a necessary element of decision making on important questions such as revenue options. Even when explicit criteria for decisions are not stated, criteria are implicit when current systems or proposals are criticized as having "problems" or "disadvantages." Statements of problems (such as, "the current tax system won't raise enough money") contain implicit criteria (such as, the system should raise enough to fund current services in an inflationary environment, or the system should cover enough to fund current activity plus Investment Plan A).

Some criteria may involve tradeoffs with others and some criteria ultimately involve political questions. As a New Hampshire tax study report put it:[39]

> Any discussion of the appropriate revenue system . . . should ideally make clear the basis for selecting one set of tax instruments over another and for selecting a particular form of each tax. . . . The process of determining the appropriate fiscal goal . . . is an inherently political one, especially since . . . the goals are often in conflict. Nevertheless, when a legislature makes the political decision to alter its revenue system, a set of criteria or guiding principles is needed by which to make policy choices.

The criteria used for selecting criteria for evaluating revenue alternatives include (1) appearance in the public finance academic literature, (2) use in past studies of revenue alternatives in policy-oriented reports of tax study commissions or similar groups, and (3) use in past assessments of transportation revenue alternatives.

The evaluation of taxation alternatives in Chapter 3 involves applying the criteria that have been developed from a review of both the general public finance literature and practice and the transportation finance literature and practice.

The use of criteria from general tax studies has some potential disadvantages. (1) It does not provide criteria specifically oriented toward selection of transportation revenue sources as distinct from general revenue sources, and (2) it is harder to implement than simply developing a unique set of criteria for this project.

However, using generally accepted criteria has several strong advantages. (1) Readers are more likely to begin from a starting point for analysis that they have seen before; (2) the acceptance of the resulting analysis is likely to be enhanced; and (3) the potential errors are minimized. More precisely, this approach produces widely accepted, time-tested criteria, reflecting decades of assessments of options under political combat conditions. While using such criteria does not guarantee acceptability of particular transportation financing options, it does put them in a framework in which financing proposals have regularly been adopted.[40]

General Categories of Criteria

Four general categories of criteria are used, each of which can be broken down into several specific criteria. The four are

- adequacy;

TABLE 10. Criteria and other issues

Adequacy
Yield in Relation to Need, Uses, and Investment Requirements
Responsiveness to Inflation
Stability of Revenues over Time
Potential for Needed Increases
Equity
Costs Occasioned
Ability to Pay and Benefits Received
Equity Among Types of Economic Activity
Equity by Geographic Area
Equity in Perception and in Fact
Efficiency
Bringing About Better Decisions on Travel and Investments
Paying Costs Imposed on Others
Creating Disincentives for Undesirable Activities
Economic Growth
Simplicity
Administrative Cost
Compliance Cost
Enforcement Cost
Evasion
Additional Issues of Concern
Public Understanding and Support
User Charge Rationale
Earmarking Revenue to Unrelated Purposes
An Old Tax Is a Good Tax
Accountability
Potential to Get Out of Hand
Exportability
Federalism
Process Criteria
Finance Decision and Spending Criteria

- equity;
- efficiency; and
- simplicity and effectiveness.

These are not all categories that are generally considered and well understood in the transportation taxation field, so an explanation is provided below for the transportation finance concerns that are covered within each of the four categories.

Table 10 lists the specific criteria and other issues that should be considered under each of the four categories, plus an "additional issues of concern" category, with considerations that are generally not considered to be evaluation criteria. These deal less with the substance of the impacts and more with perceptions and processes, such as perceived acceptability, and the probabilities that political forces would cause changes.

The proposed criteria closely coincide with criteria used in the most recent comprehensive state tax study performed for the widely respected Select Committee on Tax Equity in Texas. That blue-ribbon group initially identified nine criteria (adequacy, equity, efficiency, stability, economic competitiveness, simplicity, balance, breadth of the tax base, and intergovernmental linkages) to guide its work. By the time it filed its final report, it concluded that "these criteria can be collapsed into the following categories: adequacy, equity, economic efficiency, and simplicity."[41]

Although the vocabulary differs slightly, the four proposed criteria also coincide with a 1992 tax study in Alabama[42] that seriously considered an overhaul of the tax system. The entirety of its discussion of criteria appears below:

> Tax and fiscal policies should be based on several principles: fairness; simplicity; neutrality; and effectiveness. Fairness requires that taxpayers in similar situations should be treated similarly and that taxpayers who are less fortunate should bear less of the tax burden than those who are more fortunate. Simplicity makes it easy for taxpayers to comply with the law, for businesses to plan, for the state to administer, and for citizens to understand the system so that they know that others are also paying their fair share of the taxes. It is important that the system be neutral so that taxpayers can decide where to conduct business, what to invest in, and what to consume without tax considerations being dominant. Finally, it must be kept in mind that the principal purpose of a tax system is to raise revenue to provide essential public services.

All highway taxation studies consider adequacy and equity. Concern with economic efficiency is more common in the academic literature on transportation finance, although it has been used to a limited extent in transportation finance studies. Simplicity, or administrative and compliance costs, is not generally a criterion identified in transportation finance literature. However, highway finance studies often have been concerned with administrative costs, compliance costs, and likely levels of evasion. These latter concerns are part of the simplicity category, but they are sometimes considered to be part of the equity criterion.

In a description of cost allocation studies,[43] the U.S. Department of Transportation (DOT) discusses three objectives of cost allocation: equity, efficiency, and cost recovery. These are comparable to the three criteria of adequacy, equity, and efficiency used in this report. The DOT report does not deal with the fourth, simplicity, probably because most cost allocation studies focus primarily on changes to existing taxes, rather than on new types of taxes. Some state cost allocation studies, however, do address the costs of administering and enforcing different taxes.

Adequacy

Adequacy is the criterion of most concern to transportation administrators. Adequacy is determined by revenue yields in relation to funding requirements, the stability of revenue streams over time, the responsiveness of revenue yields to inflation, and the ease of revising fees or tax rates when needs increase.

The obvious test for a revenue source is whether it provides enough revenue. Adequacy in the highway field has traditionally been defined to be the revenues required to satisfy "needs," which are usually defined to be the costs of improvement, operations, and maintenance programs driven by accepted engineering standards. Most standards, however, are based on professional judgment rather than rational economic criteria. In a few of the more complex needs studies, engineering standards are varied to analyze the tradeoffs between them and total program costs (adequacy).

The academic transportation literature, in contrast, would implicitly define adequacy as the amount necessary for an investment program that maximizes net benefits to the economy. Unfortunately, we know of no example of an actual application of such a criterion in the surface transportation field, despite extensive literature supporting this approach in theory.

Efforts to make adjustments to fuel tax rates have frequently emphasized the insensitivity of the fuel tax to inflation losses.

After the rapid fuel price increases in 1973–74 and 1980, several states shifted to a percentage tax based on fuel price, but this approach proved to be untimely, because of subsequent declines in fuel prices. Legislatures have been reluctant to permit automatic inflation adjustments; they have preferred to require agencies to return from time to time to request increases.

The idea of "automatic" inflation adjustments raises the issue of what inflation rate should be used for adjustments. Linking the tax rate to highway cost indices at the state level could have the perverse effect of encouraging unproductive practices. Only Wisconsin has used an automatic per-gallon fuel tax formula. The formula is based on federal highway construction and highway maintenance and operations cost indices. This minimizes the argument that such indexing encourages unproductive practices.

Equity

Because the user charge principle is widely accepted in highway finance, the equity criterion is usually based on the allocation of cost responsibility among user groups, particularly vehicle classes. Considerable attention also has been paid in research studies to equity based on benefits derived by user classes, but no major studies have actually used this criterion. The types of taxes proposed for achieving equity also result in a greater emphasis on administrative costs and enforceability than in more general tax studies.

Less attention has been paid within transportation finance to issues of equity among persons of different income levels, although this is the major equity concern of the more general studies of tax systems. Because transportation taxes have generally been levied as user fees, usually there has been little concern with how impacts differ among industries. Because of the fact that highway user taxes are a small percent of costs, industry impacts have not often been an issue, except to the for-hire motor carrier industry. States frequently give tax breaks to important local industries such as agriculture or forestry, but these tax breaks are seldom based on criteria that are subjected to any analysis.

Equity among geographic regions recently has been cited as a reason for not raising motor fuel taxes at the federal level. The argument commonly is made that those who are more dependent on motor vehicles in rural areas would pay more in proportion to household income. However, this argument has not been subjected to analysis that distinguishes among various types of users in rural areas.

Efficiency

None of the many state highway cost allocation studies has used economic efficiency as a criterion. However, one major federal study[44] has, and there is general agreement in academic literature that user charges should be based on an efficiency criterion. Particular emphasis in this literature has been on marginal costs of vehicles' contribution to congestion and, to a lesser extent, their contribution to pavement wear and emissions. State studies have not been influenced by this literature, largely because of the difficulty of implementing the results of such an approach from both a technical and political perspective. This implies that the simplicity criterion is being used as a constraint in considering the efficiency criterion.

Almost all the literature in the highway field on economic efficiency deals with allocating costs among users rather than between users and general taxpayers. Little attention has been paid to rational criteria for allocating tax responsibility between users and general taxpayers in transportation programs.[45]

Although economic efficiency has long been a major criterion in academic literature, it is only now receiving serious attention by policy makers. Pricing is advocated for its potential to alleviate congestion, to make users pay for external effects of their use of highways, and to aid in determining what investments are warranted.

Neutrality is a term often used in general revenue studies and sometimes in transportation revenue studies. These studies argue that taxes should not distort free markets, but, ideally, should be neutral. This seems to conflict with transportation finance literature that emphasizes achieving greater economic efficiency through pricing. Both arguments are consistent because efficient user charges would result in a neutral tax structure in impacts on different users and thereby would improve economic efficiency in the use of highways.

Simplicity

The criteria that have been developed for evaluating highway taxes often give more attention to simplicity issues than is given in general taxation studies. A highway tax structure that satisfies the equity criterion requires a certain degree of complexity and can be relatively expensive from administrative, compliance, and enforcement standpoints. For this reason, highway tax studies sometimes distinguish evasion or enforcement costs as a major criterion distinct from that of routine administrative and compliance costs.

Fuel taxes and some other transportation taxes are often collected by government from establishments at the wholesale rather than the retail level. The higher up the distribution chain taxes are collected, the lower are the compliance and collection costs in two respects: (1) there are far fewer establishments to deal with, and (2) the opportunity for tax evasion is appreciably reduced with fewer sellers of untaxed products.

Where new taxes are introduced in transportation finance studies, the simplicity criterion is sometimes dealt with as a constraint on implementing certain types of taxes, such as weight-distance taxes. Studies of administrative, compliance, and evasion costs of weight-distance taxes have been conducted by AASHTO, FHWA, and others. These aspects of the simplicity criterion are issues of continuing debate between the motor carrier industry and transportation officials.

Additional Issues of Concern

This remaining category does not consist of criteria for evaluation *per se* but rather of issues that often are considered. These issues relate mostly to the political acceptability of tax or user fee alternatives.

It is possible to be so preoccupied with these factors that "studies" become little more than determining what decision makers want to do, and recommending it. This gives excessive

weight to preliminary positions of decision makers by failing to recognize their willingness, after hearing expert advice, to vary from original, less informed positions.

Public Understanding and Support

Some taxes are more acceptable to the public than others. There are enough polling data on taxes so that statements can be made about the characteristics that seem to add and subtract appeal. Other things being equal, perceived fairness is important. Fairness includes assuring that neighbors and competitors also are complying in tax system design.

"Improve perception of tax system's fairness" was an explicit criterion for transportation taxes in a 1983 AASHTO study.[46] Concerns over perceptions were related to alleged evasion by small independent truckers and recognition that unresolved arguments over cost responsibility of heavy trucks suggested that transportation taxes were likely to be perceived as unfair by someone.

To some extent taxes will be judged by how money is spent as well as how it is raised. No tax system will be judged to be fair if there is widespread perception that the money it raises is wasted. The Texas report reviewed in Appendix B presented this factor this way:

> The Texas fiscal system and related issues are poorly understood by taxpayers. One problem the Committee has encountered—and finds highly disturbing—is the widespread lack of understanding of the Texas state and local fiscal system, how it is financed and what it buys. For many Texans, the debate over state and local fiscal policies is being conducted in a shadow world of poorly understood policies and programs. In fiscal matters, complete public trust can only be built on complete public understanding.

There is considerable evidence from transportation bond referenda and from polls that taxpayers are far more supportive of taxes linked to specific construction projects, programs, or system plans than of tax measures that are vaguely committed to transportation programs in general.

User Charge Rationale

Other things being equal, user charges are more acceptable than unrelated taxes. The whole user charge philosophy in highways hinges on the relationship between the service provided and the fee for that service. It has typically implied a direct relationship between the vehicle, the use of a highway, and the tax. This concept has been bent over time, with more or less apparent acceptance from users. For instance, shifts of funds between areas, from urban to rural, from high-density to low-density states, and from highways to transit have seemed to find public support, particularly when such shifts are part of an adopted plan or program.

A recent survey of use of earmarking in state government[47] found that motor fuel taxes were earmarked to some extent in every state and that highway programs were the most common function receiving earmarked funding. The report's guidelines on when to earmark provide little guidance for specific situations:

> Earmarking is controversial, involving complex political and analytical issues. Common criticisms of earmarking include the allegations that it hampers budgetary control, leads to misallocation of resources, makes the revenue structure inflexible, and infringes on the policymaking prerogatives of the executive branch and the legislature. In contrast, earmarking is justified frequently on the grounds that it relates the benefits of government programs to their financing, assures a minimum level of expenditures and continuity for government functions, and induces the public to support increased taxes. The validity of these criticisms and justifications varies from situation to situation depending on the specific manner in which funds are earmarked.

Not only is there evidence of taxpayers' greater support for taxes directly linked with specific transportation improvements as noted above, but also there is considerable evidence that highway users will generally support increases in user fees earmarked for transportation programs. However, there is often resistance to the use of tolls as a form of double taxation, particularly if toll receipts are siphoned off for projects in other areas or if toll projects are being built in one part of a state or region but not in others.

Earmarking Revenue to Unrelated Purposes

The classic formulation of where user charges and dedicated revenue are appropriate is found in a New Jersey report reviewed in Appendix B. It criticizes the state constitutional requirement dedicating a portion of personal income tax revenues for property tax relief. It argues that such constitutional dedication of revenues "can distort budgeting and inhibit the flexibility of lawmakers to respond to changing needs or conditions." It concludes:

> The Commission is aware that some revenues, such as user fees, may appropriately be used to support a specific service or program. When these fees cover the full cost of the service, they may operate as an indirect pricing mechanism for those who enjoy the benefits of the service. In those instances where the connection between the benefits and the fee is clear, the Commission believes that the revenues may appropriately be dedicated to providing the service. The Commission recommends that the dedication be by statute rather than embodied in the Constitution so that budgetary flexibility is preserved.

An Old Tax Is a Good Tax

Because of transition costs associated with changing methods of taxation and windfall gains and losses from the change, economists have a saying that "an old tax is a good tax." The costs of change can be explicitly, though imperfectly, analyzed. In many tax studies, this criterion is called *certainty*. It is frequently linked with the criterion of stability of revenues.

A common problem is resistance to new forms of taxation by the tax collecting agencies. The only problems that would normally justify such resistance are those already considered as administrative costs, including staffing to collect the tax, revenue yield, and any lack of compliance that might arise early in the implementation of a new tax. However, resistance might also appear if the tax collecting agency perceived that its funding for tax collection might not expand to accommodate the new workload, making dilution of collection efforts for current taxes one cost of implementing a new tax.

The advent of alternative fuels and the prospect of having a myriad of taxation systems and new types of establishments involved in the tax collection process could generate this kind of reaction from taxing agencies.

Accountability

Many of the state tax studies address "accountability." The most common use of the term suggests a preference for a tax that is seen by the taxpayer rather than hidden, with increases in rates subject to explicit decision rather than automatic. A National Conference of State Legislatures report reviewed in Appendix B introduces accountability this way:

> The essence of accountability is that tax policy should be explicit. Hidden tax increases should be avoided. If government wants to increase the tax burden, this should result from explicit action rather than an automatic process. Likewise, decisions about tax breaks should be overt rather than obscure.

A New Jersey report reviewed in Appendix B defines accountability as one of the two "dual expenditure and revenue criteria." Several concepts involved appear in discussions of specific recommendations.

An entirely different concept of accountability appeared in the Arizona report reviewed in Appendix B:

> ACCOUNTABILITY: Provide links between revenue raising responsibility and spending authority, so that voters can hold elected officials responsible for both revenue and spending decisions.

Potential to Get Out of Hand

An otherwise valid proposal may be considered invalid because the outcome will be unstable. For example, it is frequently argued that a fair allocation of highway taxes that includes a truck-specific tax will result in all future new tax burdens' being imposed solely on heavy trucks. This is also the major argument against a personal income tax in New Hampshire and Texas and against a value-added tax nationally. This concern about truck-specific taxes by an AASHTO steering committee was responsible for the addition of a criterion in a 1983 study for that organization.[48] That criterion was this: "Trucking industry concern that tax rates could be easily changed in the future for some types of tax structures."

Exportability

To most observers, the best tax is one paid by someone else. This concept finds its way into some tax studies as a criterion of exportability—the extent to which tax burdens can be shifted outside the jurisdiction where the tax is being levied. Although important at the state and local level in some settings, the concept has little applicability to nationwide decisions.

The opposite concern occurs in regard to the fact that higher taxes can drive consumers across borders. This occurs at local, state, and international borders and across a range of products and taxes. It is a particularly important constraint on states in setting higher user-tax rates. States cannot let their fuel taxes get too far beyond those of surrounding states for fear that a consumer reaction will shift purchases of fuel out of state. This has happened with respect to truck registration fees, with some states establishing "flags of convenience" to attract registrants from other states, just as states compete on incorporation laws and nations compete for shipping registry.

Federalism

Consideration of transportation revenue alternatives in the United States inherently cuts across issues of federal, state, and local responsibilities for planning and implementing transportation policy, as well as for financing transportation investments. Long-established patterns of passing resources from the federal government to the states and from states to local governments tend to dictate power over spending. For example, some states share personal income revenue "off the top" with local governments, so additional revenue raised from that source is reduced before becoming available for a specific objective such as transportation. Many states share registration fees and fuel tax revenues with local government, sometimes based on where revenue is raised rather than on transportation needs. Property taxes (sometimes including vehicles as well as real estate) generally are used only for revenues that remain in the hands of local government.

These complex patterns mean that tax concepts that are inherently neutral relative to roles of separate governments in the federal system are not neutral in practice. As a result, criteria for transportation taxes often include some consideration of the intergovernmental dimension. For example, in the 1983 AASHTO assessment of alternatives, criteria included the major ones proposed in this report and three related to federalism: (1) improve cooperation among states and within states; (2) accommodate special needs of states, such as concern over federal preemption and accommodating needs of specialized industries; and (3) achieve a balance between uniformity among states and flexibility.

Process Criteria

All the criteria discussed so far in this section deal with methods for evaluating the substance of tax policy decisions. Another dimension of tax policy is the process by which policy is made. Many reports deal with this subject, probably because the authors recognize that some of their recommendations will not be politically acceptable in the short run.

One example is the scheduled termination of tax law provisions, as is found in congressional actions for some tax exemption legislation and substantive legislation, such as transportation legislation, which has revenue-raising provisions. At the state and local levels, where these devices are less common, they are called *sunset provisions*.

Mild versions of the sunset provisions are periodic reports required, usually from the executive branch, on particular tax law provisions viewed as being inherently suspect and unlikely to be reviewed without special procedures for flagging them. Such reports on exemptions and deductions from broad-based taxes, called tax expenditures, are required at the federal level and in at least a dozen states.

The Finance Decision and Spending Criteria

The distinctions between decisions affecting revenue, which are covered in this report, and decisions on spending, which are not, are often extremely subtle. In fact, identical decisions can be thought of as revenue design questions and spending questions.

Providing access to transit by certain groups (school children, the poor, the handicapped) offers an example. A subsidy to a transit agency by a school district or a general purpose government to buy down fares for the groups is not considered a revenue policy issue. However, an identical fare structure for the target group could be obtained by revenue decisions, simply accepting, for example, a zero or discounted fare for them. If this is done, the result is arguably a revenue policy.

In this context, it becomes possible to complicate greatly the criteria to be used for tax policies in general and transportation taxes in particular. The list of possible additional criteria is nearly endless. For example, in assessing transit policy for New Jersey, Sydec[49] identified such objectives as providing mobility for the elderly, handicapped, and young; facilitating employment; shaping land development; conserving energy; improving environmental quality; and conserving the natural and community environment.

2.5 IMPACTS OF PROGRAMS AFFECTING ALTERNATIVE FUELS AND FINANCING OF U.S. SURFACE TRANSPORTATION PROGRAMS

This section summarizes Appendix C, which contains a detailed review of various programs that may affect the future of surface transportation finance. The review in Appendix C focuses on the most important aspects of several important programs and their anticipated impacts on the use of both conventional and alternative fuels and, implicitly, on financing of U.S. surface transportation programs. These programs include

1. the Alternative Motor Fuels Act (AMFA) of 1988;
2. California alternative fuels programs;
3. the Clean Air Act Amendments (CAAA) of 1990;
4. other Department of Energy (DOE) programs;
5. the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991; and
6. the Energy Policy Act of 1992.

This review of all important current programs that can potentially affect alternative fuels and financing of U.S. surface transportation programs leads to four general conclusions:

- No single program is likely to have a major impact on surface transportation finance within the time frame of the program.
- The cumulative effects of all the programs will be less than the sum of the individual effects because some of them are aimed at accomplishing the same objectives or will have nonadditive impacts.
- The cumulative effects of all the programs, however, will be substantially greater than the effects of any single program because some of them will have multiplicative impacts or partially additive impacts.
- The long-term impacts of the programs are difficult to predict because many of them are short- to mid-term in duration, and in most cases the impacts depend on factors outside the control of the agencies responsible for implementing the programs.

The AMFA of 1988 is intended to encourage the development of methanol, ethanol, and natural gas fuels and the development of a market for alternative fuel vehicles (AFVs). The federal government will purchase and operate a significant number of light-duty AFVs and will promote the development and testing of heavy-duty trucks and buses in several locations around the country. Corporate Average Fuel Economy (CAFE) incentives are likely to promote a small amount of production of AFVs by manufacturers. U.S. Department of Energy R&D programs, a data center, and various technical studies will provide substantial assistance to government and industry in deciding about the development of alternative fuels and AFVs.

California's zero-emission vehicle requirement is the only current program that is expected to result in a substantial penetration of AFVs in the market. It has an increasing sales requirement and it is the only program that requires sales of AFVs to the consumer market (as distinct from government and certain other fleets, and as distinct from vehicles that burn "clean" fuels, which may be reformulated petroleum fuels).

Other California programs and the CAAA of 1990 will result in substantial improvements in emission controls and substantially cleaner-burning petroleum-based fuels. Together with new requirements of ISTEA, they will probably also result in transportation plans and transportation control measures that will cause modest reductions in VMT below current growth trends in many metropolitan areas, and may even cause small absolute reductions in VMT in a few serious, severe, and extreme air quality nonattainment areas.

DOE's strategy for implementing the AMFA of 1988 is to encourage the commercial production of methanol, ethanol, and natural gas vehicles and the widespread use of these fuels by consumers in the transportation sector. The aim is to achieve a self-sustaining alternative fuels industry that will continue to expand after the program has ended.

Yet industry is having substantial difficulties in developing cost-competitive AFVs. Although long-term forecasts and technological projections suggest that there will likely be future markets for AFVs, there does not appear to be a likely market of substantial size within the next few years under current regulations and programs and those already scheduled to go into effect in the next few years.

Because of the long lead time required and the high cost of accelerating development of AFVs and their support systems, it appears likely that AFVs will penetrate the market slowly and be limited primarily to centrally fueled fleet vehicles over the next few years. If reformulated fuels prove to be closely comparable to AFVs, then existing federal and state regulations will probably not result in material displacement of petroleum. However, under certain conditions, some types of AFVs may be cost competitive with reformulated gasoline by 2000.

The principal uncertainty is government regulation. Congress may go further in mandating alternative fuels because reformulated conventional fuels frustrate the goals of developing domestic alternative fuels, reducing dependency on imported petroleum, and shifting to renewable energy sources.

The detailed review of current programs has been used, along

with other research summarized below, to develop several future scenarios and to evaluate alternative surface transportation finance programs within the context of these futures.

2.6 FUTURE SCENARIOS AND TAX ALTERNATIVES

This section includes (1) a summary review of recent literature on relevant forecasts and analyses of scenarios by others, (2) consideration of basic dimensions of scenarios that are important for this study, (3) a definition of selected scenarios, and (4) elaboration of the selected scenarios and evaluation of tax alternatives under the scenarios.

Conclusions from the Review of Recent Scenario Analyses

Appendix D summarizes about 20 recent sources that involve either trend-based forecasts, policy-driven forecasts, or scenarios dealing with energy futures and related factors of interest to this project. The purpose of this review is to provide background for the development of several scenarios in this section.

The review in Appendix D produced very useful background information for the development and analysis of scenarios for this project. The many research efforts reviewed span the range of likely futures in almost all dimensions, and they provide the basis for defining baseline forecasts for all variables of interest. They also provide more than adequate technical data needed to assess the sensitivity of key variables to major policy options and conditions that need to be defined for each scenario.

In particular, the Argonne forecasts and comparisons of other forecasts provide a basis for defining consensus baseline forecasts to 2010 for VMT for light and heavy vehicles, vehicle stocks, fuel consumption, fuel economy, and vehicle utilization. These were compared with forecasts developed in some of the other reports reviewed.

Several of the other research efforts provided guidance for defining the likely upper bounds for the penetration of alternative fuels. The DOE and Jack Faucett Associates (JFA) scenarios provided such guidance for one possible mixed AFV scenario. Dan Sperling's research provided a basis for a possible high methanol scenario and a pathway associated with it. Several sources provided a range of possible high electric vehicle and CNG penetration scenarios and a range of technological options for them. The Purdue University scenarios provided a basis for a long-range, high fuel economy scenario, and this is supported by other studies with somewhat shorter time horizons. The Data Resources (DRI)/Environmental Protection Agency (EPA) scenarios, supported by the work of Michael Walsh and the work of the coalition of environmental groups, provided analyses of CO_2 emissions and global warming impacts, which are missing from most of the other sources. Finally, IVHS America and some other sources provided a basis for defining what might be achieved in the development of automated vehicle monitoring, vehicle control systems, and automated highway and high-occupancy vehicle (HOV) lanes. These in turn helped to provide a basis for defining a scenario in which the measurement of individual vehicle VMT or miles of travel on major automated routes becomes a feasible substitute for, or complement to, motor fuel taxes.

Basic Dimensions of Scenarios

A first step in defining scenarios was the consideration of several basic dimensions that could be used in defining alternative futures, evaluating their importance, and selecting those most important for the purposes of this project. We separated out this first step in the process of defining scenarios to assure that explicit consideration was given to fundamental differences among the scenarios. This avoided the possibility that an important potential future is overlooked because of focusing attention on only those basic dimensions that are most obvious, such as those that have been used by others in previous studies.

Our work plan for this study identified several dimensions that should be considered in the process of developing a set of scenarios. We noted that there is a very large number of possible basic dimensions along which scenarios might be distinguished and observed that the most obvious include

- proportion of fossil fuels replaced by other energy sources;
- improvements in fuel efficiency of motor vehicles;
- improvements in emissions controls for various pollutants;
- developments in understanding of the consequences of environmental impacts of fossil fuels on human health, other forms of life, and the ecosphere; and
- extent of use of fuel taxes for nontransportation purposes, such as energy conservation, environmental impact reduction, and reduction of budget deficits.

We also noted a few other, somewhat less obvious basic dimensions that should be considered:

- developments in vehicle monitoring technology, and markets for that technology, related to mileage reporting;
- developments in automated highway systems technology leading to large-scale automated control of motor vehicles on major routes;
- substantially higher or lower growth rates for the national economy and for VMT; and
- major changes in the degree of concentration of control of surface transportation programs at the national level versus the state, local, and regional levels.

Based on the Appendix D review of recent forecasts and scenario development studies in this field, several basic dimensions emerged as possible bases for defining scenarios:

- rate of introduction of alternative fuels,
- type of alternative fuels used,
- different environmental strategies,
- tax options to achieve environmental and/or energy goals,
- fuel economy achievements or standards, and
- success of vehicle monitoring technology.

The primary criteria used in this project for choosing among these different possible dimensions for scenarios were (1) what potential future directions are most likely to affect surface transportation funding, and (2) what potential future directions are likely to present unique challenges to surface transportation funding?

In defining scenarios, we did not make any clear distinctions between conditions that result from national policy decisions

and those that result from technological advances and economic influences; i.e., we treat all these influences as essentially exogenous. Although transportation administrators do have some ability to influence national policy decisions, this ability is relatively limited. Accordingly, transportation administrators must recognize the possibility that national energy and environmental policy may complicate the task of funding the transportation system and they must be prepared to deal with any such possible futures. Furthermore, many of the conditions to be addressed (e.g., improvements in fuel efficiency) may well result from a combination of technological advances, economic influences (increasing real energy costs), and national policy. Our focus is on how the conditions that result from these developments can best be addressed, not the extent to which these conditions can be influenced by transportation administrators.

Preliminary Definition of Scenarios and Policy Options

On the basis of the preceding review, we initially concluded that transportation finance policy should be capable of dealing with alternative futures that may differ from each other in three ways:

- types of fuels used;
- fuel economy and energy conservation; and
- technological capability for measuring VMT.

These three principal dimensions and a secondary dimension of VMT growth rate are discussed below.[50]

Fuels Used

Not only the amount of penetration of alternative fuels, but also the mix of different alternative fuels will be crucial factors in future surface transportation finance. Even if there is a trend away from the funding linkage to user fees, the penetration of alternative fuels may be critical depending on the relative timing of these trends.

The total amount of penetration of alternative fuels may affect the amount of loss of transportation revenue, depending on the extent of exemptions granted to these fuels. The extent of exemptions is likely to vary among the alternative fuels, and these differences will have an effect on the relative consumption of alternative fuels, as well as on potential revenue losses.

The possible combinations of conventional and alternative fuels that will be used in the future are many. However, the most important taxation alternatives to be evaluated can be derived under no more than four fuel-use futures:

- little alternative fuel use,
- high methanol,
- high CNG or electric, and
- mix of alternative fuels.

Little Alternative Fuel Use. This future assumes that the current efforts of the petroleum industry and motor vehicle manufacturers are successful in meeting the increasingly strict emissions and air quality standards at costs below the life-cycle costs of any alternative fuels and AFVs. Reformulated fuels become the dominant fuel in all nonattainment regions with an unspecified mix of conventional and reformulated fuels used in other regions.

High Methanol. This future assumes that the life-cycle costs of methanol AFVs, fuel production and distribution, and support systems are lower than all other alternatives including reformulated conventional fuels. Methanol would displace the maximum feasible amount of petroleum fuels, taking into account supply limitations, vehicle turnover, and other constraints. By 2000, methanol would displace about 5 percent of gasoline consumption; by 2020, about 40 percent. Methanol was initially selected as an alternative fuel for analysis because it has been seen by some experts in the field as having the best chance of becoming the dominant alternative to petroleum fuels. It is superior to all existing and foreseeable forms of petroleum-based fuels from an environmental perspective, although it is not "clean" enough in comparison with some of the other alternatives to gain the support of many environmentalists.

The taxation of methanol fuel is a subject that would require investigation if this scenario were to be analyzed in detail. State laws commonly cover methanol and other alternative fuels under the general category of "special fuels." However, the low BTU content of methanol (about half that of gasoline) suggests that methanol should be taxed at a lower per-gallon rate than other special fuels. Scaling the per-gallon gasoline tax on the basis of relative BTU content would be appropriate, though some methanol advocates and producers have argued for leaving methanol untaxed as a means of encouraging its use.

Methanol production and distribution is likely to evolve into a relatively concentrated industry with a fairly small number of suppliers, distributors, and production plants, and a dedicated pipeline distribution system. If so, tax collection is likely to be similar to that for gasoline. Opportunities for using untaxed methanol as a motor fuel are likely to be fairly limited for several reasons: fuel-grade methanol costs less to produce and would be produced in much larger volumes than chemical-grade methanol; and most current methanol motor fuel is actually a blend of 85 percent methanol and 15 percent gasoline (also called "M85"). Since "E85" (85 percent ethanol and 15 percent gasoline), if it were to become popular, would also have many of these qualities, much of what would be learned from studying methanol would be applicable to E85 as well.

High CNG or Electric. This future involves similar assumptions for these alternative fuels as does the High Methanol scenario, with about the same level of penetration achieved by the combination of these two types of energy sources. CNG and electricity are the two very clean fuels that probably have the best chance of high penetration of the market. Because of their superiority to methanol from an environmental perspective, either or both of these fuels could potentially achieve greater governmental support and become dominant instead of methanol.

This future differs substantially from the High Methanol future in difficulties in collecting fuel taxes. Natural gas and electricity currently are used widely as energy sources for

purposes other than transportation. Therefore it probably will not be feasible to tax either of them at their production centers or at concentrated points in the distribution system. Neither of the two energy sources is likely to differ in any special way from the form in which it is used for other purposes, except that natural gas is compressed for motor vehicle use. However, this can be done easily in almost any location, such as in private homes or garages. Consumption of CNG or electricity by vehicles may need to be monitored directly if these fuels are to be taxed.

Mix of Alternative Fuels. This future assumes that no one or two alternative fuels becomes dominant, and that each of several of them is successful in achieving governmental support and continuing to compete for a significant share of the total alternative fuels market. The total market penetration might be the same as in the High Methanol and High CNG or Electric scenarios, with differences in the rates of penetration by particular fuels as discussed in the literature review in Appendix D.

This future is likely to be an unstable situation with potential for a rapid shift toward one or two dominant fuels at some time before the end of the forecast period. The reason is the economies of scale involved in AFV manufacture and in the production and distribution systems. It is thus of less long-term concern than the other scenarios. The primary reason this scenario might be worth studying would be to analyze likely problems in monitoring and taxing diverse fuel production and distribution systems. However, this scenario would probably require a relatively long-term governmental subsidy for several alternative fuels, including tax rate reductions and/or exemptions with corresponding losses of tax revenue. This appears to be an unlikely long-term policy because the economies of scale of particular alternative fuels would become more evident as each alternative reaches a significant market penetration.

Fuel Economy and Energy Conservation

As a result of comments by the Project Panel, greater attention was paid to a future involving substantial improvements in fuel economy for all motor vehicles in the context of greatly increased national energy conservation policies.

As discussed further below, a High Fuel Economy scenario was substituted for the originally proposed Reduced VMT Growth scenario, which would have been driven by some of the same concerns. The two candidate future scenarios might have had comparable impacts in reducing surface transportation revenue. However, a High Fuel Economy scenario would involve one additional challenge not involved in a Reduced VMT Growth scenario—i.e., that traffic growth, and therefore highway needs, would continue to grow at rates comparable to the base case. When higher CAFE standards are coupled with other energy conservation policies, such as substantial increases in fuel taxes, the effects of the fuel tax increase are substantially reduced or eliminated because fuel costs per mile may be affected very little.

A High Fuel Economy scenario is likely to be driven by many of the same concerns as the alternative fuels scenarios—e.g., concerns about air quality, global warming, and dependence on foreign oil imports. Some tradeoffs are involved between the two types of scenarios. To the extent that a high level of penetration of alternative fuels is achieved, there will be less pressure to achieve high fuel economy standards, particularly for conventional fuels. Similarly, to the extent that high fuel economy standards are achieved for conventional fuels, there will be less pressure to achieve a high level of penetration of alternative fuels.

The literature review in Appendix D reveals that a wide range of possible future levels of fuel economy has been considered. Energy and Environmental Analysis (EEA) forecasts that average new auto fuel economy would increase only 11 percent (from 23.8 to 26.5 mpg) from 1986 to 2010—less than 0.5 percent per year (see Table D.1). In contrast, the Gas Resource Institute (GRI) forecasts a 35 percent increase over the same period for new autos.[51]

High fuel economy scenarios, as distinct from forecasts, not surprisingly fall into an even wider range. In 1982, Purdue developed a baseline scenario that was not far from GRI's 1988 forecast and high fuel economy scenarios ranging from 43.3 to 64 mpg for new autos in 2020.

OTA's more recent (1991) scenarios provide somewhat less ambitious CAFE targets for new autos of 39 and 55 mpg for a shorter time horizon (2015). OTA predicts a baseline forecast of 36.6 mpg for average new auto fuel economy by 2015.

OTA's target of 39 mpg for new autos by 2015 in its "Moderate Efficiency" scenario appears to be a reasonable basis for our High Fuel Economy scenario based on a recent careful review of CAFE standards and related policies by the National Research Council (NRC).[52] Table 11 summarizes NRC's conclusions regarding "technically achievable" fuel economy for passenger cars. Note that OTA's target of 39 mpg for 2015 would not be achieved by 2006 according to NRC's technically achievable limits unless (1) all autos sold were subcompacts built within the lower incremental costs for improved fuel economy of $500–$1,250, or (2) the average size of the autos sold was between a subcompact and a compact and they were built at the higher incremental costs for improved fuel economy of $1,000–$2,500, or (3) some mix of sizes and incremental costs between the two choices. Presumably, the size and incremental costs to meet the 39 mpg target by 2015 would be less difficult, but only slightly less.

NRC emphasizes that "technically achievable" should *not* be taken to mean the technological limit of what is currently possible, nor are the limits shown in Table 11 intended to be recommendations. The estimates are based on autos' being "mass produced somewhere in the world [. . .] that pay for themselves at gasoline prices of $5 to $10 per gallon or less (1990 dollars). . . . As a point of reference, the EPA's composite average fuel economy for Model Year (MY) 1990 passenger cars and light trucks, by size class, was as follows: passenger cars—subcompact, 31.4 mpg, compact, 29.4; midsize, 26.1; large, 23.5. . . ."

Based on the assessment by NRC shown, we believe that the use of OTA's Moderate Efficiency scenario as the basis for our High Fuel Economy scenario is the upper limit of what is likely to be achieved under aggressive policies by 2015.

As noted in the review of OTA's study, the Moderate Efficiency scenario was assessed as having the highest total positive scores of all the five diverse futures analyzed. OTA's High Efficiency scenario was rated lower overall because of its negative economic impact, the difficulty of achieving the required infrastructure investment, and the lack of public acceptance.

TABLE 11. National Research Council's "technically achievable" fuel economy for MY 2006 passenger cars

Vehicle Size Class	Ranges of "Technically Achievable" Fuel Economy in MY 2006 (mpg)		Incremental Retail Price Equivalent for Improved Fuel Economy in MY 2006 (1990 dollars)	
	Higher Confidence	Lower Confidence	At Higher Confidence Fuel Economy	At Lower Confidence Fuel Economy
Subcompact	39	44	500 - 1,250	1,000 - 2,500
Compact	34	38	500 - 1,250	1,000 - 2,500
Midsize	32	35	500 - 1,250	1,000 - 2,500
Large	30	33	500 - 1,250	1,000 - 2,500

Technological Measurement Capability

The technical capability of measuring the amount of travel by specific vehicles and the difficulty involved in doing it will largely determine whether it is feasible and desirable to substitute taxation of miles traveled for taxation of fuel consumed. This substitution might be partial even in the long term, or eventually it might become a complete replacement for fuel taxes.

The ability to measure travel also might be partial or complete, even in the long term. Partial measurement might be achieved by a series of spot observations of vehicles on main routes or by continuous measurement of miles traveled on freeways or automated guideways. Complete measurement or approximate estimates of total miles traveled might be achieved by tracking of vehicles either on a continuous or frequent but periodic basis, or by periodic or annual readings of "tamper-proof" odometers. All of these technical capabilities might vary widely in accuracy and degree of automation.

Two alternative measurement capability futures will be considered:

1. No improvement beyond the capabilities that currently exist in the United States or other countries; or
2. Development of a fully successful capability for measuring VMT for at least part of the highway system.

Growth in VMT

Two alternative futures for VMT growth were considered initially as scenarios. One would have represented likely growth in VMT under current policy conditions; i.e., it would have been a base case VMT forecast.

The second VMT future initially considered was a low VMT growth future in which personal-use VMT in 2020 would be appreciably below that forecast in the base case future.

There are several possible reasons why national policy might result in reducing personal-use VMT. These include the adoption of policies for

- reducing energy consumption (e.g., via high taxes on all fuel, transportation fuel, or the carbon content of fuel);
- reducing vehicular emissions (e.g., via emissions fees); or
- reducing the budget deficit.

Many of the policies designed primarily to achieve any one of the above goals could also have a positive effect on achieving one or both of the other goals. More important, from the standpoint of transportation finance, initial proposals for any taxes implemented to achieve these policy goals (with the possible exception of the tax on transportation fuel) may not include revenue for the transportation system as a use for any of the tax proceeds. The primary purpose for incorporating a low VMT future into the scenarios would be to determine the effect of such a future on transportation finance and to develop any case that should be made for using a portion of the resulting revenue for transportation expenditures.

The above policies can be expected to have a smaller effect on the VMT of commercial-use vehicles than on the VMT of personal-use vehicles. For most of the policies, the effects on commercial-use vehicles are likely to result primarily from effects on the overall economy, though some diversion to more fuel-efficient modes (primarily rail) are also likely.

A third VMT future initially considered is a high growth scenario that could result from adopting a national policy of substantially increased investment in the highway system (and, perhaps, in all public infrastructure systems). Such a policy would be expected to result in increased highway use and increased highway revenue, but the increased revenue would not be expected to match the increased costs. However, it was presumed that the adoption of such a national policy implies the adoption of a mechanism for funding the increased investment (e.g., from general revenue or from substantially increased fuel taxes), or at least the federal share of this investment. The problem that such a policy could pose for state highway finance would be finding matching funds to provide the states' share of the costs of such an expanded investment program.

After considering the review comments of the Project Panel, the researchers decided that it would not be desirable to focus on a Reduced VMT Growth scenario, as had been recommended in the Technical Memorandum. Because the base case VMT forecast is intended to be a most likely future, and because VMT growth may be as likely to be above the base case as below it, they concluded that it made more sense to consider both high and low VMT growth rates.

Review of the Technical Memorandum in light of the Panel's comments also led to the conclusion that variations in VMT growth are less important than several of the other futures from the perspective of this project's objectives. Therefore, consider-

TABLE 12. Summary of scenarios initially considered and selected

	Scenario							
	A	B*	C*	D	E	F	G*	H*
Fuels Used								
1. Little Alternative Fuel Use	X				X	X		X
2. High Methanol		X						
3. High CNG/Electric			X				X	
4. Mix				X				
5. High Fuel Economy								X
Growth in VMT								
1. Base Case	X	X	X	X			X	X
2. Reduced Growth					X			
3. Increased Growth						X		
VMT Measurement								
1. Current Capability	X	X	X	X	X	X		X
2. Full Capability							X	

*Selected scenarios to be analyzed.

ation of changes in VMT growth should be reduced to a secondary consideration within the context of other selected scenarios, as appropriate to each case.

Scenarios Initially Selected for Analysis

The alternate futures discussed in the three preceding subsections were used to define eight potential scenarios for formal analysis during Phase II of this study. These scenarios are defined schematically in Table 12. Asterisks at the top of each column indicate the four scenarios that we recommended analyzing further based on the considerations discussed above and review comments by members of the Project Panel.

For convenience, the researchers have given the scenarios brief titles:

A. Little Alternative Fuel Use,
B. High Methanol,
C. High CNG and Electric,
D. Mix of Alternative Fuels,
E. Reduced VMT Growth,
F. Increased VMT Growth,
G. Full VMT Measurement Capability, and
H. High Fuel Economy.

Each scenario considered consists of one fuel-use future, one VMT future, and one VMT measurement capability future. All scenarios except E and F would be based on a base-case VMT forecast, involving a continuation of trends. Scenario E is the originally proposed Reduced VMT Growth case, and Scenario F is an Increased VMT Growth case that was discussed but not proposed for formal analysis. Because of lack of interest in these futures from the perspective of this project's objectives, these two candidate scenarios were relegated to secondary consideration as appropriate to the issues to be analyzed within the context of the selected scenarios.

Scenarios A–D and Scenario H, which was added in the Interim Report based on the Panel's review comments, each combines the base case VMT forecast and current VMT measurement capability with different fuel use futures. In the Interim Report we proposed to analyze three of these five candidates to highlight issues of most concern that needed to be addressed further in Phase II; i.e., special finance problems associated with the most likely alternative fuels and special finance problems associated with the possibility of major improvements in fuel economy.

The two fuel-use scenarios not recommended for further analysis (A & D) were of lesser interest because they did not highlight important issues in any unique manner. Scenario A, Little Alternative Fuel Use, was a likely future, but it was essentially a continuation of current conditions in terms of the finance issues of interest in this project. Scenario D, Mix of Alternative Fuels, was seen as an unlikely long-term future, and the special issues it raised (regarding the difficulty of collecting taxes from diverse alternative fuels) could be dealt with fully in Scenarios B and C (High Methanol and High CNG/Electric).

Finally, Scenario G presumed the development of an effective capability for measuring each vehicle's VMT, and combined this capability with the base-case VMT forecast and the high CNG, high electric vehicle future (the fuel-use future that most requires the availability of an effective VMT-measurement capability).

In addition to the scenarios selected in Table 12 for formal analysis, other possible futures of interest were considered on a more informal basis. These include

A. A national program of high highway investment (combined with any of the fuel-use alternatives), and
B. Full VMT measurement capability with little use of alternative fuels (or with use of other alternative fuels).

Discussions of appropriate revenue policies for these possible futures were developed from the results of the more formal scenario analyses to be performed. The researchers proposed not to analyze a separate scenario in which the total replacement of fossil fuels occurs. Such complete replacement is unlikely to occur within the next several decades, and any substantial movement toward such an occurrence is likely to be accompanied by significant changes in the economy that would make specification of such a scenario highly conjectural. More important, the most significant highway-finance issues that would be posed by such a scenario, reduced use of light vehicles and significant use of fuels that are not easily taxed, are issues that may have to be faced in the near future and that are represented in a more realistic form in Scenarios C and H. The researchers concluded that analyses of these two scenarios would be a more productive use of study resources than analysis of a total no-fossil-fuels scenario.

Scenarios Used in Evaluation Process

Changes in the selected scenarios were made based on the panel's review of the Interim Report. Table 13 summarizes these

TABLE 13. Application of evaluation framework to scenarios

Scenarios	Basic Policy Directions		
	Business As Usual	Improve and Adopt Motor Fuel Taxation	Transition to VMT-Based Taxation
1. High Methanol	Limited Evaluation Required	Limited Evaluation Required	
2. High CNG & Electric	Elaborate on Expected Problem	Apply Evaluation Framework	
3. High Fuel Economy	Elaborate on Expected Problem	Apply Evaluation Framework	
4. Tax Diversion/ Subsidy	Elaborate on Expected Problem	Apply Evaluation Framework	
5. Full VMT Measurement Capability	Elaborate on Missed Opportunity		Apply Evaluation Framework
Base Case		Elaborate As Needed for Above Evaluations	Elaborate As Needed for Above Evaluations
Combinations of Above		Discuss in General	Discuss in General

revisions and the extent of evaluation that has been performed under each scenario.

Scenario 4 in Table 13, "Tax Diversion/Subsidy," was added after the Interim Report based on review by the Project Panel. Scenario 4 would involve a combination of (1) maximum diversion of motor fuel tax receipts to the achievement of other national and international goals such as deficit reduction, energy independence, air quality improvement, and reduction of global warming impacts; (2) maximum tax subsidies for alternative fuels, alternative fuel vehicles, and fuel efficient vehicles; and (3) reduction of, and eventual elimination of, the dedication of fuel tax receipts for surface transportation finance.

When such a scenario is coupled with no major improvements in VMT measurement capability, transportation officials would most rapidly lose their dependence on motor fuel taxes and would have to depend more on nonuser revenues than in any other scenario considered. Application of the tax structure evaluation framework in this context involves another type of base case for comparison with the other results. It addresses the question of how the highway user tax structures under the other scenarios compare with reliance on the general tax structure in equity, efficiency, and other considerations.

In addition, Table 13 identifies several other items that required attention in the evaluation process:

1. It is helpful to distinguish the three basic policy directions that are available to transportation officials in dealing with the surface transportation finance issues—i.e., the columns in Table 13.
   (a) Business as usual, or efforts to "muddle through" with no basic change in policy. This is a base case for policy options.
   (b) Improvement and adoption of motor fuel taxation. This would involve substantially increased efforts to reduce evasion by expansion of the initiatives described in Chapter 3, and new efforts to respond to the challenges that would be intensified under each of the scenarios.
   (c) Transition to VMT-based taxation. This would involve substantial new commitment to a broad program of studies, R&D, demonstrations, and development of technologies and systems for measuring VMT.
2. The business-as-usual policy option does not deserve to be treated in the same depth of evaluation as the other basic policy options. It is used as a basis for comparison of the other policy options. The evaluation framework need not be explicitly applied under this policy direction; however, when the framework is used under each selected combination of scenario and basic policy option, the business-as-usual option has been considered as a basis for comparing the results of each application of the evaluation framework.
3. Similarly, the base case scenario, involving little mix of alternative fuels and trend-based projections of other factors, did not need to be subjected to the same depth of evaluation as the other selected scenarios. It has been used as a basis for comparison of the other results of applying the evaluation framework under each of the selected scenarios. It required sufficient elaboration to provide data required for these evaluations.
4. Combinations of the selected scenarios have been used as the basis for extending the evaluation results to a wider range of future conditions.

Assessment of Surface Transportation Finance Under Selected Scenarios

This subsection provides an assessment of surface transportation finance under each of five scenarios. It begins with a brief discussion of the key factors in the transition paths between

TABLE 14. Summary of key factors in transition paths for selected scenarios

Key Factors	High CNG & Electric	High Fuel Economy	Tax Diversion and Fuel Subsidies	Full VMT Measurement Capability
Major Technical Options for Paths	CNG/electric mix Battery technologies Guideway technology options	Engine and vehicle design		Hubodometer, AVI on toll roads, congestion pricing, AVI on Interstates, satellite tracking, guideway technology options
Major Policy Options	Investment in vehicle design, battery development Subsidy of fuel or vehicles	CAFE standards and penalties, including light trucks Taxing fuels Fees and rebates based on mpg of vehicles 55 mph speed limit	Amount of subsidy for alternative fuels Extent of diversion of highway user taxes Source of surface transportation funds	R & D and demos for all technologies Reorientation of IVHS program Assistance to states in implementation
Major Uncertainties and Hurdles	Breakthroughs needed in battery technology Costs to consumers	Safety Industry impacts Costs to consumers	Funding from other sources to offset diversion and subsidy	Invasion of privacy Cost of administration and enforcement for light vehicles

current conditions and the five futures defined by the scenarios. These key factors include major technical options for the paths, major policy options, and major uncertainties and hurdles that need to be overcome in each scenario. Then each scenario in turn is subjected to an assessment of the impact that it will have on surface transportation finance.

The subsection concludes with a finding regarding actions that should be taken to improve future conditions. In brief, the conclusion is that the policy decisions that are appropriate under the Full VMT Measurement Capability scenario are desirable decisions to make regardless of which of the five scenarios, or combination of them, eventually evolves. These policy decisions are required to facilitate the development of the ideal surface transportation finance system defined in this study.

Key Factors in the Transition to Scenarios

Table 14 summarizes the key factors involved in the transition paths between current conditions and each of the four futures defined by the scenarios. The key factors are of three types:

- major technical options for alternative fuels, vehicle design, and ways of measuring VMT;
- major policy options for government investment in R&D, demonstration programs, subsidies for alternative fuels, and regulatory controls; and
- major uncertainties and hurdles that have to be overcome to achieve stated objectives under each scenario.

Although it is not one of the selected scenarios, the scenario that has been subjected to the most careful analysis in each of the critical aspects of the transition period is the High Methanol scenario. Appendix D contains a summary of an article by Daniel Sperling, which analyzes all important aspects of a transition over a period of up to 20 years. His transition scenario is intended to represent "the upper limit of opportunities for introducing methanol fuel to this country"—resulting in the production of 1.5 million barrels per day (MMBD). This would be a higher level of use of any single alternative fuel than any of the other scenarios or forecasts reviewed.

In the impact on surface transportation finance, the relative mix of alcohol fuels that occurs in the High Methanol scenario is important only to the extent that the two are treated differently in subsidies, such as through reduction or elimination of the fuel tax. Ethanol currently receives large tax subsidies at both the state and federal levels; whereas methanol currently does not.

The key factor at present is that ethanol has a large constituency in agricultural areas, but methanol does not. Because methanol would be produced from natural gas initially and later from coal, it may never develop such a broad popular constituency as ethanol. For this reason, methanol might not receive as large a tax subsidy as ethanol. The high level of penetration of ethanol assumed as part of this scenario might be achieved, as postulated by Daniel Sperling, through government investment in development of the technology and distribution system and with *temporary* removal of excise taxes.

The transition paths for the High CNG and Electric scenario involve somewhat similar policy options regarding government investment in vehicle design and subsidy of fuels and/or vehicles, but have much greater potential impact on surface transportation finance. Because of the fact that these are much cleaner-burning fuels (depending on the fuel source and location of power plants in the case of electric), there is a much greater likelihood of tax subsidies, particularly for electric.

Because CNG is more likely to be taxed, the relative mix of the two may be important for surface transportation finance. The DOE scenario described near the beginning of Appendix D projects a larger fleet of EVs by 2010, but because CNG would be a dominant alternative fuel for heavy vehicles it is projected to displace somewhat more petroleum product than electricity.

Two technical options under this scenario should be of concern, and are deserving of attention in future research:

- the feasibility of developing a tamper-proof meter for CNG

compressors and requiring it to be installed on all compressors used for motor vehicle fueling, as a basis for tax assessment; and

- the feasibility of taxing batteries as a proxy for highway use, without introducing the perverse effect of discouraging the introduction of batteries with longer lives.

The High Fuel Economy scenario also involves a variety of technical options for achieving the targets of this future; however, the paths that have been proposed do not involve large-scale government investment in engine and vehicle design, nor in infrastructure, unlike the first two scenarios. Most of this investment is expected to be made by the private sector in response to increased CAFE requirements or increasing price of fuels.

The recent NRC study referenced above in developing this scenario recommends that consideration be given to a variety of improvements in CAFE regulations if further major fuel economy improvements are to be mandated. Consideration should be given to applying CAFE standards to various size classes of vehicles and extending them to light trucks. Other recommendations include increased fuel taxes, a tax/rebate schedule for vehicle sales based on mpg ratings, and reintroduction of the 55 mph speed limit.

The High Fuel Economy scenario might have somewhat less effect on surface transportation revenues than the other scenarios, depending on the extent to which fuel taxes, or proxies for fuel taxes, are collected from CNG and electric vehicles. Because the cost to highway users resulting from increased fuel taxes would approximately be offset by fuel economy improvements, costs per mile would not be significantly affected, and highway construction, maintenance, and operating costs would not be greatly affected — the same as in most of the other scenarios.

The Tax Diversion and Alternative Fuels Subsidy scenario differs from the other scenarios in that no technological development challenges or hurdles are involved, nor is the evolution of related technologies likely to have substantial influence on the likelihood of this scenario's being realized. An end to the dedication of user taxes is a policy decision that is almost completely independent of technological developments. Some general relationship may arise between the development and deployment of alternative fuels technologies and the extent of tax subsidies, but the relationship is a weak one. A range of possible levels of tax subsidy for alternative fuels is consistent with a range of possible levels of development of alternative fuels and related technologies. The major policy options for the diversion and subsidy scenario are

- the amount, timing, and duration of tax subsidies for the development and deployment of each type of alternative fuel, alternative fuel distribution system, and alternative fuel vehicles;
- the extent of diversion of highway user taxes from transportation funds to other uses, at both the federal and state levels; and
- the source of funding for surface transportation programs, which could range from continuing reliance primarily on user taxes and fees to almost no reliance on them and almost complete reliance on general revenues and other specific sources.

The critical uncertainty in the diversion and subsidy scenario that is of most importance to surface transportation is the degree of success that transportation administrators might have in obtaining funding from other sources to offset losses due to diversion and subsidy of alternative fuels. The degree of success in obtaining such funding is likely to depend on how well transportation administrators perform in their efforts to develop an improved financing system such as the ideal contract with taxpayer-users recommended in this report. Development of this ideal type of financing system is probably more important under this scenario than under any other scenario because of the loss of dependence on stable, growing user revenues.

The transition paths for the Full VMT Measurement Capability scenario differ greatly from the others in important ways. There is a variety of technological paths. Several technologies might be used throughout the transition period and several mature technologies might remain in use indefinitely. The choice among technological options and the speed of their development will be controlled largely by transportation officials, unlike the choices in the other scenarios. And, most important, the success of the technological development is positively correlated with improvements to surface transportation finance, as will be discussed further below.

Impacts of the Scenarios on Revenues

Each of the selected scenarios has been defined in quantitative terms in Figure 7 as to a likely level of impact on receipts available for surface transportation programs in 2020. The exhibit is intended to portray one example of the impact on revenues of each scenario — one of a range of possible impacts, but one that is as consistent as any with the definition of each scenario. All values shown in the exhibit represent total federal and state receipts available for surface transportation programs.

The base case assumes continuing growth in highway user revenues from 1991 at 2 percent per year, with about the same level of dedication of user revenues as today. All projections are consistent with an assumption of continuing moderate economic growth, and continuing of current growth trends for VMT, with some leveling off of the rate of growth due to increasing congestion, saturation of the vehicle market, and saturation of travelers' time budgets for travel. VMT growth would be slightly lower in the Tax Diversion and Alternative Fuels Subsidy scenario because of significantly higher fuel taxes, and slightly higher in the Full VMT Measurement Capability scenario because of the effects of congestion pricing on reducing congestion and the benefits of having 10 percent more money available for transportation improvements, as described later.

Fuel tax and mileage-related tax receipts would be directly affected by changes in VMT growth rates under each of the scenarios. VMT growth, in turn, would be directly affected by general economic growth rates, as well as by other factors such as discussed above.

The detailed assumptions made in developing the projections of receipts for each scenario are documented in Appendix E. The assumptions made for each scenario are intended to reflect the high end of the likely range of change for each factor that defines the scenario. For example, the receipts projected for the High CNG and Electric scenario are consistent with a level of penetration of both CNG and electric vehicles that is about as high as any of the projections that have been made in the literature reviewed in Appendix D. Similarly, the High Fuel Economy scenario projection of receipts is consistent with achievement of

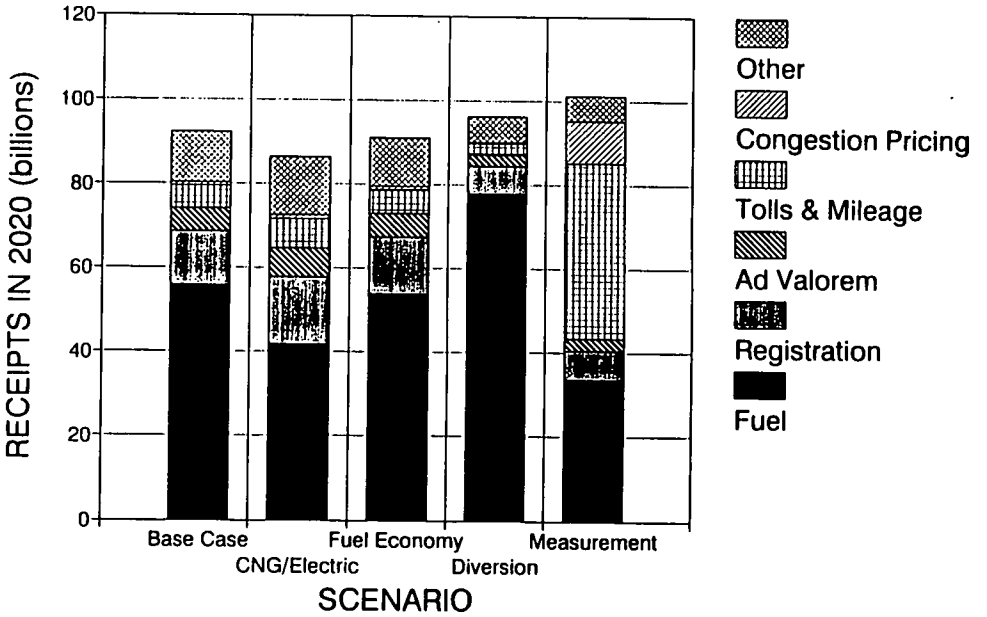


Figure 7. Projected highway user receipts in 2020 for each scenario by type of tax.

the highest "technically achievable" fuel economy for passenger cars according to NRC's conclusions, as described above in the definition of that scenario. Comparable statements can be made for the other two scenarios.

The projections shown in Figure 7 result in about 6 and 1 percent reductions in total receipts available for the High CNG and Electric and High Fuel Economy scenarios respectively, and about 5 and 10 percent increases in total receipts for the Tax Diversion and Subsidy and Full VMT Measurement Capability scenarios respectively. Fuel tax receipts as a percent of total receipts change from about 60 percent in the base case to

- 48 percent for High CNG and Electric;
- 59 percent for High Fuel Economy;
- 80 percent for Tax Diversion and Alternative Fuels Subsidy; and
- 33 percent for Full VMT Measurement Capability.

In the Tax Diversion and Alternative Fuels Subsidy scenario, total fuel tax receipts are assumed to increase by well over the amount of general revenue and other funds made available for surface transportation, but a total of 80 percent of all funds available for surface transportation would come from these other sources.

The most dramatic changes occur in the last scenario, which is the only scenario involving large increases in weight-distance tax receipts (from 1% in the base case to 7% of total receipts), VMT taxes and tolls (from 5% to 34%), and congestion pricing (from 1% to 10%).

In general, the transitions to each of these scenarios would involve gradual, approximately straight line projections of these changes over the 29-year period, with the following exceptions:

- The rate of penetration of CNG and electric vehicles is likely to be low during the 1990s, accelerate during the next decade, and then level off somewhat, as projected by DOE in Appendix D. However, tax subsidies might begin to increase at a somewhat faster rate in the 1990s and level off sooner.
- The rate of improvement in fuel economy for new vehicles is likely to be greater in the first half of the projection period, but high rates of improvement in fleet fuel economy are likely to continue for a few years beyond the middle of the period.
- Tax diversion is likely to occur in substantially large increments during particular periods at the federal level, and perhaps to a lesser extent at the state level. However, it is not helpful to speculate when these increments of diversions might occur and how large they might be because there is no logical basis for estimating when they might occur.
- The timing and rate of introduction of VMT measurement technology probably depends on the mix of technologies to be used. Some are available now, but others are not likely to be deployed until late in the period. The overall rate is likely to be low during the 1990s and to continue to increase for the rest of the transition period under that scenario.

The tax structures described above for each scenario are subjected to a general assessment using the evaluation framework recommended in Chapter 3.

ENDNOTES

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2. Gary R. Allen, "Highway User Fees: Are These Old Taxes Still Good Taxes?" *Understanding the Highway Finance Evolution/Revolution,* AASHTO (January 1987), page 31.
3. FHWA, *Highway Statistics,* 1990.
4. FHWA, *Highway Statistics: 1990,* Table FE-101.

5. *Ibid.*
6. The tire tax also applies to bus tires, but school buses, buses used in scheduled service to transport the general public, and most charter buses are exempt.
7. FHWA, *op. cit.,* Table FE-101.
8. *Ibid.,* pages 38–39.
9. DOE, *Second Interim Report of the Interagency Commission on Alternative Motor Fuels* (September 1991), page 16.
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11. The Road Information Program, *1992 State Highway Funding Methods,* page 12; and Frank Moretti, The Road Information Program, personal communication (October 1992).
12. FHWA, *op. cit.,* Table MF-121T.
13. FHWA, *Highway Statistics: 1990,* Table MF-121T.
14. Gary Maring, "Federal Heavy Vehicle Cost Responsibility and Weight Distance Tax Studies," AASHTO Annual Meeting Proceedings (1988), pages 53–62.
15. FHWA, *Highway Statistics: 1990,* Table MF-121T.
16. John Berg, FHWA, personal communication (February 1992).
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22. *Ibid.,* Table MF-109.
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24. International Bridge, Tunnel and Turnpike Association (IBTTA), "Profile of the U.S. Toll Industry," Washington, D.C. (no date).
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27. Norman H. Wuestefeld, "Toll Roads," *Understanding the Highway Finance Evolution/Revolution,* AASHTO (January 1987), page 68.
28. *Ibid.,* pages 69–71 and 78.
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31. Energy Information Administration, *Studies of Energy Taxes,* Department of Energy (1991).
32. A.T. Reno and J.R. Stowers, *Rationalization of Procedures for Highway Cost Allocation,* prepared by The Urban Institute and Sydec for the Trucking Research Institute (1990).
33. James C. Nicholas, "The Use of Benefit Fees and Assessments in Financing Transportation Improvements," AASHTO, *op. cit.,* pages 83–115; and C. Michael Walton, Mark A. Euritt and Reginald R. Souleyrette, II, "Private Participation in Financing Highway Projects and Providing Property for Highway Improvements," AASHTO, *op. cit.,* pages 141–165.
34. C. Michael Walton, *et al., op. cit.,* page 144.
35. *Highway Taxes and Fees: 1991, op. cit.,* Table S-106.
36. *Highway Statistics: 1990, op. cit.,* Table SB-2.
37. *Ibid.,* Table SB-3.
38. C. Michael Walton *et al., op. cit.,* page 149.
39. KPMG Peat Marwick, *A Study of the New Hampshire State and Local Revenue Structure,* 1992.
40. For a contrasting approach, see the report prepared by Booz-Allen & Hamilton, Inc. for the 1993 Oregon Roads Finance Study, Task III-B, "Evaluate Alternative Sources of Revenue." The report deviates from traditional approaches in two major respects, both with inherent pitfalls.

    The first is to turn criteria, such as equity and efficiency, with potentially conflicting approaches into quantified ranking functions. The hazard of the approach is admitted, but understated, in the report, "While the system is designed to provide more objectivity, considerable subjective judgment is still involved in deciding weights for criteria, and in scoring individual funding sources against individual criteria."

    The second is the introduction of what this report calls institutional criteria into otherwise objective factors such as efficiency. Examples are ranking functions (criteria) of political acceptability, legal authority, and conflict, rejecting revenue sources if already claimed for some other function. The report also evaluates taxes as to whether they could be used to back debt financing. This criterion is irrelevant for governments using pay-as-you-go financing (including the federal government and many states) and for governments to finance transportation investments with debt backed by the full faith and credit of the state, rather than particular tax sources.
41. The Select Committee on Tax Equity was established by legislation in 1987 to deal with widely recognized dissatisfaction with the Texas tax system. The group was constituted of four appointees each selected by the governor, the speaker of the House, and the lieutenant governor (who serves as the Senate leader in Texas), plus the comptroller, who is the state's official revenue estimator. The group reported in early 1989 under the title Rethinking Texas Taxes. Volume 2 of the report contains a chapter by the group's executive director detailing the original nine criteria. In the subsequent debates over Texas tax policy, the Governor's Task Force on Revenue produced a short report (*Charting a Course for Texas' Future: Toward a More Equitable System of Taxation,* 1991) which explicitly adopted the nine criteria plus one. That one was "affordability: It [a good tax system] should be affordable, both for individual citizens and for businesses."
42. Alabama's tax system has triggered many reports over the past four decades. The quoted one is the *Report of the Alabama Commission on Tax and Fiscal Policy Reform* (1991).
43. U.S. Department of Transportation, *Federal Highway Administration, State Highway Cost-Allocation Guide* (1984).
44. E.g., USDOT, *The Feasibility of a National Weight-Distance Tax,* December 1988; and Jack Faucett Associates, *Revenue Derived from State Motor Carrier Taxes and Fees,* prepared for FHWA (November 1984).

45. A highly arbitrary rule of thumb approach for determining nonuser highway cost responsibility, called the "earnings-credit method" has been used in several older studies, but has no validity as a rational economic criterion. The only known application of rational economic criteria for determining nonuser highway cost responsibility is contained in Appendix F of the 1982 Final Report on the Federal Highway Cost Allocation Study.
46. Sydec and Harold A. Hovey, *AASHTO Study of Motor Carrier Taxation and Registration Issues,* AASHTO (1983).
47. National Conference of State Legislatures, *Earmarking State Taxes* (1987).
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49. System Design Concepts, Inc., and Simpson & Curtin, *New Jersey Public Transportation Organizational and Financing Study* (1976).
50. The fourth dimension—differences in VMT growth rates—was initially considered for definition of scenarios in Technical Memorandum 1. However, after review by the Project Panel, this dimension was reduced to secondary consideration within the context of other scenarios.
51. These are all on-the-road mpg values, which are about 5 mpg lower than EPA ratings. All the values in the paragraphs that follow are believed to be based on EPA ratings.
52. National Research Council, *Automotive Fuel Economy: How Far Should We Go?* (1992), Table ES-1, page 4.

CHAPTER 3

EVALUATING ALTERNATIVE SOURCES FOR PUBLIC TRANSPORTATION FINANCE

3.1 A NEW CONTRACT BETWEEN TRANSPORTATION AGENCIES AND THEIR CUSTOMERS

A new approach is recommended to create a direct link between surface transportation finance and the benefits to be derived from transportation programs. The new approach has several characteristics:

1. It recognizes, and builds upon, the frequently observed fact that taxpayers will commonly support increased user taxes and fees if they know that the money is committed to desirable transportation improvements.
2. The new approach can be described as a contract between the transportation provider (state DOT, transit agency, etc.) and the consumer, in the sense that a binding commitment would be made to achieve a given level of service and other specific objectives in return for the commitment of a specific set of taxes and level of funding.
3. A systematic framework has been developed for evaluating alternative tax structures as a central tool for agencies to use in a variety of decision-making contexts. This framework is a practical, operational tool that encompasses all of the criteria used in state-of-the-art tax studies, can be applied at all levels of government and for different time horizons, and is designed to aid in developing the revenue side of the contract with consumers.
4. The new approach will integrate the revenue options evaluation framework developed in this project with the several new management systems required by the ISTEA. It proposes that these several new management systems all be interrelated in a single comprehensive management system to be developed and demonstrated as part of a high priority project, following completion of this project.

This new contract approach is an ambitious proposal because it seeks to link several separate management systems into a single framework using a systems approach, and also seeks to create a continuing planning and decision-making process in a field that has traditionally involved only occasional one-shot major studies. However, we believe it is timely to develop such an ambitious approach because of the opportunities that have been created by the new flexibility under ISTEA and the development of the several new management systems. We also believe that many transportation administrators will understand the broad appeal that this new approach could have and will want to develop the capability and demonstrate its application.

The key to successful demonstration of this new approach will be the selection of the best context for the demonstration. The most appropriate agency for conducting the demonstration should be selected with due consideration given to

- operational capability with the several new ISTEA management systems;
- interest in conducting a comprehensive review of the tax structure used for surface transportation finance;
- feasibility of having the agency's current planning and programming process evolve into the proposed new approach; and
- ability of the agency to commit to developing and using the new approach over a long enough time to demonstrate its success or determine how it should be modified.

These considerations would be essential in achieving sufficient success to show that this new contract approach could help build increased credibility of transportation agencies in the eyes of the public.

The Nature of the Contract

The new contract approach ties surface transportation financing to economic growth, environmental preservation, and mobility enhancement by keying financial, investment, and management strategies to economic, environmental, and mobility goals and performance objectives. The approach allows different agencies and different levels of government to choose their own appropriate emphasis on economic, environmental, and mobility concerns.

In most applications at the state and local levels, the emphasis would be on delivering a specific level of service improvement in specified corridors or areas within a given program period, in return for the commitment of a specified tax package. Periodic monitoring and reporting to the public would be part of the contract. In air quality management programs, specific reductions in emissions and improvements in air quality would also be major commitments under the new contract approach.

This new approach to financing transportation can be used to explain to the public, and to administrators and legislators, how their interests as consumers and as constituent representatives will be met through proposed surface transportation fees, investments, and management actions. The new approach provides a method for agencies to develop programs, revenue sources, and funding levels that can be demonstrated to be in the best interests of their customers. It would involve choices among finance

sources and fee levels based upon their benefits to consumers and the society. It thus differs from the current approach, which is based on tradition and on incremental changes in fee structures and rates being deliberated irregularly.

This new contract between agencies and their customers would assure a greater understanding of their stake in the agencies' programs, finance sources, and overall investment and management actions.

Relationship to ISTEA

This new contract approach linking surface transportation finance to performance objectives and to consumer interests should be integrated with implementing ISTEA and its state and metropolitan area management systems. In turn, the management systems called for under the ISTEA will provide the analytical capabilities that will support the integration of decisions on surface transportation finance with the setting of performance objectives. ISTEA management systems for congestion, safety, pavements, bridges, public transportation facilities and equipment, safety, and intermodal transportation will provide the basic information on how program levels will relate to the achievement of objectives.

How It Will Work

Surface transportation financing levels, programs of investment, and management strategies are determined in the new approach by choosing financing sources that are consistent with chosen mobility, economic, and environmental objectives, and by setting finance levels necessary to achieve major economic, environmental, and mobility objectives. Agency top management and legislative bodies will target finance sources to each set of objectives — economic, environmental, and mobility — and will set fee levels based on performance objectives.

Fee and tax levels will be indexed and set so as to achieve these important consumer and societal objectives. The fee levels will be adjusted in the next agency budget and/or programming cycle if the levels of performance differ from the selected objectives.

The new approach recognizes that surface transportation capital facilities and management strategies exist not for their own sake but for the sake of consumers of transportation and consumers of environmental quality and mobility. Transportation capital facilities and management strategies can leverage enormous consumer benefits in operating costs, economic development opportunities, and environmental and livability benefits. Surface transportation finance and programs have been recognized in past approaches to be integrally tied to mobility objectives, and the new approach incorporates mobility objectives as well.

Economic Objectives

Public investments and management expenditures for surface transportation (on highways and on surface mass transportation) now total around $80 billion per year, and largely determine the level of surface transportation operating costs that consumers will pay. Currently, consumers pay around $1 trillion per year nationally in direct costs of operating surface passenger and freight transportation, and incur another $1 trillion per year in travel time and unreimbursed safety costs. Public agency expenditures of $80 billion per year may seem substantial, but in perspective they are only 4 percent of the private total surface transportation costs of over $2 trillion per year.

The public sector supplies, from its modest share, very important elements of the transportation system that are critical in determining overall user costs and user mobility levels as well as other economic benefits and environmental impacts.

Economic objectives will be defined to set user fees and taxes at levels that achieve specified rates of return on those investments to the users or consumers of surface transportation. Programs that provide desirable rates of economic returns to surface transportation consumers and to society will be funded. Rates for fees to finance these programs will be set so programs and projects with the specified highly positive returns can be funded within a given period of years.

For highway programs, states and regions can use procedures such as the ISTEA management systems and the Highway Economic Requirements System (HERS) to identify investment levels and programs with the desired direct user benefits. HERS selects highway improvements based on economic returns, which include private user costs. Illustrative analyses using the HERS have shown that state highway investment programs at higher levels of expenditure than today's can yield very high returns to users — with annual benefits from increased investments at seven to ten times the increased annual costs.

For public transportation and transportation demand management, the ISTEA management systems for congestion and public transportation facilities and equipment will provide performance information linked to fee levels, investments, and actions.

In addition to the direct impacts on user costs, surface transportation capital and management investments can affect opportunities for economic development and private sector productivity. For some studies of highway and transit improvements, solid conclusions can be reached that improvements generate opportunities to expand and reorient activities, with added nonuser benefits. Nonuser benefits have sometimes been as large as the direct benefits.

Environmental Objectives

Some states or urban regions may wish to integrate surface transportation finance with the achievement of environmental or livability goals and objectives. Environment-related fees would be designed to achieve clean air objectives by providing that fee levels will be set and adjusted based on the estimated levels necessary to contribute to achieving necessary reductions in emissions. The new approach to using surface transportation finance as an integral part of achieving environmental objectives in particular areas will be to set fees such that they "kick in" or are raised when scheduled reductions in transportation emissions are not being achieved.

Mobility and Safety Objectives

Basic mobility and safety objectives are served by transportation programs. Routine highway and transit maintenance and

rehabilitation keep facilities in service and maintain mobility for the users, even if not associated with changes in user costs or changes in emissions. Preservation of transit services preserves mobility for many who have no viable alternative means of travel.

Preserving or improving basic mobility and safety is a valid goal of surface transportation finance programs, and in most places it has already been recognized as tied to surface transportation finance. For the mobility objective, only modest changes in current programming and budgeting information are required.

Decision Making Under the New Approach

To put together a budget under the new financing approach, the agency determines which programs and projects are necessary to meet the economic, environmental, and mobility objectives and identifies a level of overall fees that will provide the necessary financial resources for the investment and operating programs. This is not an exercise that most agencies have already undertaken. However, it can be accomplished before the ISTEA management systems are fully operational, and it can be accomplished readily when they are implemented as part of a carefully planned demonstration project.

3.2 APPLYING THE EVALUATION FRAMEWORK: INTRODUCTION AND OVERVIEW

The proposed evaluation framework provides a comprehensive but readily usable methodology that can be applied at the federal, state, or regional level to evaluate alternative revenue sources and help reach agreement on revenue sources to be used to fund surface transportation.

The evaluation framework is then a set of criteria against which all options are to be gauged. It provides a structured process to guide decision making in a real-world environment. Because state or local conditions and judgments are very important, a revenue source could be well suited in one context but not appropriate or applicable in another. The evaluation framework provides a set of steps that recognizes where judgments and well-informed choices, based on values, must be made by the key decision makers. Information is presented within the framework to inform those judgments and choices.

The application of the evaluation framework involves eight steps:

1. Gather relevant information to be used in the evaluation of revenue sources.
2. Screen the suggested revenue sources to determine whether they could provide adequate revenues and whether the sources could be dedicated to support the specific surface transportation program.
3. Evaluate the promising sources that can provide adequate revenues and that can potentially be dedicated to surface transportation with regard to each other criterion, using the procedures described in the applications manual.
4. Select the revenue sources that are most promising. This is basically a judgment by management about what sources should be considered in the decision process.
5. For the most promising revenue sources, define an overall revenue structure that would result from the phasing in of one or more alternative sources. This could include current revenue sources' continuing or being enhanced or phased out.
6. Perform tradeoff analyses to display to decision makers what the choice of one future revenue structure rather than another gains or loses, including a comparison of new revenue structures to the continuation of the current revenue structure.
7. Perform sensitivity analyses with regard to major factors influencing the scenarios, including alternative fuels, vehicle miles of travel, fuel efficiency, monitoring and measurement technologies, and travel demand management.
8. Prepare recommendations and negotiate a course of action with the responsible decision makers.

The steps are shown and accomplished in a sequential manner, but in an area as complex as revenue structures, feedback or a return to previous steps is likely in response to the dynamics of the decision process. Each step is further outlined below.

Step 1. Gathering Information

The following information should be gathered from appropriate sources. Where sources are lacking, it may be necessary to apply judgment or extrapolate from existing information. Information needed for current tax sources includes but may not be limited to

- tax rate and base;
- revenue yield;
- administrative costs and procedures;
- estimated compliance costs;
- estimated evasion;
- forecasts of future revenue; and
- estimated incidence by vehicle class.

For alternative revenue sources, the following information is also needed:

- definitions and list of alternative sources;
- current measurable "units" affecting yields;
- forecasts of "units" over time; and
- previous proposals and studies.

Step 2. Initial Screening

The initial screening is accomplished through a preliminary evaluation of the revenue sources that considers several basic criteria related to adequacy of the revenue sources. Adequacy criteria include

- adequacy and tax rate;
- stability and predictability;
- responsiveness (to inflation and to road usage);
- flexibility; and
- appropriateness for dedication.

Initial screening in accord with these criteria provides information about whether the revenue source could provide sufficient, stable, and responsive revenues to be worth considering as a major element of future revenue sources, whether the revenue source could replace or augment motor fuel taxes, and whether or not there is a likelihood that the source or sources could be dedicated to surface transportation. Analytical resources required for these assessments are limited, and thus the screening can be accomplished without expensive analysis. This step allows study resources and policy efforts to be focused on alternatives that can meet these fundamental criteria.

The adequacy criteria are the most important screening criteria because a basic goal of this project is to identify alternatives to motor fuel taxes and evaluate them in comparison to continued reliance on motor fuel taxes. Motor fuel taxes account for 75 percent of federal highway tax revenues and for about 60 percent of all state highway agency revenues. If the alternative revenue source cannot provide comparable — or greater — revenues to federal or state governments, and if the source is not relatively stable and predictable, then it does not represent a reasonable alternative to motor fuel taxes.

If particular revenue sources do not satisfy these criteria, however, this does not imply that those sources should not be used. Even if particular sources do not meet these criteria, they can provide useful revenues to accomplish important goals.

Procedures and data sources for applying the adequacy criteria are identified in Table 15. Much of the application of adequacy criteria includes elements of judgment. The example evaluation in this chapter provides a discussion of these factors and example analyses of several potential types of revenue sources, including current fuel taxes, taxes on alternative fuels, registration fees, vehicle sales taxes, VMT fees, emissions fees, congestion pricing, and pavement-damage fees or weight-distance taxes.

Step 3. Application of Evaluation Criteria

Following screening for adequacy, the framework incorporates a comprehensive set of criteria under the categories of adequacy, equity, efficiency, and simplicity. Criteria related to adequacy are discussed in Step 2. The evaluation framework includes a description of how to develop estimates of how each potential revenue source will perform with regard to each criterion.

Simplicity and Effectiveness

Procedures and data sources for evaluating simplicity and effectiveness criteria are described in Table 16. They can be adapted based on experience in the specific local or state context and based on a range of previous and ongoing studies of these factors.

Equity

Equity evaluations are most commonly made with regard to

- vehicle class;
- income group; and
- geographic area.

Vehicle class equity is assessed through highway cost allocation studies. Available software can be used to allocate highway costs. However, experience has shown that the expenditure data are not quickly compiled or kept by agencies in the format necessary for highway costs allocation. To carry out a highway cost allocation study, detailed information on projected expenditures is necessary in categories for which allocation procedures are applied. Detailed information on the elements making up bridge projects, pavement rehabilitation projects, widening projects, new facilities, right-of-way, safety projects, and so forth, is necessary.

Income group equity should be assessed for all proposed individual sources and overall revenue packages defined in the next step. It is unlikely that any specific area data sources will be available in a format that allows evaluation of income group equity for various tax sources. Therefore, the national sources cited in the applications manual should be used for estimates.

Geographic equity among urban and rural users can be determined through a highway cost allocation study or from results of past studies, as illustrated in the applications manual. Both patterns of expenditure and patterns of usage by geographic area can be considered in determining geographic equity.

Economic Efficiency

The relationship of the proposed revenue source to economic efficiency should be considered. The evaluation of efficiency should be accomplished through a judgmental determination of whether the revenue source is likely to approximate the marginal cost of travel. Marginal cost is the cost of the trip to all of society including the impact of congestion on other users, not just on the trip maker. Congestion pricing and pavement damage pricing would charge the marginal cost of travel, or at least move in that direction.

Political Implementability

The potential for political support and implementability must be estimated judgmentally by management.

Step 4. Selecting Promising Sources

Based on the evaluation results, some potential sources may no longer seem to be promising. These sources should be deleted from further consideration. This step is based primarily on the judgment of top management. The remaining steps help guide the harder choices from among the more promising revenue source alternatives, and evaluate how promising sources could fit into an evolving revenue structure.

Step 5. Defining Overall Revenue Structure Alternatives

In this step, analysts will define for the most promising sources an overall revenue structure or alternative structures that

TABLE 15. Procedures and data sources for adequacy screening

Specific Adequacy Criterion	Data Sources	Recommended Procedures
Consistency with New Approach	Review proposed new approach and modify as necessary for applicability to specific context	Apply judgment
Adequacy and Tax Rate	Current tax rates and yields for existing sources Units of activity for new sources	Estimate future year yields by multiplying rates by forecast units of activity Adjust for evasion Compare to needed revenues
Stability and Predictability	Compilations of: (1) revenue trends for existing sources (2) unit trends for new sources (3) comparisons of forecast versus actual revenues	Stability: Review data and apply judgment of whether source has been or will be monotonically increasing or stable over time. Predictability: assess available forecast procedures and apply judgment of confidence level in forecasts.
Responsiveness - to inflation - to road usage	Compilations of: (1) yearly revenue trends for existing sources 2) units of activity for new sources Compare to: (1) inflation trends (2) VMT trends	Compare trends of existing revenue sources graphically and in terms of average annual growth rate to trends in inflation and VMT. For new sources, compare trends in taxable units to trends in inflation and VMT.
Flexibility	Compilations of: (1) history of changes in tax rates (2) any special factors which have fostered or hindered changes	For existing sources, compile average number of tax rate changes over ten year period; apply judgment about whether future will reflect past. For new sources, apply judgment.
Appropriateness to Dedication	Compilations of: (1) relationship of tax source to vehicles, fuels, vehicle activity (2) dedications of other sources to other functional areas	Apply judgment of whether or not a case can be made that the potential source is a user fee or can otherwise be related to surface transportation program needs.

would result from phasing in one or more alternative sources. The overall revenue structure could include current revenue sources' continuing, being enhanced, and/or being phased out. For each individual revenue source, the adequacy, simplicity, and effectiveness criteria can be assessed. However, overall revenue structures are the appropriate focus of analyses of equity and efficiency.

The development of packages should be based on the findings

TABLE 16. Procedures and data sources for simplicity and effectiveness criteria

Simplicity and Effectiveness Criteria	Data Sources	Recommended Procedures
Point of Taxation	For existing sources, compile tax code and procedures, and numbers of accounts or filings or other transactions.	For existing sources, summarize taxable activity, and numbers of accounts or filings or other transactions.
Number of Taxpayers	For new sources, estimate point of taxation and numbers of accounts, from activity being taxed and taxable units.	For new sources, estimate activity to be taxed, and numbers of taxable entities (e.g., households and businesses, vehicles, sales establishments, etc.)
	Use examples from the applications manual for default values.	Use examples from the applications manual for guidance on estimates.
Compliance Cost	For existing sources, compile available estimates of time for compliance made by agency or other entities.	Multiply numbers of accounts or transactions by average unit cost of compliance.
	Use sources from examples in the applications manual for default values.	Use sources from examples in the applications manual for default values.
Potential for Tax Evasion	Solicit available studies of evasion of agency revenue sources.	Expert judgment by tax agency auditing and analytical staff.
	Solicit estimates of tax collection administrators and auditors.	Interview participants in FHWA sponsored fuel tax evasion studies for judgments.
	References cited in the applications manual for default or comparative values.	Review against results of studies cited in the applications manual.
Administrative Costs	For existing sources, compile: (1) costs and personnel levels for administration of taxes (2) other costs for audit and enforcement (office and field) (3) estimates of units of taxpayers	Apply expert judgment of administrative managers of tax collection agencies, utilizing existing administrative costs as a guide.
	For new sources, contact outside agencies, if any, which use such sources. Review procedures and assumptions from examples in the applications manual.	For new sources, utilize the referenced estimates from previous studies as included in the applications manual.

of the analysis to date, and on the known problems of the current revenue structure (e.g., declining revenues, inequity, high administrative cost, etc.). The rationale for each package should be identified. The major goal of this step is to select potentially promising evolutionary paths for revenue structures.

Step 6. Tradeoff Analysis of Revenue Alternatives

A key part of the framework is the use of tradeoff analysis to illustrate to all decision makers and analysts the critical differences among the revenue alternatives. Tradeoff analysis is a means of determining and illustrating what is better or worse about one choice versus other choices. It provides focused answers to what is gained and what is lost with one choice versus another choice. The framework provides an illustration of how to display the critical tradeoffs and how to provide a supporting discussion that will facilitate a decision.

Tradeoff analysis is recommended because it provides the best summary information on which to base a decision. It is not like scoring functions, which purport to supply "weights" to all variables. Scoring functions hide the critical choices in a mass

of calculations and judgments. There is no objective way to assign weights to the different criteria, despite the fact that scoring functions attempt to do so. The best approach is to use tradeoff analysis within the decision-making process itself to determine the weights, rather than to determine the weights outside the real decision process.

The tradeoff analysis proceeds with the following steps:

1. Summarize the comparisons of revenue structure alternatives. Table 17 illustrates a summary comparison of revenue alternatives, showing side by side how particular promising tax sources look on each of the principal criteria. It is critical to note that the criteria are not given any judgmentally different levels of importance in this display. This allows decision makers and others to see the alternatives next to each other, and informs them of their comparative importance. Entries in the table are taken from the example evaluation results included in the interim report. Those were generally presented for both state and federal levels in ranges; the entries here are simplified because this is only an example of a display rather than a presentation of the results of applying the methods.

The example illustrates current motor fuel taxes versus a complete switch to fees based on VMT, which would vary across different vehicle classes.

2. Compare each alternative with continuation of current revenue sources. Table 18 illustrates how an alternative can be compared to the current revenue structure in what has to change, what is gained, and what is lost. This table is a consolidation of Table 15; rows for which the alternative revenue sources or structures show no appreciable differences have been deleted.

3. Display the differences among alternatives. A table that illustrates the major differences between the alternatives will look exactly the same as Table 18 except with a comparison between two new potential revenue sources or structures. To construct this table, those criteria on which the two alternatives are basically equal are deleted. Of course, different criteria may be deleted for each two-by-two comparison of this type.

Step 7. Performing Sensitivity Analysis with Regard to Scenarios

In this step, the analyst and top management identify the scenarios, if any, they wish to consider for the future. These could include such items as penetration of alternative fuels, diversion of user fees to nontransportation programs, and development of vehicle monitoring and VMT measurement technologies. A scenario spreadsheet analysis procedure is made available through TRB for these analyses. Scenarios and the methodology for scenario analysis are discussed below. Table 19 shows an example result of how scenarios have an impact on the comparison of motor fuel taxes and VMT fees.

Step 8. Preparing Recommendations and Negotiating a Course of Action

In this step, the study phase is completed and top management decides on a preferred revenue structure and strategy.

3.3 APPLYING THE EVALUATION FRAMEWORK: AN EXAMPLE

This section provides an example of how a state transportation agency might apply the methodology. While the example is based on data from a case available to the project team, the following illustrations are general and cannot be taken as conclusions for an actual study. First, the example is introduced by the illustrative summary tables that will result from the application of the framework. Then, each step is discussed.

Alternative Taxes To Be Evaluated

The five alternative taxes selected for evaluation are

1. VMT tax;
2. emissions-indexed VMT tax;
3. congestion tax;
4. enhanced vehicle registration fees; and
5. sales tax on new vehicles.

The five categories of evaluation criteria to be used are

1. adequacy,
2. simplicity and effectiveness,
3. equity,
4. economic efficiency, and
5. ease of implementation and acceptability.

In this example, results of the evaluation will be developed for each of the five categories of criteria. Exhibits accompanying the discussion illustrate the types of comparative information that result at each step in the evaluation process. The following example proceeds only through Step 7, the sensitivity analysis.

■ STEP 1: GATHERING INFORMATION ON CURRENT TAXES AND YIELDS

Based on data reported in the FHWA publication *Highway Taxes and Fees: How they are Collected and Distributed, 1991,* motor fuel taxes in the state yielded $1,918,999,000. Alternative taxes will be considered relative to this revenue base. Table 20 details the rates and yields from the fuel tax and other state transportation and vehicle ownership taxes and assessments.

■ STEP 2: INITIAL SCREENING

Table 21 shows the required tax rate and taxable "unit" for each of the revenue alternatives under consideration. The required rate is that which will yield the necessary tax revenue, i.e., the rate that will produce revenue equal to that of the existing motor fuel taxes.

The calculation of these required rates assumes the tax will have no effect on the behavior of motor vehicle owners and operators. This "zero elasticity" assumption is intended as a baseline. To the extent that behavior is modified by the tax, the tax rate would need to be raised to compensate for the decline in VMT, emissions, congestion, vehicle registrations and/or new vehicle sales. These calculations using Table 21 are discussed below for each revenue source.

TABLE 17. Summary comparison of current fuel taxes and VMT fees

Criterion	Current Fuel Taxes	VMT Fees	Differences
Consistency with a New Approach	Partially	Fully	VMT fees more consistent
Adequacy and Tax Rate	Yes	Yes	No difference
Stability and Predictability	Yes	Yes	No difference
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation, unless indexed; Partially responsive to VMT	Non-responsive to inflation, unless indexed; Fully responsive to VMT	No difference for inflation; VMT, of course, tracks VMT best
Flexibility	Yes; can be adjusted	Yes; can be adjusted	No difference
Appropriateness of Dedication	Yes	Yes	No difference
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes many fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$13 to $22/year per taxpayer	Motor fuel taxes less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% (perhaps greater)	Gasoline taxes lower evasion than VMT fees; diesel and gasohol comparable to VMT fees
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$290 million per year for all states combined	Motor fuel taxes less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	VMT fees more appropriate
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	VMT fees slightly less incident on lower income groups than fuel taxes	No appreciable difference
Equity by Geography	Dependent on highway cost allocation results	Dependent on highway cost allocation results	No appreciable difference
Relationship to Economic Efficiency	Partially promotes economic efficiency	Partially promotes economic efficiency	No appreciable difference
Ease of Implementation	Assumed high	Assumed low	Fuel taxes more implementable

ADEQUACY CRITERIA

VMT Tax

Revenue Sufficiency. Annual vehicle miles of travel (VMT) in the state is 257,976 million miles. A tax rate of 0.74¢ per mile would produce just over the necessary yield of $1,918,999,000 (from the tax to be replaced), assuming it were assessed on all vehicles traveling in the state ($.0074 × 257,976,000,000 = $1,909,022,400.) If the tax were assessed only on those vehicles registered in the state, the tax rate would need to be increased to compensate for the revenue lost on the

TABLE 18. Summary of differences between current fuel taxes and VMT fees

Criterion	Current Fuel Taxes	VMT Fees	Differences
Consistency with a New Approach	Partially	Fully	VMT fees more consistent
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation, unless indexed Partially responsive to VMT	Non-responsive to inflation, unless indexed Fully responsive to VMT	No difference for inflation VMT, of course, tracks VMT best
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes many fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$13 to $22/year per taxpayer	Motor fuel taxes less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% (perhaps greater)	Gasoline taxes lower evasion than VMT fees; diesel and gasohol comparable to VMT fees
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$290 million per year for all states combined	Motor fuel taxes less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	VMT fees more appropriate
Ease of Implementation	Assumed high	Assumed low	Fuel taxes more implementable

miles traveled within the state by vehicles registered out of state. One would need to estimate the percent of VMT attributed to in-state and out-of-state vehicles to develop the appropriate scaling factor. If, for example, 90 percent of VMT is attributed to in-state vehicles, the appropriate tax rate would rise to 0.82¢/mile (0.74/0.9 = 0.82).

Stability. A VMT tax would be relatively stable. VMT is projected to continue to grow as population and vehicle ownership grow, barring any unforeseen fuel shortages. Tax revenues would grow in proportion to the growth in VMT.

Inflation/usage effects. Inflation would erode the value of this tax so it might become necessary to alter the tax rate to obtain a targeted real yield. VMT growth rates will also be under pressure in districts that fail to meet current air quality standards. To the extent that the travel demand management measures are successful at reducing VMT, VMT tax yields will also decline.

Emissions-Indexed VMT Tax

Revenue Sufficiency. The average exhaust emissions for the state's passenger car fleet was 0.73 g/mi. Other vehicle classes (e.g., trucks), on average, have higher emission rates per mile. The passenger car fleet emissions of exhaust are expected to fall to 0.47 g/mi in the future as air quality improvement plans are implemented. If the current automobile emissions rate is used for the state's entire vehicle fleet, a tax rate of just over 1¢/g/mi would yield the necessary revenue (1.02¢/g × 0.73 g/mi × 257,976,000,000 mi = $1,920,889,296). If the tax were assessed only on passenger vehicles, the rate would rise to 1.44¢/g, assuming that passenger vehicles account for 71 percent of VMT. The latter rate applied only to passenger vehicles would yield $1,926,125,700 (1.44¢/g × 0.73 g/mi × 183,231,140,000 mi).

Stability. Evasion, enforcement, and revenue instability would be endemic in an emissions-indexed VMT tax. Vehicle owners would be required to have functioning odometers and present their vehicles for emissions inspection to assess the tax incurred. Even if odometer and emissions-systems tampering were not possible, the revenue stream would decline over time as newer, less-polluting vehicles replace the existing fleet. The decline in emissions/mile overwhelms the expected 1 percent to 2 percent annual growth in VMT. (The emissions decline from 0.73 g/mi to 0.47 g/mi is a 35.6 percent reduction. While this rate of emissions reduction per mile cannot continue indefinitely, a decline is projected through the beginning of the next century.) The rate per gram would need to be continually revised upward to maintain a steady revenue stream as emissions/mi fall at a faster rate than VMT grows.

Inflation/Usage Effects. Inflation would erode the real value of the revenue from this alternative. The tax is directly related

TABLE 19. Example analysis of sensitivity of tradeoffs to scenarios

Criterion	Current Differences	Differences Under Scenarios
Consistency with a New Approach	VMT fees more consistent	VMT fees more consistent under VMT measurement scenario
Responsiveness (to Inflation and to Road Usage)	No difference for inflation VMT, of course, tracks VMT best	VMT fees become better under VMT measurement scenario; fuel taxes become worse under High Fuel Economy Scenario
Point of Taxation and Incidence	Motor fuel taxes assessed on fewer taxpayers	None
Compliance Cost (Cost of Paying)	Motor fuel taxes less expensive	Differences diminish under High CNG/Electric Scenario
Potential for Tax Evasion	Gasoline taxes lower evasion than VMT fees; diesel and gasohol comparable to VMT fees	Evasion of VMT fees becomes less under VMT measurement scenario; Evasion of fuel taxes becomes greater under High CNG/Electric Scenario
Administrative Costs (Costs of Collecting) and Issues	Motor fuel taxes less expensive	Differences diminish under High CNG/Electric and VMT Measurement Scenarios
Equity by Vehicle Class	VMT fees more appropriate	Equity under fuel taxes diminishes under Diversion Scenario
Ease of Implementation	Fuel taxes more implementable	No change

to VMT so revenue would grow in line with increased road usage. If fleet average emissions/mile stabilize in the future (long term), the emissions-indexed VMT tax becomes a *de facto* VMT tax.

Congestion Tax

Revenue Sufficiency. If travel on all roads is subject to a congestion tax, virtually any revenue target could be achieved. However, if only certain roads are subject to the tax, motorists could seek untaxed alternatives, possibly leading to revenue shortfalls. The tax yield is critically dependent upon the extent of the taxable road network.

Stability. Congestion tax is unlikely to be stable. If the tax succeeds in reducing congestion, either through reducing trips or diverting them to alternative facilities or different times of the day, the revenue yield would fall. If travel patterns are not greatly affected by the tax, then revenue would become a function of changes in VMT, which should be relatively stable. More in-depth study is needed before this elasticity can be estimated with any degree of confidence.

Inflation/Usage Effects. Inflation would erode the real value of the tax yield unless the tax rate were indexed. Yield will increase as congestion rises and decline if congestion is reduced. If nontaxed alternative roads exist, the congestion tax yield may not be sensitive to total roadway usage.

Enhanced Vehicle Registration Fee

Revenue Sufficiency. All motor vehicles are currently assessed a registration fee. The fee could be increased by vehicle class to attain any targeted revenue. An average increase of $79.00 per vehicle would attain the required revenue.

Stability. Vehicle registrations are unlikely to experience any significant changes in their growth rates unless fees become excessively high. In the absence of high fees, revenue would be expected to grow at a stable rate, approximately in line with population growth.

Inflation/Usage Effects. If the registration fee is a flat fee per vehicle class then inflation will erode its value. If the rate is indexed to the vehicle value, inflation will not reduce the real yield. The responsiveness of the yield to road use depends on the intensity of vehicle use. High registration fees would be expected to lead to more intensive use (i.e., registration of fewer vehicles with no corresponding reduction in VMT) to reduce

TABLE 20. Rates and yields of current taxes and assessments

Tax or Revenue Source	Rate or Unit Cost	Yield ($ thousand)
Motor Fuel:		$1,918,999
gasoline, diesel, gasohol	$ 0.15/gallon	
other	0.06/gallon	
Driver Licensing	$ 4/year	$76,946
Vehicle Registration:		$1,075,710
automobile	$ 24/year	409,535
bus	202/year	5,107
truck	110/year	522,181
trailer	68/year	121,461
motorcycle	27/year	17,426
Vehicle Licensing: Averages		$2,202,538
automobile	$ 98/year	1,668,642
bus	166/year	4,185
truck	95/year	452,401
trailer	33/year	57,927
motorcycle	30/year	19,383
Carrier Gross Receipts		$13,255
Other		$262,214
Total including motor fuel		$5,549,662

TABLE 21. Alternative taxes and rates

Tax or Revenue Source	Taxable Unit	Fuel-Tax Yield Equivalent Rate
VMT tax	Miles traveled	$0.0074/mile
Emissions-indexed VMT tax	Grams/mile of HC times miles traveled	$0.0102/gram/mile
Congestion tax	Miles traveled	*
Enhanced vehicle registration fees	Vehicle	$79/vehicle
New vehicle sales tax	Vehicle	$1,269/vehicle

*More detailed data needed on travel patterns, including time of day, route and link choices, for a full congestion pricing analysis. The average would be the same as for the VMT tax.

average cost per mile for vehicle owners. This wedge between road use and fees would be expected to be minimal if fees were low enough not to discourage the ownership of additional vehicles. An average of $79.00 per vehicle is probably low enough.

Sales Tax on New Vehicles

Revenue Sufficiency. The state registered 1,005,896 new passenger vehicles and 502,267 new trucks in a recent year. At an average tax of $1,269 per vehicle, a sales tax on new vehicles

would yield sufficient revenue: $1,269 × 1,508,163 = $1,913,858,874. The tax would be about 8.5 percent for a $15,000 vehicle. If assessed only on passenger vehicles, the average tax per vehicle would rise to $1,908, a rate of 12.7 percent for a $15,000 vehicle. Rates of this magnitude are not infeasible but are high enough to be considered unlikely.

Stability. Purchases of new cars respond to (as well as help cause) fluctuations in the business cycle. Revenue based on new car sales would be unstable, showing periods of large increases and periods of substantial declines. In addition, a tax on new vehicles might have the initial effect of delaying purchases as people find it more worthwhile to maintain the existing fleet. Increasing longevity of motor vehicles, due in part to better construction, will be expected to reduce the rate of new vehicle purchases, even during periods of economic expansion.

Inflation/Usage Effects. A flat tax per vehicle will not respond to inflation. A tax indexed to vehicle value, as sales taxes typically are, will not be harmed by inflation. The tax yield will be only minimally responsive to road usage, however, because more intensive usage of the existing fleet is a viable alternative to new vehicle purchases in many instances. A very high rate will discourage new vehicle purchases but may have no effect on VMT.

■ STEP 3: APPLICATION EVALUATION CRITERIA

Evaluation of each revenue source against the criteria described previously is based on data gathered from federal or state sources.

VMT Tax

Additional Compliance Costs. Assuming a one-time cost of $30.00 per car for a hubodometer, the cost for retrofitting the entire fleet of private and commercial automobiles would be $512,034,090. The annual filing fee of $1.70 per vehicle would cost $37,153,913 if all classes of vehicles were required to file and $29,015,265 if only automobiles were assessed. The $1.70 per vehicle estimate assumes the reporting takes 10 minutes per vehicle and time is valued at $10.00 per hour.

Evasion Potential. With current odometer technology, tampering is simple and widespread. A hubodometer would reduce tampering. If vehicle owners read their own odometers and report their own mileage there is a strong potential for underreporting. The estimated evasion rate is 10 percent.

Additional Administrative Costs. Marginal enforcement costs are estimated to be $14,643,013 if the VMT tax is assessed on all vehicle classes and $11,435,428 if assessed only on automobiles.

Emissions-Indexed VMT Tax

Additional Compliance Costs. As with the VMT tax, a more reliable odometer would be needed. The one-time fee of $512,034,090 described under the VMT tax would also apply to the emissions-indexed VMT tax. In addition, vehicle owners would be required to have their vehicles' emissions measured at a state-certified location. The travel and wait time costs of the inspection are estimated at $20/vehicle. If all classes of vehicles are subject to the tax, the annual time costs would be $437,104,860. If the tax were applied only to automobiles, the time costs would be $341,560,060.

Evasion Potential. As with the VMT tax, the degree of "tamper-proofness" of the odometer has a significant impact on the ability to underreport mileage. In addition, older vehicles' emissions control systems are prone to malfunctioning or tampering. If the tax is based on a single emissions test, there is a strong incentive for vehicle owners to minimize emissions for the test but allow them to rise afterward. Random roadside emissions inspections would help reduce this problem. Estimated evasion rate is 2 percent to 10 percent, but could be higher if lower enforcement levels occur.

Additional Administrative Costs. Marginal enforcement costs are estimated to be $14,643,013 if the emissions-indexed VMT tax is assessed on all vehicle classes and $11,435,428 if assessed only on automobiles. Remote sensing and/or roadside inspections would increase these costs.

Congestion Tax

Additional Compliance Costs. Individual vehicle transponders would be required to record travel along congested roadways. These one-time costs range from $20.00 to $50.00 per vehicle, for a fleet total of $437,104,860–$1,092,762,150, assuming all private and commercial automobiles, buses, and trucks were outfitted. Annual filing fees have been estimated at $11/vehicle, a fleet total of $240,407,673. Annual transaction fees (to record vehicle movement past receptors) are estimated at $78/vehicle, a fleet total of $1,704,708,954.

Evasion Potential. If all roadways are charged, it would be difficult to evade the tax. However, if the toll applies only to selected roads, legal evasion, in the form of alternate routes, may be quite high. It is unclear to what extent the automated identification systems can be fooled or evaded by a given vehicle.

Additional Administrative Costs. Costs for billing, collection, and enforcement have been estimated to range from $20.00 to $40.00 per vehicle, for annual costs of $437,104,860–$874,209,720.

Enhanced Vehicle Registration Fee

Additional Compliance Costs. Changing the rate would produce no additional filing costs.

Evasion Potential. Same as for current vehicle registration fees, estimated at 1 percent to 5 percent.

Additional Administrative Costs. None.

Sales Tax on New Vehicles

Additional Compliance Costs. A rate change would incur no additional compliance costs.

Evasion Potential. Same as for current new vehicle registrations.

Additional Administrative Costs. None.

EQUITY CRITERIA

VMT Tax

Vehicle Class. If tax rates vary by class based on the results of a state highway cost allocation study, the results will be highly equitable between classes.

Income Group. Based on recent household travel survey results, a VMT fee will have a disproportionate impact on lower-income households despite their relatively low VMT (the lowest income quintile produced 9 percent of regional household VMT while the highest income quintile produced 33 percent). A tax of 1¢ per mile would amount to 2.6 percent of household income for the lowest income quintile but only 0.4 percent of household income for the highest income quintile. This is clearly regressive. It is also consistent with national data indicating that lower income households spend a higher proportion of income on vehicle operating costs, oil, and fuel than do higher income households: 7.9 percent for the lowest quintile and 1.9 percent for the highest quintile, according to the U.S. Department of Energy's *1988 Household Vehicles Energy Consumption* survey.

Geographic. Nearly 80 percent of the state's total VMT occurs on urban roads. If these roads receive approximately the same percentage of funds from the VMT tax, it would be considered equitable.

Emissions-Indexed VMT Tax

Vehicle Class. Although certain vehicle classes have higher emissions per mile than others, the emissions-indexed VMT tax is based on an estimate of total emissions per vehicle (emissions per mile times miles traveled equals total emissions). Because taxes are directly proportional to emissions, equity is high between vehicle classes when assessed in the context of the emissions externality. In the context of road damage and benefits, heavier vehicles would probably need to be assessed a higher tax rate per mile unless their average emissions per mile are proportionately higher than other vehicle classes.

Income Group. Within the class of private vehicles, the emissions tax, like the VMT tax, has a disproportionately harder impact on lower income households. Although the state's lowest income quintile does not necessarily own the majority of higher emitting (pre-1980) vehicles, older vehicles constitute a relatively high percentage of the vehicles owned by these households. Lower income households would pay the lowest annual emissions tax of any income group ($252.00 compared to $303.57 for the second-highest income quintile) but this represents a higher percentage of household income (4.2% and 0.7%, respectively).

Geographic. This tax would be equitable in the emissions externality because air quality degradation is greater in areas with high VMT. However, unless the tax rate varied geographically, it would value the damage caused by a gram of emissions in a relatively unpolluted region the same as one in a polluted region although the latter causes greater marginal social damage. If rural households own a disproportionate share of high-emitting vehicles, this tax would be inequitable because they would pay a greater share in taxes than they would receive in roadway benefits.

Age distribution of vehicles by county would be used to analyze the expected tax by location.

Congestion Tax

Vehicle Class. If all vehicles face the same rate per mile, the results would be inequitable because heavy trucks use more road space and cause greater roadway wear than do passenger vehicles. If vehicle rates differ by vehicle class, equity can be obtained.

Income Group. Generally inequitable for the same reasons discussed under the VMT tax. Increasing the operating cost/mile has a disproportionate impact on lower income households. The extent of the inequity depends in part on the extent of the congestion pricing network. If unpriced roads continue to exist, they may offer an opportunity to avoid paying the congestion tax. However, this may result in increased time costs if the alternative becomes congested.

Geographic. Congested locations bear the burden of the tax while uncongested areas get a "free ride." This is equitable for pricing the congestion externality itself. However, to the extent that revenues are used to support the uncongested roadways, the tax is inequitable.

Enhanced Vehicle Registration Fee

Vehicle Class. This can be equitable only to a point even if rates vary across classes. Road use is not directly affected by this annual fixed cost, so low-use vehicles within a class would pay a disproportionate share relative to the benefits they receive.

Income Group. A flat fee per vehicle will be regressive. A fee that is based on vehicle value will be more equitable across income groups because lower income households, on average, own vehicles of lower value than do higher income households.

Geographic. The equity would depend on the nature of the fee (flat fee or dependent on vehicle value) and the number and value of vehicles in different geographic locations relative to the road financing requirements in those regions. More detailed study would be required.

New Vehicle Sales Tax

Vehicle Class. This is somewhat equitable between vehicle classes if rates vary across classes but it places an undue burden on new vehicle owners relative to other road users. As with registration fees, by uncoupling the tax from roadway usage, the tax does not balance costs with benefits within a vehicle class.

Income Group. Lower income households generally buy fewer new vehicles than higher income households, so the aggregate effect appears to be equitable. However, if the sample is limited only to those households that purchase new vehicles, the tax will be regressive. This is especially true for a flat tax. The inequity lessens if the tax is assessed as a percentage of new vehicle value.

Geographic. A more detailed study of the average age of vehicles in urban and rural areas and the number of new vehicles purchased relative to the roadway revenue received in different regions would be required to assess the geographic equity of this tax.

Economic Efficiency Criteria

VMT Tax

Because different vehicle classes impose different marginal costs on the roadway, setting varying rates for VMT across classes is a step toward economic efficiency. However, the marginal social cost of travel *within* vehicle classes depends on roadway conditions, particularly the level of congestion. As the VMT tax assesses all miles traveled by vehicle class at a constant rate, the tax rate will rarely equal the variable marginal social cost.

VMT-Indexed Emissions Tax

As with the VMT tax, the marginal social cost of a gram of emissions varies with atmospheric conditions. Given that the tax rate is fixed and the marginal social damage of the emission varies, this tax cannot be economically efficient. However, to the extent that higher-polluting vehicles would pay higher taxes, an emissions tax would be efficiency-enhancing.

Congestion Tax

If the rate varied with the instantaneous level of congestion experienced on the roadways, this tax would be efficient. To the extent that rates can vary with the average level of congestion, this tax is a big step toward economic efficiency.

Enhanced Vehicle Registration Fees

This tax is inefficient because it imposes a fixed cost on vehicle ownership but is completely unrelated to vehicle usage. Ownership imposes no social cost on the roadways.

New Vehicle Sales Tax

As with registration fees, this is a fixed cost and has no direct relationship to road usage. It cannot be economically efficient.

Ease of Implementation, Political Acceptability, and Other Criteria

VMT Tax

As with any new tax, the political acceptability is questionable. The tax would require additional paperwork although it could be assessed in conjunction with the mandatory emissions inspection (odometer readings are already part of the inspection). If "tamper-proof" odometers are required to be retrofitted onto the existing fleet, implementation would be more complicated.

Emissions-Indexed VMT Tax

This tax is more complicated than most other existing taxes. Public education would be required, complicating both political acceptability and ease of implementation. In addition, the possibility of tampering with the odometer and the emissions control system argues for a frequency of testing (either remote sensing or roadside inspections) that would result in a perception of a greater invasion of motorists' privacy than that of other taxes.

Congestion Tax

Political acceptability of this tax is difficult to assess. Most travelers are acutely aware of the problems of congestion but few wish to take any responsibility for it. Years of trying to "build oneself out of congestion" have left many believing that is still the answer. However, more people recognize that new solutions to congestion are needed and may be willing to give this one a try. Implementation would be very difficult as technology would be required for monitoring vehicle movement and billing or debiting the appropriate accounts.

Enhanced Vehicle Registration Fee

Relatively easy to implement because this is simply a rate change for an existing fee. If this tax replaced motor fuel taxes it would probably be more politically acceptable than if it were to supplement them. A graduated tax rate based on the vehicle's value might be more acceptable than a flat rate because of income equity concerns with the latter.

New Vehicle Sales Tax

Easy to implement because fees are already collected at the time new vehicles are registered. Politically this would be more difficult, however, because the automobile industry would not be keen to see the average price of their product increase by $1,000 or more.

APPLYING STEPS 4, 5, AND 6

The results of these evaluations are summarized in Tables 22 through 26. The tables are the product of Step 3 in the overall process. Step 4 entails selecting the most promising candidates from those sources analyzed in Steps 2 and 3. For this example, all sources are assumed to be promising, so none are dropped.

Step 5, the "packaging" of potential new sources assuming present sources are continued, reduced, or expanded can quickly become unwieldy. There will typically be many possible combinations but some will be inconsistent or redundant. For example, a VMT tax would not be packaged with a congestion or emissions-indexed VMT tax due to the overlap in measurement units but a new vehicle sales tax could be considered in a package with use-based fees. The interdependencies of the sources are considered at this step, particularly the ability of one to overcome a deficiency in another. For example, sales tax revenue should keep pace with inflation while fuel taxes would not. Both have low administrative and compliance costs. Sales tax revenue is prone to cyclical shocks while fuel taxes are fairly stable. This type of analysis does not justify a particular package but provides the basis for evaluation of packages that may initially appear to be promising.

Step 6 allows alternatives to be compared across the criteria and provides a framework for highlighting the differences. In the example following, summary comparisons are shown between current motor fuel taxes and each other promising source. Tables 27 through 36 illustrate the summary comparisons and major differences between motor fuel taxes and each other major source: VMT fees, emissions-indexed VMT fees, congestion fees, enhanced registration fees, and sales taxes on new vehicles.

STEP 7: PERFORMING SENSITIVITY ANALYSIS WITH REGARD TO SCENARIOS

The major evaluation activity conducted for this research was the development and assessment of future scenarios that could have an impact on surface transportation finance. A detailed literature review was conducted of studies over the last 20 years that dealt with the potential for alternative fuels, fuel efficiency changes, technological changes, and other factors that would affect transportation revenues and transportation energy use. (Refer to Appendix D.)

As a result of the literature review of recent forecasts and scenario development studies in this field, several basic dimensions emerged as possible bases for defining scenarios:

- rate of introduction of alternative fuels;
- types of alternative fuels used;
- different environmental strategies;
- tax options to achieve environmental and/or energy goals;
- fuel economy achievements or standards; and
- success of vehicle monitoring technology.

The primary criteria used for choosing among these many basic different possible dimensions for scenarios are (1) What potential future directions are most likely to affect surface transportation funding? and (2) What potential future directions are likely to present unique challenges to surface transportation funding?

In defining scenarios, we did not make any clear distinctions between conditions that result from national policy decisions and those that result from technological advances and economic influences; i.e., we treat all these influences as essentially exogenous. Although transportation administrators do have some ability to influence national policy decisions, this ability is relatively limited. Accordingly, transportation administrators must recognize the possibility that national energy and environmental policy may complicate the task of funding the transportation system and they must be prepared to deal with any such possible futures. Furthermore, many of the conditions to be addressed (e.g., improvements in fuel efficiency) may well result from a combination of technological advances, economic influences (increasing real energy costs), and national policy. Our focus is on how the conditions that result from these developments can best be addressed, not the extent to which these conditions can be influenced by transportation administrators.

On the basis of the review of related programs, we concluded that transportation finance policy must be capable of dealing with alternative futures that may differ from each other in three ways:

- types of fuels used;
- fuel economy and energy conservation; and
- technological capability for measuring VMT.

After considering futures in each of these dimensions, we defined five scenarios for formal analysis in close consultation with the project panel. The five scenarios are described briefly below. Their implications for evaluation of alternative financing sources are summarized in Tables 37 through 41.

1. High Methanol. This future assumes that the life-cycle costs of methanol alternative fuel vehicles (AFVs), fuel production and distribution, and support systems are more reasonable than all other alternatives including reformulated conventional fuels. Methanol would displace the maximum feasible amount of petroleum fuels, taking into account supply limitations, vehicle turnover, and other constraints. By 2000, methanol would displace about 5 percent of gasoline consumption, and about 40 percent by 2020. Methanol was selected as an alternative fuel for analysis because it has been seen by some experts in the field as having the best chance of becoming the dominant alternative to petroleum fuels. It is superior to all existing and foreseeable forms of petroleum-based fuels from an environmental perspective, although it is not "clean" enough in comparison with some of the other alternatives to gain the support of many environmentalists.

Methanol production and distribution is likely to evolve into a relatively concentrated industry with fairly small numbers of suppliers, distributors, and production plants, and a dedicated pipeline distribution system. If so, tax collection is likely to be similar to that for gasoline. Opportunities for using untaxed methanol as a motor fuel are likely to be fairly limited.

2. High Compressed Natural Gas (CNG) or Electric. This future involves similar assumptions for these alternative fuels as does the High Methanol scenario, with about the same level of penetration achieved by the combination of these two types

TABLE 22. Adequacy and the tax rate: Summary table

Adequacy Criterion	VMT Tax	Emissions-Indexed VMT Tax	Congestion Tax	Enhanced Vehicle Registration Fee	New Vehicle Sales Tax
Can the tax generate as much revenue as the fuel tax?	Yes	Yes	Yes	Yes	Yes if rate is high enough
Will the revenue yield be stable over time?	Stable rate of growth	Should decline as cars get "greener"	Should decline if conditions get better	Stable rate of growth	Substantial cyclical fluctuations
Responsive to: - inflation? - road usage?	Inflation: no Usage: yes	Inflation: no Usage: yes	Inflation: no Usage: somewhat	Inflation: yes if based on vehicle value Usage: minimally	Inflation: yes Usage: minimally
Flexibility: how difficult is it to change the rate?	Moderate	Moderate	Difficult	Moderate	Moderate
Appropriate for dedication?	Yes	Somewhat	Yes	Yes	Yes

TABLE 23. Simplicity and effectiveness: Summary table

Simplicity & Effectiveness Criterion	VMT Tax	VMT-Indexed Emissions Tax	Congestion Tax	Enhanced Vehicle Registration Fee	New Vehicle Sales Tax
Point of Taxation	Individual vehicle/owner	Individual vehicle/owner	Individual vehicle/owner	Individual vehicle/owner	Individual vehicle/owner
Number of Taxpayers	Equals number of vehicle owners	Equals number of vehicle owners	Probably equals number of vehicle owners	Equals number of vehicle owners	Equals number of buyers of new vehicles
Additional Compliance Costs per Vehicle	$30: hubodometer + $1.70/year filing	$30: hub-odometer + $20/year time costs for vehicle inspection	$20-50: for transponder + $11/year filing + $78/ year transaction fees	None	None
Evasion Potential	Moderate to high	High	Low to high	Low	Low
Additional Administrative Costs per Vehicle	$0.67/year for enforcement	$0.67/year for enforcement	$20-40/year	Part of current collection system (nominal)	Part of current collection system (nominal)

TABLE 24. Equity: Summary table

Equity Criterion	VMT Tax	VMT-Indexed Emissions Tax	Congestion Tax	Enhanced Vehicle Registration Fee	New Vehicle Sales Tax
Vehicle class	Low if same rate for all vehicles; high if rate varies by class.	High if tax is assessed on all vehicle classes.	High if rates differ by class; low otherwise.	Low to moderate depending on degree of vehicle classification.	High if rates vary by vehicle class.
Income groups	Moderate; VMT grows with income.	Low to moderate; total emissions increase with VMT.	Low if alternative travel time/route not available.	High if % of vehicle price; low if *ad valorem*.	High if % of vehicle price; low if *ad valorem*.
Geographic	Low, since VMT varies by area	High if tax rate based on regional air quality.	High: congested locations pay; others do not.	High	High

TABLE 25. Economic efficiency: Summary table

Efficiency Criterion	VMT Tax	VMT-Indexed Emissions tax	Congestion tax	Enhanced Vehicle Registration Fee	New Vehicle Sales Tax
Can the tax rate be set in accordance with the marginal social cost? Is it likely to be?	No. Pricing travel aids efficiency but marginal social cost of VMT is variable, even within vehicle classes.	Could be based on damages caused by the emission but this is too complicated to assess in real time.	Efficient if rate varies with level of congestion as it should.	No, because fee would not affect usage. Basing fee on vehicle characteristics would be more efficient than a flat fee.	No. Tax discourages the purchase of new vehicles which are likely to be less polluting and safer; inefficient.

TABLE 26. Other criteria: Summary table

Criterion	VMT Tax	VMT-Indexed Emissions Tax	Congestion Tax	Enhanced Vehicle Registration Fee	New Vehicle Sales Tax
Ease of implementation	Low to moderate	Low	Most difficult	High	High
Political acceptability	Low	Low	Low	High	Low to moderate

TABLE 27. Case example: Summary comparison of current fuel taxes and VMT fees

Criterion	Current Fuel Taxes	VMT Fees	Differences
Adequacy and Tax Rate	Yes	Yes	No difference
Stability and Predictability	Yes	Yes	No difference
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; partially responsive to VMT	Non-responsive to inflation unless indexed; fully responsive to VMT	No difference for inflation; VMT, of course, tracks VMT best
Flexibility	Yes; can be adjusted	Yes; can be adjusted	No difference
Appropriateness of Dedication	Yes	Yes	No difference
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$30 per vehicle one-time cost for hubodometer; $1.70 per vehicle on-going reporting	Motor fuel taxes less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% (perhaps greater)	Gasoline taxes lower evasion than VMT fees; diesel and gasohol comparable to VMT fees
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$11.4 to $14.6 million per year for California	Motor fuel taxes less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	VMT fees more appropriate
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	VMT fees slightly less incident on lower income groups than fuel taxes	No appreciable difference
Equity by Geography	Dependent on highway cost allocation results	Dependent on highway cost allocation results	No appreciable difference
Relationship to Economic Efficiency	Partially promotes economic efficiency	Partially promotes economic efficiency	No appreciable difference
Ease of Implementation	Assumed high	Assumed low	Fuel taxes easier to implement

of energy sources. CNG and electricity are the two very clean fuels that probably have the best chance of high penetration of the market. Because of their superiority to methanol from an environmental perspective, either or both of these fuels could potentially achieve greater governmental support and become dominant instead of methanol.

This future differs substantially from the High Methanol future in difficulties in collecting fuel taxes. Natural gas and electricity currently are used widely as energy sources for purposes other than transportation, and therefore it probably will not be feasible to tax either of them at their production centers or at concentrated points in the distribution system. Neither of the two energy sources is likely to differ in any special way from the form in which it is used for other purposes, except that natural gas is compressed for motor vehicle use. However, this can be done easily in almost any location, such as in private

TABLE 28. Case example: Summary of differences between current fuel taxes and VMT fees

Criterion	Current Fuel Taxes	VMT Fees	Differences
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation, unless indexed; partially responsive to VMT	Non-responsive to inflation, unless indexed; fully responsive to VMT	No difference for inflation VMT, of course, tracks VMT best
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$30 per vehicle one-time cost for hubodometer; $1.70 per vehicle ongoing reporting	Motor fuel taxes less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% (perhaps greater)	Gasoline taxes lower evasion than VMT fees; diesel and gasohol comparable to VMT fees
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$11.4 to 14.6 million per year for California	Motor fuel taxes less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	VMT fees more appropriate
Ease of Implementation	Assumed high	Assumed low	Fuel taxes easier to implement

homes or garages. Consumption of CNG or electricity by vehicles may need to be monitored directly if these fuels are to be taxed.

3. High Fuel Economy. A High Fuel Economy scenario is likely to be driven by many of the same concerns as the alternative fuels scenarios — e.g., concerns about air quality, global warming, and dependence on foreign oil imports. Some tradeoffs are involved between the two types of scenarios. To the extent that a high level of penetration of alternative fuels is achieved, there will be less pressure to achieve high fuel economy standards, particularly for conventional fuels. Similarly, to the extent that high fuel economy standards are achieved for conventional fuels, there will be less pressure to achieve a high level of penetration of alternative fuels.

The literature review revealed that a wide range of possible future levels of fuel economy has been considered. After careful review of various forecasts and scenario analyses by others, we concluded that a target of 39 mpg for new autos by 2015 is a likely upper limit. This is based on a "Moderate Efficiency" scenario by the Office of Technology Assessment and a recent careful review of CAFE standards and related policies by the National Research Council (NRC).

NRC defined this level of fuel economy as "technically achievable," stressing that this should *not* be taken to mean the technological limit of what is currently possible. Rather, it is based on autos that are being mass produced somewhere in the world and that pay for themselves at gasoline prices of $5.00 to $10.00 per gallon or less (1990 dollars).

4. Tax Diversion/Alternative Fuels Subsidy Scenario. This scenario involves a combination of (1) maximum diversion of motor fuel tax receipts to the achievement of other national and international goals such as deficit reduction, energy independence, air quality improvement, and reduction of global warming impacts; (2) maximum tax subsidies for alternative fuels, alternative fuel vehicles, and fuel efficient vehicles; and (3) reduction of, and eventual elimination of, the dedication of fuel tax receipts for surface transportation finance.

When such a scenario is coupled with no major improvements in VMT measurement capability, transportation officials would most rapidly lose their dependence on motor fuel taxes and would have to depend on nonuser revenues more than in any other scenario considered. Application of the tax structure evaluation framework in this context involves another type of base case for comparison with the other results. It addresses the question of how the highway user tax structures under the other scenarios compare with reliance on the general tax structure in equity, efficiency, and other considerations.

5. Full VMT Measurement Capability Scenario. The technical capability of measuring the amount of travel by specific vehicles and the difficulty involved in doing it will largely deter-

TABLE 29. Case example: Summary comparison of current fuel taxes and emissions-indexed VMT fees

Criterion	Current Fuel Taxes	Emissions-Indexed VMT Fees	Differences
Adequacy and Tax Rate	Yes	Yes	No difference
Stability and Predictability	Yes	Less stable; expected to decline as emissions fall	Fuel tax more stable
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; partially responsive to VMT	Non-responsive to inflation unless indexed; responsive to VMT if emissions are constant	No difference for inflation; emissions-indexed VMT tax more responsive to VMT
Flexibility	Yes; can be adjusted	Yes; can be adjusted	No difference
Appropriateness of Dedication	Yes	Somewhat since also responds to need to improve air quality	Fuel tax more appropriate
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$30 per vehicle one-time cost for hubodometer; $20 per vehicle time cost for annual emissions inspection	Motor fuel taxes much less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% minimum	Gasoline taxes lower evasion; diesel and gasohol comparable
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$11.4 to $14.6 million; higher if remote sensing or random inspections also used	Motor fuel taxes less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Unlikely to reflect vehicle class cost responsibility per mile	No appreciable difference
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	Emissions-indexed VMT fees more incident on lower income groups than fuel taxes	Emissions-indexed VMT tax somewhat less equitable
Equity by Geography	Dependent on highway cost allocation results	Dependent on vehicle age distributions in different regions; rural fees likely to be higher	Emissions-indexed VMT tax expected to be less equitable
Relationship to Economic Efficiency	Partially promotes economic efficiency	Partially promotes economic efficiency	No appreciable difference
Ease of Implementation	Assumed high	Assumed low	Fuel taxes much easier to implement

mine whether it is feasible and desirable to substitute taxation of miles traveled for taxation of fuel consumed. This substitution might be partial even in the long term, or eventually a complete replacement for fuel taxes.

The ability to measure travel might also be partial or complete, even in the long term. Partial measurement might be achieved by a series of spot observations of vehicles on main routes or by continuous measurement of miles traveled on freeways or automated guideways. Complete measurement or approximate estimates of total miles traveled might be achieved by tracking of vehicles either on a continuous or frequent but periodic basis, or by periodic or annual readings of "tamper-proof" odometers. All these technical capabilities might vary widely in accuracy and degree of automation.

TABLE 30. Case example: Summary of differences between current fuel taxes and emissions-indexed VMT fees

Criterion	Current Fuel Taxes	Emissions-Indexed VMT Fees	Differences
Stability and Predictability	Yes	Less stable; expected to decline as emissions fall	Fuel tax more stable
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation, unless indexed; Partially responsive to VMT	Non-responsive to inflation unless indexed; responsive to VMT if emissions are constant	No difference for inflation; emissions-indexed VMT tax more responsive to VMT
Appropriateness of Dedication	Yes	Somewhat since also responds to need to improve air quality	Fuel tax more appropriate
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$30 per vehicle one-time cost for hubodometer; $20 per vehicle time cost for annual emissions inspection	Motor fuel taxes much less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	10% minimum	Gasoline taxes lower evasion; diesel and gasohol comparable
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$11.4 to $14.6 million; higher if remote sensing or random inspections also used	Motor fuel taxes less expensive
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	Emissions-indexed VMT fees more incident on lower income groups than fuel taxes	Emissions-indexed VMT tax somewhat less equitable
Equity by Geography	Dependent on highway cost allocation results	Dependent on vehicle age distributions in different regions; rural fees likely to be higher	Emissions-indexed VMT tax expected to be less equitable
Ease of Implementation	Assumed high	Assumed low	Fuel taxes much easier to implement

3.4 THE EVALUATION FRAMEWORK: CONCLUSIONS

The framework described in this chapter consists of a set of five types of criteria (i.e., adequacy, effectiveness, capacity, economic efficiency, and political implementability) for assessing potential sources of revenue for financing public surface transportation investment and an eight-step process for undertaking such assessments. The framework generally relies on comparison of alternative revenue sources to conditions now occurring with the motor vehicle fuel tax as the primary source of revenue.

As the example illustrates, data are generally available to support such analyses at state or substate levels, but substantial judgment is required. The framework is consequently useful primarily to structure thinking and discussion about alternative revenue sources. Final decisions about use of new sources as supplements or alternatives to the fuel tax will depend on the needs and values of transportation agency policy makers and their customers, working together within the context of a new contract linking more directly the sources of revenue and the beneficiaries of the investments.

TABLE 31. Case example: Summary comparison of current fuel taxes and congestion fees

Criterion	Current Fuel Taxes	Congestion Fees	Differences
Adequacy and Tax Rate	Yes	Yes if all roads taxed	No difference if all roads taxed
Stability and Predictability	Yes	Less predictable; depends on available untaxed alternatives	Congestion fee revenue less predictable
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; Partially responsive to VMT	Non-responsive to inflation unless indexed; Partially responsive to VMT	No difference for inflation; VMT response depends on ability to shift travel time/route
Flexibility	Yes; can be adjusted	Yes; can be adjusted	No difference
Appropriateness of Dedication	Yes	Yes	No difference
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$20-50 per vehicle transponder + annual filing fee of $11/vehicle + annual transactions fee of $78/vehicle	Motor fuel taxes much less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	Depends on extent of priced road network and technology used for recording and billing	Gasoline taxes lower evasion; diesel and gasohol taxes likely to have lower evasion, too
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$437 to $874 million per year	Motor fuel taxes much less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	Congestion fees more appropriate
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	Inequitable if alternate time/route not avail-able for lower income travelers	Fuel taxes more equitable
Equity by Geography	Dependent on highway cost allocation results	Rural travelers facing low congestion unlikely to pay full share of highway costs	Fuel taxes more equitable
Relationship to Economic Efficiency	Partially promotes economic efficiency	Promotes economic efficiency	Congestion fees more efficient
Ease of Implementation	Assumed high	Assumed very low	Fuel taxes much easier to implement

TABLE 32. Case example: Summary of differences between current fuel taxes and congestion fees

Criterion	Current Fuel Taxes	Congestion Fees	Differences
Adequacy and Tax Rate	Yes	Yes if all roads taxed	No difference if all roads taxed
Stability and Predictability	Yes	Less predictable; depends on available untaxed alternatives	Congestion fee revenue less predictable
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; partially responsive to VMT	Non-responsive to inflation unless indexed; partially responsive to VMT	No difference for inflation; VMT response depends on ability to shift travel time/route
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	$20-50 per vehicle transponder + annual filing fee of $11/vehicle + annual trans-actions fee of $78/-vehicle	Motor fuel taxes much less expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	Depends on extent of priced road network and technology used for recording and billing	Gasoline taxes lower evasion; diesel and gasohol taxes likely to have lower evasion, too
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	$437 to $874 million per year	Motor fuel taxes much less expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be set to vehicle class cost responsibility per mile	Congestion fees more appropriate
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	Inequitable if alternate time/route not available for lower income travelers	Fuel taxes more equitable
Equity by Geography	Dependent on highway cost allocation results	Rural travelers facing low congestion unlikely to pay full share of highway costs	Fuel taxes more equitable
Relationship to Economic Efficiency	Partially promotes economic efficiency	Promotes economic efficiency	Congestion fees more efficient
Ease of Implementation	Assumed high	Assumed very low	Fuel taxes much easier to implement

TABLE 33. Case example: Summary comparison of current fuel taxes and enhanced vehicle registration fees

Criterion	Current Fuel Taxes	Enhanced Vehicle Registration Fees	Differences
Adequacy and Tax Rate	Yes	Yes	No difference
Stability and Predictability	Yes	Yes	No difference
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; partially responsive to VMT	Flat tax does not respond to inflation but vehicle value tax does; minimally responsive to VMT	Registration fee potentially more responsive to inflation; neither very responsive to VMT
Flexibility	Yes; can be adjusted	Yes; can be adjusted	No difference
Appropriateness of Dedication	Yes	Yes	No difference
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	no additional cost	Motor fuel taxes more expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	Low	Registration fee evasion much lower than fuel tax
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	part of current collection system	Motor fuel taxes more expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Cannot be set to vehicle class cost responsibility per mile because the fee is a fixed cost	Fuel taxes more appropriate although neither is strongly linked to cost responsibility
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	Less incident on lower income groups if based on vehicle value; flat fee is regressive	Registration fees potentially more equitable
Equity by Geography	Dependent on highway cost allocation results	Depends on geographic distribution of vehicles	No appreciable difference
Relationship to Economic Efficiency	Partially promotes economic efficiency	Fixed cost cannot promote economic efficiency	Fuel taxes more efficient
Ease of Implementation	Assumed high	Assumed high	No appreciable difference

TABLE 34. Case example: Summary of differences between current fuel taxes and enhanced vehicle registration fees

Criterion	Current Fuel Taxes	Enhanced Vehicle Registration Fees	Differences
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; partially responsive to VMT	Flat tax does not respond to inflation but vehicle value tax does; minimally responsive to VMT	Registration fee potentially more responsive to inflation; neither very responsive to VMT
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	Vehicle owners; many taxpayers	Motor fuel taxes assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	No additional cost	Motor fuel taxes more expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	Low	Registration fee evasion much lower than fuel tax
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	Part of current collection system	Motor fuel taxes more expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Cannot be set to vehicle class cost responsibility per mile because the fee is a fixed cost	Fuel taxes more appropriate although neither is strongly linked to cost responsibility
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	Less incident on lower income groups if based on vehicle value; flat fee is regressive	Registration fees potentially more equitable
Relationship to Economic Efficiency	Partially promotes economic efficiency	Fixed cost cannot promote economic efficiency	Fuel taxes more efficient

TABLE 35. Case example: Summary comparison of current fuel taxes and sales taxes on new vehicles

Criterion	Current Fuel Taxes	New Vehicle Sales Tax	Differences
Adequacy and Tax Rate	Yes	Yes	No difference
Stability and Predictability	Yes	Subject to strong cyclical fluctuation	Sales tax much less stable
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; Partially responsive to VMT	Responsive to inflation; Non-responsive to VMT	Sales tax responds to inflation; fuel tax responds to VMT
Flexibility	Yes; can be adjusted	Yes; can be adjusted	No difference
Appropriateness of Dedication	Yes	Yes	No difference
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	New vehicle buyers	Gasoline tax assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	No additional costs	Motor fuel taxes more expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	Minimal	Motor fuel tax evasion higher than sales tax
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	No additional costs	Motor fuel taxes more expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be high if rates vary by class based on cost allocation but low if based on vehicle price	Sales tax potentially more equitable across vehicle classes
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	High if based on vehicle price; low if flat fee per vehicle	Sales tax potentially more equitable across income groups
Equity by Geography	Dependent on highway cost allocation results	Cannot assess	No appreciable difference
Relationship to Economic Efficiency	Partially promotes economic efficiency	Fixed costs cannot promote economic efficiency	Fuel taxes more efficient
Ease of Implementation	Assumed high	Assumed high	No difference

TABLE 36. Case example: Summary of differences between current fuel taxes and sales taxes on new vehicles

Criterion	Current Fuel Taxes	New Vehicle Sales Tax	Differences
Stability and Predictability	Yes	Subject to strong cyclical fluctuation	Sales tax much less stable
Responsiveness (to Inflation and to Road Usage)	Non-responsive to inflation unless indexed; Partially responsive to VMT	Responsive to inflation; non-responsive to VMT	Sales tax responds to inflation; fuel tax responds to VMT
Point of Taxation and Incidence	Varies, but few taxpayers for gasoline	New vehicle buyers	Gasoline tax assessed on fewer taxpayers
Compliance Cost (Cost of Paying)	Very low	No additional costs	Motor fuel taxes more expensive
Potential for Tax Evasion	Gasoline 3-5% Diesel and Gasohol 15-25%	Minimal	Motor fuel tax evasion higher than sales tax
Administrative Costs (Costs of Collecting) and Issues	$200 million per year for all states combined	No additional costs	Motor fuel taxes more expensive
Equity by Vehicle Class	May or may not be proportional to vehicle class cost responsibility	Can be high if rates vary by class based on cost allocation but low if based on vehicle price	Sales tax potentially more equitable across vehicle classes
Equity by Income Group	Somewhat higher proportion of income spent by lower income groups	High if based on vehicle price; low if flat fee per vehicle	Sales tax potentially more equitable across income groups
Relationship to Economic Efficiency	Partially promotes economic efficiency	Fixed costs cannot promote economic efficiency	Fuel taxes more efficient

TABLE 37. Sensitivity of tradeoffs to scenarios: VMT fees

Criterion	Current Differences	Differences Under Scenarios
Consistency with a New Approach	VMT fees more consistent	VMT fees more consistent under VMT Measurement Scenario
Responsiveness (to Inflation and to Road Usage)	No difference for inflation VMT, of course, tracks vmt best	VMT fees improve under VMT Measurement Scenario; fuel taxes worsen under high fuel economy scenario
Point of Taxation and Incidence	Motor fuel taxes assessed on fewer taxpayers	No change
Compliance Cost (Cost of Paying)	Motor fuel taxes less expensive	Differences diminish under high cng/electric scenario
Potential for Tax Evasion	Gasoline taxes lower evasion than vmt fees; diesel and gasohol comparable to vmt fees	Evasion of vmt fees declines under vmt measurement scenario; evasion of fuel taxes increases under high cng/electric scenario
Administrative Costs (Costs of Collecting) and Issues	Motor fuel taxes less expensive	Differences diminish under high cng/electric and vmt measurement scenarios
Equity by Vehicle Class	VMT fees more appropriate	Equity under fuel taxes diminishes under diversion scenario
Ease of Implementation	Fuel taxes easier to implement	No change

TABLE 38. Sensitivity of tradeoffs to scenarios: Emissions-indexed VMT fees

Criterion	Current Differences	Differences Under Scenarios
Stability and Predictability	Fuel taxes more stable	Emissions-indexed VMT tax becomes slightly more predictable under VMT Measurement scenario but still less stable than motor fuel tax
Responsiveness (to Inflation and to Road Usage)	No difference for inflation; emissions-indexed vmt tax more responsive to vmt	Fuel taxes become worse under high fuel economy scenario; emissions-indexed VMT tax improves under VMT measurement scenario
Appropriateness of Dedication	Fuel tax more appropriate	No change
Point of Taxation and Incidence	Motor fuel taxes assessed on fewer tax-payers	No change
Compliance Cost (Cost of Paying)	Motor fuel taxes much less expensive	Differences reduced under high CNG/Electric scenario
Potential for Tax Evasion	Gasoline taxes lower evasion; diesel and gasohol taxes comparable to emissions-indexed vmt fees	Reduced evasion of emissions-indexed VMT fees under VMT Measurement scenario; fuel tax evasion increases under high CNG/Electric scenario
Administrative Costs (Costs of Collecting) and Issues	Motor fuel taxes less expensive	Differences reduced under high CNG/Electric and VMT Measurement scenarios
Equity by Income Group	Emissions-indexed VMT tax somewhat less equitable	Income group equity worsens under high methanol, high CNG/Electric, high fuel economy scenarios until lower income groups can afford these lower emitting vehicles
Equity by Geography	Emissions-indexed VMT tax expected to be less equitable	Equity under fuel taxes diminishes under diversion scenario
Ease of Implementation	Fuel taxes much easier to implement	No change

TABLE 39. Sensitivity of tradeoffs to scenarios: Congestion fees

Criterion	Current Differences	Differences Under Scenarios
Consistency with a New Approach	Congestion fees more consistent	Congestion fees more consistent under diversion scenario
Adequacy	Congestion fees yield may be insufficient if only part of road network is taxed	Differences diminish under high fuel economy and diversion scenarios
Stability and Predictability	Congestion fee revenue less predictable	No change
Responsiveness (to Inflation and to Road Usage)	No difference for inflation; VMT responsiveness of congestion fee depends on ability to shift travel time/route	Fuel taxes worsen under high fuel economy scenario
Point of Taxation and Incidence	motor fuel taxes assessed on fewer taxpayers	No change
Compliance Cost (Cost of Paying)	Motor fuel taxes much less expensive	Differences diminish under high CNG/Electric scenario
Potential for Tax Evasion	Gasoline taxes lower evasion than vmt fees; diesel and gasohol taxes likely to have lower evasion, too	Fuel tax evasion increases under high CNG/Electric scenario
Administrative Costs (Costs of Collecting) and Issues	Motor fuel taxes much less expensive	Differences diminish under high CNG/Electric scenario
Equity by Vehicle Class	Congestion fees more appropriate	Equity under fuel taxes diminishes under diversion scenario
Equity by Income Group	Motor fuel taxes more equitable if alternative route or time not available for lower income travelers	Fuel tax equity worsens under high fuel economy scenario until lower income groups can afford the more efficient vehicles
Equity by Geography	Motor fuel taxes more equitable	Equity under fuel taxes diminishes under diversion scenario
Relationship to Economic Efficiency	Congestion fees more efficient	No change
Ease of Implementation	Fuel taxes much easier to implement	No change

TABLE 40. Sensitivity of tradeoffs to scenarios: Enhanced vehicle registration rees

Criterion	Current Differences	Differences Under Scenarios
Responsiveness (To Inflation and to Road Usage)	Registration fee potentially more responsive to inflation; neither very responsive to VMT	Fuel taxes worsen under high fuel economy scenario
Point of Taxation and Incidence	Motor fuel taxes assessed on fewer taxpayers	No change
Compliance Cost (Cost of Paying)	Motor fuel taxes more expensive	Differences increase under high CNG/electric scenario
Potential for Tax Evasion	Registration fees more difficult to evade than fuel taxes	Differences increase under high CNG/electric scenario
Administrative Costs (Costs of Collecting) and Issues	Motor fuel taxes more expensive	Differences increase under high CNG/electric scenario
Equity by Vehicle Class	Fuel taxes more appropriate although neither is strongly linked to cost responsibility	No change
Equity by Income Group	Registration fees more equitable if based on vehicle value	Fuel tax equity worsens under high fuel economy scenario until lower income groups can afford the more efficient vehicles
Relationship to Economic Efficiency	Fuel taxes more efficient	No change

TABLE 41. Sensitivity of tradeoffs to scenarios: New vehicle sales tax

Criterion	Current Differences	Differences Under Scenarios
Stability and Predictability	Sales tax much less stable	No change
Responsiveness (to Inflation and to Road Usage)	Sales tax responds to inflation; fuels tax partially responsive to VMT	Fuel taxes less responsive to VMT under high fuel economy scenario
Point of Taxation and Incidence	Motor fuel taxes assessed on fewer taxpayers	No change
Compliance Cost (Cost of Paying)	Motor fuel taxes more expensive	Differences increase under high CNG/electric scenario
Potential for Tax Evasion	Motor fuel tax evasion higher than sales tax	Evasion of fuel taxes increases under high CNG/electric scenario
Administrative Costs (Costs of Collecting) and Issues	Motor fuel taxes more expensive	Differences increase under high CNG/electric scenario
Equity by Vehicle Class	Sales tax potentially more equitable if rates vary by vehicle class	Equity under fuel taxes diminishes under diversion scenario
Equity by Income Group	Sales tax potentially more equitable across income groups	Fuel tax equity worsens under high fuel economy scenario until lower income groups can afford the more efficient vehicles
Relationship to Economic Efficiency	Fuel taxes more efficient	No change

CHAPTER 4

CONCLUSIONS AND SUGGESTED RESEARCH

This chapter presents conclusions and suggested research in two sections. Conclusions are provided in three categories: (1) conclusions regarding threats and opportunities related to highway user taxation, (2) conclusions from the analysis of future scenarios, and (3) conclusions about desirable agency actions. Recommended research is provided in three categories: (1) research related to the evaluation framework, (2) research on motor carrier taxation, and (3) research on technologies.

4.1 CONCLUSIONS

The evaluations of the scenarios and of the individual tax sources lead to the following general conclusions, which could differ under the circumstances that prevail in some states or regions.

Conclusions with regard to threats to the current fuel taxation system and opportunities to improve it include the following:

- A major threat to the viability of fuel taxes is the potential for widespread use of electric or natural gas vehicles, which could be refueled at many businesses and residences.
- Different procedures are necessary to collect fees on compressed natural gas (CNG) or electricity, involving a meter on the vehicle.
- A meter on the vehicle could monitor either fuel used or miles of travel. Because miles of travel provides a superior measure of vehicle cost responsibility, miles of travel should be metered for electric or CNG vehicles.
- The transition toward electric or CNG vehicles should include, if necessary, special means to collect revenues from electric or compressed natural gas vehicles, without necessarily changing the types of tax sources applied to gasoline or diesel vehicles.
- Another threat to motor fuel taxation is increased fuel efficiency of the vehicle fleet, which lowers the revenue accrued from each mile of travel. Adjustments to fuel tax rates, though requiring legislative action, can address this threat.
- Reductions in vehicle use, through travel demand management or other actions, are also major challenges, primarily because they may impose costs while also reducing fuel tax revenues.
- A major opportunity can be the potential to broaden tax sources to include taxation of miles of travel, either as a VMT tax or through congestion pricing; or taxes on vehicles.
- Another major opportunity can come through the development of technologies which could monitor or measure vehicle use.
- Mileage-based taxes (including fees based on VMT by vehicle type, and congestion fees) are superior to other types of taxes in their potential equity between and within vehicle classes, no matter what rules are applied to determine equity.
- The feasibility and desirability of mileage-based taxes depend on the available technologies to measure miles of travel and to control evasion and minimize administrative and compliance costs.
- Currently, implementation of mileage-based taxes will impose higher administrative costs on agencies, and will impose higher compliance costs on consumers, than implementation of fuel taxes.
- In the future, the availability of AVI or of smart-card technologies on all vehicles could reduce the administrative and compliance costs of mileage-based taxes.
- In the future, it may be feasible to record vehicle miles traveled using electronic interrogators of vehicle smart cards or AVI at refueling stations.
- If technologies are available that minimize administrative and compliance burdens for mileage-based taxes, they may be more attractive than other types of fees.
- Current and proposed IVHS research efforts should be examined continuously to determine whether revenue-related issues are all being addressed in the programs.
- Transportation agencies should take a proactive role in fostering research on technologies that relate to monitoring and measuring VMT, because the successful outcome of such research opens up new opportunities for broader and more desirable revenue programs.
- Mileage-related taxes should be phased in rather than switched to suddenly.

Overall conclusions resulting from the analysis of future scenarios include these:

- All scenarios examined in this study have major uncertainties and hurdles to overcome.
- All scenarios involve potentially serious threats to transportation finance.
- Only one scenario offers the potential for major improvements in finance — the Full VMT Measurement Capability scenario.
- Only in the Full VMT Measurement Capability scenario are decisions on major technical and policy options the responsibility of transportation officials.
- It is not possible now to determine the optimal technological systems for measuring VMT. Therefore, several technical paths should be pursued.

Overall conclusions about desirable agency actions include the following:

- Agencies should seek a smooth transition towards a broadening of the revenue sources applied to surface transportation, as opposed to a strategy to implement a sudden replacement of motor fuel taxes.
- The three major tax sources, consisting of taxes on vehicles, fuels, and vehicle miles of travel, will in some combination be the mainstay of revenue approaches.
- Taxation of fuels is now a viable revenue source for supporting surface transportation (currently 60 to 75 percent of total state and federal user taxes) and will remain an important element under all scenarios for at least the next 20 to 30 years.
- Even though taxation of fuels will remain a viable and productive revenue source, other sources have or will have desirable attributes, and transportation agencies should take actions to assure that the alternative sources can be implemented at the lowest administrative and compliance costs—primarily by assuring that technologies are developed for monitoring vehicle activity.
- Fuel taxes should be augmented with promising new approaches, particularly VMT fees or congestion fees, rather than be eliminated suddenly.
- Each level of government can choose to alter its current dependence on fuel taxation, as a percentage of all revenues to support transportation, either up or down, without affecting substantially the viability of the fuel tax source itself.
- Alternative liquid fuels (all potential short-term fuels except compressed natural gas and electricity) can be taxed through the same procedures that are now used for gasoline and diesel fuel.

4.2 SUGGESTED RESEARCH

Suggested research falls into several categories, each of which is discussed briefly below:

- research to apply and improve the new approach and the evaluation framework;
- research on motor carrier taxation alternatives and related issues;
- research to develop vehicle monitoring and VMT measurement technologies and standards; and
- research to evaluate value-added taxes.

Research to Apply and Improve the New Approach and Evaluation Framework

The development of ISTEA management systems offers transportation agencies unique opportunities to use tools that will help to explain and justify program recommendations, by illustrating the long-term consequences of alternative courses of action.

The new contract approach is an ambitious proposal because it seeks to link together several separate management systems into a single framework using a systems approach, and also seeks to create a continuing planning and decision-making process in a field that has traditionally involved only occasional one-shot major studies. However, it is timely to develop such an ambitious approach because of the opportunities that have been created by the new flexibility under ISTEA and the development of the several new management systems. Many transportation administrators will understand the broad appeal that this new approach could have and will want to develop the capability and demonstrate its application.

The key to successful demonstration of this new approach will be the selection of the best context for the demonstration. The most appropriate agency for conducting the demonstration should be selected with due consideration being given to the following:

- operational capability with the several new ISTEA management systems;
- interest in conducting a comprehensive review of the tax structure used for surface transportation finance;
- feasibility of having the agency's current planning and programming process evolve into the proposed new approach; and
- ability of the agency to commit to developing and using the new approach long enough to demonstrate its success or determine how it should be modified based on the demonstration.

These considerations would be essential in achieving sufficient success to show that this new contract approach could help build increased credibility of transportation agencies in the eyes of the public.

Research on Motor Carrier Taxation Alternatives and Related Issues

The first two phases of this project have focused on alternatives to motor fuel taxation for surface transportation finance, dealing with a range of existing and potential new taxes applying to all types of motor vehicles and their use. However, the study has not focused on several truck-related taxation issues that have become critically important recently. It has become clear during this study that state and federal DOTs and legislative bodies have an urgent need for research on the following truck-related taxation issues, all of which can build directly on the work already accomplished in the first two phases:

- administrative and enforcement costs of weight-distance and fuel taxes;
- compliance burden on motor carries;
- economic impacts on motor carrier and other industries of different types of taxes;
- evasion of weight-distance and fuel taxes;
- equity and efficiency of states' tax structure with different types of truck taxes; and
- intermodal competition impacts of different types of truck taxes.

This proposed project would involve detailed analysis of each of these issues, using data available from recent state and federal studies and program initiatives in these areas. The results of this analysis should be used to refine the evaluation methodology already developed and apply it to a small number of illustrative

case studies using data from selected state and federal sources. The study's scope should include the following tasks:

1. A survey of related studies and data available from all states, FHWA, and other sources.
2. An analysis of the prospects for current initiatives related to the issues being addressed, including fuel tax enforcement, automation of multistate tax proration systems, automation of mileage reporting, and other factors affecting each of the major types of truck taxes.
3. Estimation of current impacts and expected trends for each of the issues listed above.
4. Assessment of possible future directions for alternative programs that might be adopted, such as a base system for weight-distance taxes, use of various high-tech options for mileage reporting and tax administration, a graduated fuel tax surcharge system, the integration of all three forms of mileage reporting requirements, and a national database or interlinked state database on motor carrier tax status.

Finally, the proposed project should develop recommendations for actions that can be taken to (1) improve multistate cooperation in truck tax administration and enforcement, (2) improve the equity and efficiency of tax structures, (3) reduce evasion, (4) reduce the compliance burden on industry, and (5) reduce administrative and enforcement costs.

Research on Technologies

Further investigation is desirable of the application of the most promising technologies that can be used to monitor the use of highways as a basis for collecting user fees. These should include such technologies as "tamper-proof" odometers, odometers that can be read electronically at fueling stations or other roadside locations, tracking systems that can be used to measure VMT for each heavy truck or specified vehicle class on selected highways or all highways within specified areas, and the use of prepaid smart cards for authorized operation on selected highways or in selected areas. A testing and demonstration program, perhaps under IVHS, should be developed, covering all of the most promising improvements in technologies for monitoring vehicles' use of the highways for the purposes of improving many aspects of highway user tax collection, including both enforcement and the costs of reporting.

Research also should be directed at developing a strategy for improving the coordination of all uses of new technologies on highways, without unduly suppressing experimentation. In particular, priority should be given to the development of uniform standards for transponders in vehicles to assure compatibility among states, toll facilities, and others as the number of applications of the technologies grows.

Research should also be conducted on the legal aspects of mandatory requirements for specific types of equipment that might be used for measuring mileage, such as odometers or transponders. Research also should identify strategies for evolving toward such a requirement in a manner that would be most likely to succeed from both a technical standpoint and one of acceptance by highway users.

Further investigation is desirable on the linkages between technologies, information systems, and the level of evasion of taxes. Alternative strategies to reduce evasion should be examined. The strategies to be examined should include the specifications of the monitoring systems as well as enforcement levels and techniques. Attention should be given to

- regular reporting of data on costs of enforcement efforts in relation to benefit measures, including reduction of evasion levels and increases in revenues due to enforcement efforts;
- analysis of who evades taxes, how the taxes are evaded, and factors that affect evasion behavior by different types of taxpayers; and
- design of information systems that can be used at the national and state levels to monitor payment and nonpayment of highway user taxes of various types.

Research on Value-Added Taxes

There is wide application of value-added taxes in other countries, but not in the United States. Value-added taxes require a comprehensive evaluation, including nontransportation as well as transportation uses. Transportation interest groups or agencies might undertake a broad study in coordination with other groups or agencies. Major issues to consider would be these:

- Could value-added taxes address major priority problems in U.S. public finance?
- Could transportation-related revenues from value-added taxes reasonably be separated from other revenues and dedicated to transportation programs?

APPENDIX A

IMPORTANCE OF MOTOR FUEL TAXES AT THE FEDERAL, STATE, AND LOCAL LEVELS

Motor fuel taxes have been applied at all levels of government, and have been a particular mainstay of state and federal highway programs. Figure A.1 illustrates the recent trends (1975 to 1989) in state and federal motor fuel tax receipts and in all highway receipts in billions of current dollars. State motor fuel tax receipts, federal motor fuel tax receipts, and total highway tax receipts grew more slowly before 1982 than after 1982. The increase in federal fuel tax receipts was largely because of a $0.05 increase in federal fuel taxes that went into effect in April 1983. This revenue increase, in turn, increased the availability of federal matching funds for state highway programs, the need for state revenue, and state highway user taxes.

Several other major and minor changes in federal taxes also occurred during this period. The major changes[1] were the following:

1. The 10 percent tax on truck and trailer sales was increased to 12 percent effective April 1983 and changed from the manufacturer's sale price to the retail sales price.
2. Large increases in the tire tax, graduated by gross weight, were instituted in January 1984, and the taxes on tire tubes and tread rubber were repealed at the same time.
3. The heavy vehicle use tax (HVUT) became more steeply graduated by gross weight, but capped at $550, effective July 1984.
4. A $0.06 per gallon increase in the tax on diesel fuel (the "diesel differential") went into effect August 1984 as a substitute for a much higher HVUT that had previously been enacted, but had not yet gone into effect.
5. An additional $0.05 per gallon increase in both gasoline and diesel tax rates went into effect December 1, 1990.

Also, after the period covered by the data in Figure A.1, Congress increased the federal fuel taxes $0.043 per gallon and dedicated the increase to a deficit reduction trust fund, effective October 1, 1993.

The most important net effects of all these changes were to shift the emphasis to fuel taxes at the federal level, to increase the overall federal funding level, to shift some of the tax burden to heavier combination trucks in accord with their cost responsibility, and to stimulate substantial increases in state funding in response to federal increases.

States responded to federal tax changes by increasing their fuel taxes more rapidly after 1982, as shown in Figure A.1. However, as Figure A.2 shows, state fuel taxes did not increase as a percentage of total highway tax receipts. Indeed, the percentage of total receipts that come from fuel taxes has remained relatively constant at about 60 percent, decreasing only slightly below that in the late 1970s when inflation was high (resulting in increases in receipts for ad valorem taxes) and fuel economy was improving most rapidly. The 1983 increase in the federal fuel tax and the 1984 introduction of the diesel differential increased the fuel tax share of total receipts, but only enough to return it to the 1976 share. Since the early 1980s, the share of total receipts that come from federal fuel taxes has changed relatively little.

In Chapter 2, Figure 6 shows the proportion of highway revenues at each level of government from various sources.[2] The federal government raises the largest proportion of its highway revenues—more than 75 percent—from motor fuel taxes. States raise about 30 percent of their total receipts for highways from their own motor fuel taxes, or 43 percent of their direct taxes on highway users. Local governments raise only about 2 percent from user fees (mostly motor fuel taxes), although they receive a great deal of state aid from motor fuel taxes.

Table 9 in Chapter 2 shows the relative importance of various sources of state highway funds for each of the states and for all states as a group. (The overall distribution of revenue sources for states shown in Table 9 is slightly different from that shown in Table 6 because the data are for a different year.) Table 9 indicates that, overall, motor fuel taxes account for about 33 percent of all state highway funds and federal aid for 25 percent. Because motor fuel taxes account for about 77 percent of federal highway user fees, about 54 percent of state highway revenue is directly or indirectly derived from fuel taxes. For individual states, the share of highway funds provided by state fuel taxes ranges from a high of over 50 percent in South Carolina to a low of about 5 percent in Alaska (where significant funds come from the state's oil-royalty-rich General Fund). For most states, this share is between 20 and 50 percent.

The number of states increasing their motor fuel fees each year was substantially higher in the 1980s than in the late 1970s. Tax increases have been somewhat more common in odd-numbered years because of a preference to avoid raising taxes in election years and also because some legislatures meet only in alternate years. However, what happened in the 1980s cannot be taken as an indicator that tax rates readily can be raised.

Some other favorable developments from the standpoint of transportation administrators have occurred. Ten states now have a variable rate motor fuel tax.[3] Most states with variable rates have "floors" and/or "ceilings" on these rates.

Many states (at least 15) have had gasohol exemptions repealed or reduced. However, it is estimated that $450 million in federal revenues but only about $30 million in state revenues (in seven states) continue to be lost to gasohol exemptions.[4] On the negative side, legislatures have continued to attack their general fund deficits by diverting highway user fees to their general funds or by making highway agencies responsible for funding more activities from user fees. Local governments receive state and federal aid from motor fuel taxes, but most states

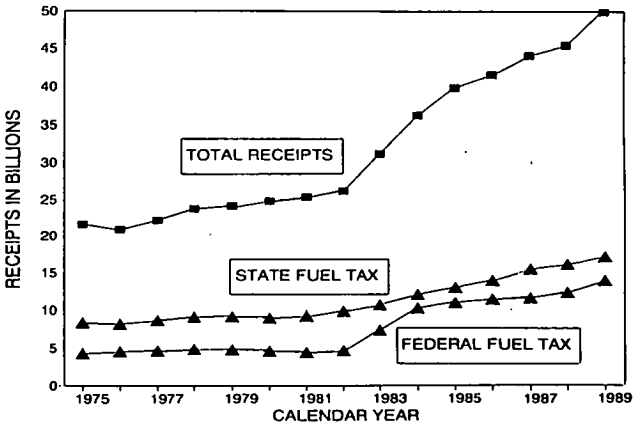

Figure A.1. Fuel taxes vs. highway receipts.

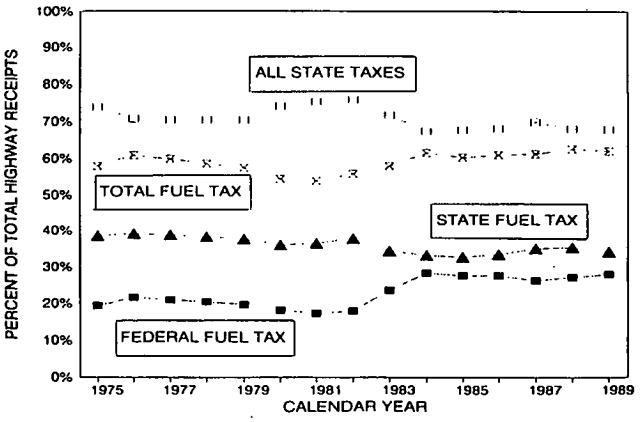

Figure A.2. Fuel tax share and all state tax shares of highway receipts.

are not allowed to tax motor fuels directly. Moreover, even when they are allowed to do so, they frequently are inhibited because, in small jurisdictions, the tax can easily be avoided by purchasing fuel outside the jurisdiction. As Figure 6 shows, state aid contributes about 27 percent to local jurisdictions for roads and streets, and tolls contribute 2 percent. The largest other sources are general funds and property taxes—two sources that are not always well differentiated in local government reports.

ENDNOTES

1. The minor changes were 1) the 10 percent tax on manufacturers' sales of buses was repealed effective October 1978; 2) the tax on highway tires was reduced from $0.10 to $0.0975 per pound, effective January 1981; 3) the $0.06 per gallon tax on lubricating oil and the 8 percent tax on parts were repealed effective January 1983; and 4) the $0.001 per gallon tax increase on gasoline and diesel fuel was dedicated to a Leaking Underground Storage Tank Trust Fund effective January 1, 1987.
2. Alan E. Pisarski, *The Nation's Public Works: Report on Highways, Streets, Roads and Bridges,* prepared for the National Council on Public Works Improvement, 1987.
3. FHWA, *Highway Statistics: 1990,* Table MF-121T.
4. The Road Information Program, *1992 State Highway Funding Methods,* page 12.

APPENDIX B

USE OF CRITERIA IN PAST STUDIES

Two general taxation reports, performed by New Jersey and Minnesota, are featured prominently in this appendix. These reports have been widely read and distributed, particularly the Minnesota report, which was published in book form and distributed as a commercial publication as well as a state report. These reports are also products of broad-based citizen commissions. Many participants in task forces in other states—business and labor leaders, legislators, tax officials, consultants, and staffs—find that what their counterparts in other states have already agreed to in such comprehensive tax studies is persuasive in guiding their own positions.

This appendix reviews how major studies have defined and used the criteria. The use of each criterion in other studies is covered, by category. The reports of tax study commissions in Minnesota and New Jersey represent the best examples of criteria used in the state commission reports. A summary of the criteria used in these two reports, along with those used by Texas' Select Committee on Tax Equity, is presented in Table B.1.

B.1 THE NEW JERSEY REPORT

The Final Report of the State and Local Expenditure and Revenue Policy Commission in New Jersey reflects the epitome of state blue ribbon tax commissions. The commission was broadly representative of power bases in New Jersey policy making, including leaders of the state's major business and labor groups, key legislators and executive branch officials concerned with tax policy, influential local officials, and leading academics. The group was established by statute in 1984, but did not report until 1988.

The commission's sweeping recommendations on state and local taxes and intergovernmental fiscal relations (e.g., state aid to local governments, allocation of functions and tax bases among levels of government) provided a basis for the many changes made in Garden State finances by legislative action in 1990. While extremely controversial, most of the changes have been retained by subsequent action and inaction of the state's legislature.

The commission's criteria list was first published in an interim report issued in late 1986. The list survived an extensive period of public comment and commission review and reappeared in the commission's final report issued in mid-1988. The criteria are the following:

Adequacy refers to the ability of state and local revenue systems to provide revenues sufficient to meet current and anticipated state and local needs based on existing policies and programs.

Certainty relates to the extent to which individual taxpayers can predict future tax liabilities or recipient units of government can predict the level of aid receipts. Certainty regarding the intricacies of the tax or aid system may facilitate financial planning and decision making by businesses, households, and units of government alike.

Competitiveness refers to the advantages or disadvantages in attracting or retaining desired firms and households, which a state and local tax system has relative to tax systems in other comparable or neighboring states.

Compliance/Simplicity indicates the ease with which individual taxpayer liability can be determined by both the taxpayer and the collection agency, and with which the provisions of the tax code can be enforced.

Diversity measures the extent to which the base of the individual tax or the whole of the tax system is broadly defined so that it can withstand long-run declines in importance of some components while reflecting long-run growth in importance of other components.

Elasticity measures the relationship between changes in measures of economic activity or population characteristics and changes in the revenue yield of the state and local tax system or selected taxes.

Equity/Fairness refers to the extent to which the revenue burdens of the state and local revenue system are distributed fairly based on either the individual's or firm's ability to pay the tax or on the benefits it receives from services financed by the tax.

Neutrality/Efficiency indicates the extent to which government financing influences private economic decision making and behavior. In general, the less the influence, the more neutral the individual tax or tax system. However, neutrality may not always be preferable, as government may decide to encourage some activities while discouraging others. Neutrality also refers to the extent to which local jurisdictions have their priorities distorted or restructured by imposed limits and by the form in which aid is received.

The commission's interim report also contained two criteria designed to bridge the commission's revenue and spending recommendations.

Accountability deals with the sensitivity of policy makers to the concerns of individuals on issues of tax burden or program administration. Are the changes in policy intentional and explicit? Is the responsibility for raising revenue aligned with the authority for making expenditure decisions? Answers to such questions are an indication of the extent to which state and local government is accountable to the concerns of individuals.

Financing indicates the relationship between a program's goals or beneficiaries and the method of financing (e.g., user fee, tax, debt) used. Relevant concerns include whether the service provides benefits to the general population or to an identifiable subgroup of recipients and the extent to which income redistribution is an objective of the program.

TABLE B.1. Criteria categories used in New Jersey, Minnesota, and Texas

New Jersey	Minnesota	Texas
Adequacy		Adequacy
Certainty	Certainty/Predictability	
Competitiveness	Competitiveness	
Compliance/Simplicity	Simplicity	Simplicity
Diversity		
Elasticity		
Equity/Fairness	Equity	Equity
Neutrality/Efficiency	Neutrality	Efficiency
Accountability	Political Accountability	
Financing		

B.2 THE MINNESOTA REPORT

The second featured report is the Final Report of the Minnesota Tax Study Commission (published locally and then by Butterworth's in two volumes [1986]).[1] The commission was established by a governor's executive order in 1983 and reported at the end of 1984. Its composition was similar to that of the New Jersey commission, except that it did not include legislators or state officials. Its report, unlike the New Jersey report, never was implemented in whole or part by one dramatic legislative move. Individual recommendations have been implemented in piecemeal fashion since the commission reported.

The Minnesota report identified seven goals for Minnesota's tax system that correspond closely to criteria used in this report:

Adequacy. While the Minnesota report mentions lessening the need for "ad hoc legislative changes" as part of its discussion of the certainty/predictability criterion, there is no adequacy criterion stated in the report. The omission probably occurred because Minnesota's highly graduated income tax means that state revenues tend to grow faster than personal income, the reverse of the long-term imbalance found in states like Texas.

Equity. Tax burdens should be distributed according to the principles of benefits received and ability to pay; they should also be consistent with the overall distributional objectives of the state. For those activities to which the benefits principle does not apply, ability to pay requires that persons with equal economic capacities pay the same amount of tax ("horizontal equity") and persons with greater capacities bear larger tax burdens ("vertical equity").

Certainty/Predictability. Taxes should be designed to give fiscal certainty to the taxpayer and government and lessen the need for ad hoc legislative changes.

Simplicity. Tax law should be easily understood by taxpayers to minimize administrative and compliance costs.

Neutrality. Taxes should be designed to avoid unintended interference with private (consumer, worker, producer) economic decisions.

Competitiveness. Minnesota's tax rates and tax burden distribution should be compared with those of other states, and then evaluated for their effects on the growth of the state's economy and employment, and on the migration of residents as the state competes for economic activity.

Political Accountability. Changes in tax burden or distribution of the tax burden should be the result of explicit and/or fully disclosed legislative actions rather than the effect of hidden or complex economic and institutional (e.g., intergovernmental) arrangements.

The Minnesota report also contains a section dealing with "guiding principles for tax reform." Two of the five principles relate to the processes of adopting tax policy: (1) making policy goals explicit in legislation and (2) not avoiding reform because it creates winners and losers, but using devices like hold harmless provisions for limited periods for cushioning transitions to new policies. The other three principles elaborate on concepts of equity, neutrality, and accountability. They are discussed, without complete quotation, in the appropriate sections of this report.

B.3 OTHER SELECTED REPORTS

The following sections present a category-by-category review of how each criterion has been dealt with in recent studies of alternative revenue sources. The sources cited are included in endnotes.

Adequacy

While not discussing adequacy, the Arizona report defined responsiveness as a separate criterion, stating, "Employ a system that adequately tracks the long-term growth in the state's economy and population."

The Louisiana report[2] deals with stability and adequacy together by asking the question, "Will the present tax structure provide in the future the revenues required by state government, without frequent legislative tax changes or expenditure reductions?" The report cites historical evidence to indicate the answer is no. A separate pamphlet report (*Tax Instability in Louisiana: Why Does It Persist? How Can It Be Eliminated?*) explores the instability theme at length.

The definition of adequacy was considered at length by a bipartisan committee in Washington[3] that considered tax and spending limits as well as revisions to the state's unique tax system. The committee accepted the concept that tax revenues should grow automatically with the underlying economy, with no legislative action required to sustain this level but with no automatic growth of revenues leading to an excess of this level. The group commented:

> The most significant principle was that government revenues and expenditures, including transportation, should track growth in the state economy over the long term. With this principle, the Committee accepted the notion that the revenue system should be constructed to keep pace with economic growth without the need for frequent tax rate increases. The Committee also agreed that government spending should not exceed economic growth without extraordinary measures and that, for the long term, government's share of the economy should not increase.

Yield in Relation to Need, Uses, and Investment Requirements

The concept of the adequacy of revenues cannot be applied without an implicit or explicit concept of appropriate spending levels to be financed with the revenues. Selecting such a level

involves a value judgment that most tax experts and blue ribbon commissions are reluctant to make.[4]

Given that they are reluctant to set their own spending levels, tax study commissions generally cast their recommendations in revenue-neutral terms and identify revenue-raising recommendations conditionally (such as, "if more revenue is needed, Tax X should be relied upon to raise it"). For example, the New Hampshire report states its adequacy criterion as producing "revenues that are adequate to finance the level of public services that the State wishes to provide regardless of what that level may be." The South Dakota report[5] talks only of "the necessary revenue" without detail on how that amount might be defined.

The City of New York[6] report ties taxes to spending without attempting to define an appropriate level of spending:

> Taxes are inextricably related to expenditure programs. The level of taxation in New York City is defined by the level of services people choose to have, the efficiency with which City government is administered, and the mandates imposed on the City by the state and federal governments.

Some commissions infer the spending target from current spending patterns or the patterns likely to follow from a continuation of current policy. In some states, the overall revenue pattern is unlikely to finance the current spending pattern—in budget parlance, a *structural deficit* exists. Structural deficits are most obvious in the case of earmarked revenues with growth profiles strikingly different from the spending they finance. One example is financing highway programs with revenues from per-gallon fuel taxes. Beginning in the mid-1970s, with the advent of increasingly fuel-efficient vehicles combined with high inflation, the built-in structural deficit of the per-gallon tax has intensified.

Responsiveness to Inflation or Price Factors

Those performing tax studies are as reluctant to define optimal future spending levels as they are to suggest that current spending levels are inappropriate. Broad-based state tax commissions usually have diverse memberships with differing views on the desired time profile of public expenditures. Typically, some members believe that the state and local sectors should shrink in relation to the private economy, while others would like to see their share of total economic activity increased. As a result, they often opt for value-neutral projections of current policies with spending implications determined by predicted changes in price levels.

Elasticity

One common formulation is to accept a measure of economic activity, such as personal income or gross state product, as a benchmark and to fault revenue systems that do not automatically raise a constant share of this base. A more explicit approach is to discuss future tax yield profiles over time in relation to profiles of the costs of maintaining current services of state and local governments, adjusted for price and workload changes (such as the number of children in school).

The New Jersey report finesses the issue of responsiveness to inflation by listing a criterion that, unlike the others, was not a normative statement but merely a definition of a term commonly used by economists in analyzing tax systems—*elasticity*. The New Hampshire report finesses the question in a similar manner to the New Jersey report in discussing its criterion of "revenue responsiveness and stability."

Elasticity in taxation studies measures the relationship between changes in measures of economic activity or population characteristics and changes in the revenue yield of the state and local tax system or selected taxes. The New Hampshire report discusses elasticity by indicating its value in responding to economic growth with additional revenues but also discusses disadvantages of automatic growth, including possible losses in stability of revenues and accountability for tax increases.

Stability of Revenues

In the National Conference of State Legislature's (NCSL's) landmark discussion of the principles of a high-quality tax system,[7] stability is discussed in two dimensions: (1) stabilizing revenue in the face of economic change, the traditional usage of the term, and (2) providing certainty, avoiding frequent changes in tax rates, and giving citizens "greater certainty about the taxes they will have to pay from one year to the next."

Stability of revenues is one of the reasons a *balanced tax system* is viewed as an objective, but there are others. The New Jersey report uses the concept of *diversity* but discusses it solely in terms of revenue stability—the extent to which a tax system can withstand long-run declines in some components while reflecting long-run growth in other components.

Some state tax studies recognize that providing a stable flow of resources to finance spending, even in recession, need not require that tax collections be stable. About half the states have established rainy day or stabilization funds designed to accumulate resources in extraordinarily good times and spend them during economic downturns. This point—i.e., that revenues don't have to equal spending exactly every year—is simply stated in a report on Washington State taxes.[8] It suggests that the adequacy criterion relates to whether the tax system can finance a given desired level of public expenditures "over the business cycle." In transportation, the concept of a countercyclical investment process for public infrastructure investment has been raised from time to time, leaning against the prevailing winds, taking advantage of lower prices in slow periods, and providing a boost to the economy. To work most effectively, projects must be "stockpiled" and ready to go when economic slowdowns occur.

Provision of Room for Potentially Needed Increases

Under certain circumstances, revenue-raising measures may have upper limits on their feasibility. That is, increases in tax rates may no longer produce significant new revenues. This concept is controversial in the extreme when applied to major federal tax sources. For example, who is to say with certainty when the rates of the federal income tax become so high as to be confiscatory and to discourage further work effort and therefore substantially curtail economic and revenue growth?

This concept has a much stronger empirical base when the revenue-raising potential is sapped by discouraging the taxable

activity, or causing large quantities of the taxable activity to migrate to the underground economy or to forms that remain untaxed for other reasons, such as being conducted outside the taxing jurisdiction or in nontaxable forms. Nontrivial examples are (1) the substantial evasion of income taxes based on unreported cash transactions; (2) the major potentials for evasion of excise taxes on tobacco and alcoholic beverages based on underground production and sales; (3) the avoidance of insurance premium taxes based on self-insurance; and (4) the losses of revenues from highway user charges based on diversion of fuels from off-highway uses to highway uses.

These problems of ceilings on existing taxes are not considered separately under the adequacy rubric because they fall neatly into other categories in this report. To the extent that a tax causes activity to migrate outside the jurisdiction of the United States (for a national source) or a particular state or community (for a local source), the effects are discussed in the economic competitiveness section of the efficiency criterion. To the extent that a tax causes activity to be reduced because of its tax burden relative to substitutes, the revenue effects are simply one of several factors affecting yield and entering the criteria through the yield estimate; and the economic losses from substitution enter the analysis through the economic efficiency criterion. To the extent that raising the rate of a revenue source increases evasion, the effects are discussed in the evasion section in the simplicity criterion.

The concept of "tax room" is neatly handled by the Alabama report, which makes revenue-neutral recommendations but then comments:

> The Commission's intention is to create a structure that is capable of raising adequate revenue in a fair and efficient manner. The level of revenue needed in any year is a matter for the legislature to decide; however, if the Commission's recommendations are fully adopted, the legislature will be able to generate the needed revenue in a fair and efficient manner by "turning the dial" up or down, i.e., adjusting the rates.

Balance

In discussion of state and local tax systems, but not in the debates on the federal tax system, the concept of a *balanced tax system* is often discussed. This concept was popularized by Robert Kleine and John Shannon when they were on the staff of the Advisory Commission on Intergovernmental Relations. The most recent incarnation is in a rating system for state tax systems developed by Kleine.[9] It includes balance as a criterion (along with broad-based, equitable, adequate and efficient, and simple taxes) in its own right, indicating the criterion is "to minimize overreliance on any one tax source." The quantitative test for state tax systems used by Kleine gives points for sales and property taxes each contributing 20–30 percent of state and local tax revenue and for personal income taxes contributing 20–35 percent.

The arguments for balance are closely tied to other criteria used in this report. One argument is that balance avoids overreliance on a particular revenue source, thereby putting a state at a competitive disadvantage with other states. Another argument often made for balance is that a factor that might depress revenues from one tax would not necessarily affect another.

The criterion of "diversified and balanced" appears in Maryland's study.[10] The report adds the concept of balance between taxes paid by individuals and businesses to the concept of balance among the major types of taxes. Obviously, balance is of interest in transportation taxation to the extent to which the revenue stream meets equity and stability criteria.

Equity

While the "equity" of tax systems is subjective, the tax studies reviewed for this report provide some insights on the application of an equity criterion. The first is that it is possible to achieve equity in the overall tax system without requiring that equity be achieved in any one tax, such as a sales tax, considered in isolation. The second is that equity can be viewed in terms of ability to pay, benefits received, or costs occasioned, a distinction long recognized in transportation cost allocation studies. The third is that equity can be measured in many dimensions besides the income group dimension most frequently used in general tax studies, or vehicle classes used in highway tax studies.

As stated in the New Hampshire report:

> Few questions of public finance are more obviously judgmental, and therefore political, than the question of "who should pay taxes." Although defining what constitutes a fair or equitable tax system is inevitably subjective, the need to consider equity as an important criterion for evaluating revenue systems is universally accepted. Accordingly, it is important that the analysis of the distribution of tax burdens be conducted as objectively as possible so that policymakers can then make their own decisions as to which of several alternative systems best satisfies their views of fairness.

Because highways are only a part of the transportation system, taxation structures in the highway system can affect competition between those who use the highway system and those who do not. Highway taxes that underrepresent infrastructure costs or that seek to produce nonhighway revenues, for instance, for deficit reduction, distort the costs of both passenger and freight competition. For those reasons it is most appropriate that equity effects be taken into account within the transportation sector.

In the highway field, equity is considered to be a far less subjective criterion than in general tax studies. Several dozen state and federal highway cost allocation studies have all relied primarily on the equity criterion, defined as costs occasioned by various vehicle classes. In general, those studies have progressively refined the data bases and technical methods used to estimate cost responsibility based on the results of evolving research.

Equity in Tax Systems, Not Individual Taxes

Assessments of equity impacts of transportation finance inherently examine only the transportation finance proposal under consideration or, at most, the total impact of all transportation financing devices in place and proposed. But the impact of all transportation finance on the overall distribution of income and wealth is often moderate in relation to the total impact of all government financing, and even smaller in relation to the total impact of all government policies—including taxing, spending, and regulation—on wealth and income.

The relative scale of transportation finance impacts is important because transportation finance may not be the optimal vehi-

cle for implementing any policies associated with equity in terms of income distribution impacts. Finely tuned transportation policies cannot affect wealth or income as well as policies directed specifically at wealth or income. Those policies often determine ability to pay by direct measurement of individual situations rather than proxy measurements for classes of individuals.

For example, a policy requiring large percentages of the income of millionaires and small percentages from the poorest to finance government can best be implemented by taxes that use income as a base, rather than by indirect transportation fees such as taxes on luxury cars on the inaccurate assumption that car purchase prices are an indicator of wealth.

Public policy decision makers, however, often recognize that changes in taxation are incremental. Therefore, for example, someone who believes that taxes bear too heavily on the poor will be tempted to try to alter each upcoming tax decision to reduce the burden on the poor. That may appear as optimal under the circumstances, even for decision makers who recognize that if empowered to alter all taxes at once, they might opt for some regressive taxes knowing they could offset any regressivity elsewhere in the tax system.

This principle of concern with equity only in the context of an entire tax system, not a particular tax, is prominent in NCSL's *Principles:*

> The progressivity or regressivity of any particular tax is not of great importance. What is significant is how the burden of the entire tax system is distributed (global incidence). Thus, levying some regressive taxes is not inconsistent with good tax policy, provided that the overall tax system is proportional.

This emphasis is also present in the Minnesota report, which endorses progressive taxation (the percentage of income paid as tax increases with income) "within limits dictated by economic reality." The report comments that in viewing progressivity, "the overall or net effect of the tax system is more important than the effect of a specific tax."

Ability to Pay and Benefits Received

The traditional equity criteria involve *ability to pay* and the *benefit* principle.

Distinctions between benefits received and ability to pay generally have been explored more in transportation finance than in public finance. The reason is the larger portion of benefits that are captured by users in transportation than in other programs, and the tradition of defraying a large portion of costs from user charges.

In a study in 1990,[11] several of the team members for this project contrasted four highway cost allocation methods: (1) benefits based, (2) marginal cost pricing (the economist's principle of efficient pricing), and (3) two versions often used in cost-allocation studies, identified as the federal method and the incremental method, which both involve allocating highway expenditures based on costs occasioned by various vehicle classes. The authors' conclusion about these methods is similar to conclusions in general tax studies about the selection of particular criteria: "The study found that each of the four evaluation methods provides a unique and potentially valuable perspective and that none of the four criteria is theoretically superior to the others."

The benefits principle reflects an attempt to equate government operations with the operations of the private sector by attaching a price in taxes to the benefits of a government service. Of course, it is usually more efficient and accurate in assessing benefits to attach the price to consumption (such as charging admission at a community pool), rather than to some characteristic of the taxpayer (such as number of children). The benefits principle provides little guidance when consumption is inherently collective, as in the case of the benefits of defending the nation against attack.

Horizontal and Vertical Equity

It is traditional in tax studies and tax policy discussions to assess ability to pay in terms of *horizontal equity* and *vertical equity*. The Arizona report, which has *separate criteria* for horizontal and vertical equity, explains horizontal equity as to "treat individuals of equal means equally." But economists have no universally accepted way of defining "equal taxpaying ability," so horizontal equity boils down to a concept dependent on the values of the evaluator. For example, if one individual has all income from dividends and does not work and another has all income from work and does not have any investments yielding dividends, it can be argued that if they have equal incomes they both should be taxed the same or that either one should be taxed more than the other.

Vertical equity also depends on normative concepts. If one taxpayer has twice the income of another, it can be argued that the higher-income taxpayer should pay twice the tax (*proportional*), more than twice the tax (*progressive*), or less than twice the tax (*regressive*). Often tax studies do not explicitly select one of those concepts. For example, the Arizona report describes vertical equity as to "impose higher taxes on individuals with greater ability to pay, or provide these individuals with fewer public services."

The concepts of horizontal and vertical equity are common in state tax studies. The Nevada study uses them, defining horizontal equity as "equal treatment of equals." Vertical equity is viewed as synonymous with "fairness" of the distribution of the tax liabilities among persons not in similar circumstances.

In the context of highway finance, horizontal and vertical equity are interpreted relative to cost responsibility. Thus, they require that vehicles with equal cost responsibility pay the same taxes and that, to the extent practical, the taxes paid by vehicles with unequal cost responsibility are proportional to their relative responsibility.

Equity Among Types of Economic Activity

State commission reports do not address detailed equity issues, such as those involving vehicle types, in their prefatory discussions of criteria. Transportation finance has many equity issues within user groups. Examples are peak versus off-peak users, heavy-load versus light-load aircraft and motor vehicles, in-state versus out-of-state vehicles, and vehicles with low annual mileage versus vehicles with high annual mileage. Resolving such issues is difficult in practice, but conceptually their resolution fits within more general criteria, such as equity as measured by benefits received or by costs occasioned.

Economists who assess tax systems recognize that the burdens of taxes on particular income groups include those that, as a legal matter, are levied on firms rather than individuals. The Mississippi study[12] comments:

> All taxes are, sooner or later, borne by individuals in the sense that higher state and local spending financed by taxes must reduce someone's disposable income. Thus, taxes imposed on business . . . will eventually impact individuals, although there is considerable dispute over how much impact is borne by different categories of individuals—shareholders, lenders, workers, and customers.

As pointed out in the Nevada study, the most commonly used index of vertical equity is income "and discussions of vertical equity usually focus on the distribution of the burden of a tax structure." The typical state tax study does not address the income distribution consequences of a state's entire tax system, thereby avoiding many controversial calculations and difficult exposition problems in reports intended for general audiences. Instead, the analysis of impacts (incidence) is often handled on a tax-by-tax basis.

Role of Taxes in Achieving Social Goals

The typical state tax study does not address individual tax incentives, such as a gasohol exemption, in terms of criteria, although many discuss individual exemptions in the tax-by-tax analyses of their reports. The criteria discussion is usually too generally concerned with horizontal equity to provide any insight into criteria applicable to such issues as incentives for a particular fuel, or extraordinary rates to discourage, for example, vehicle or fossil fuel use. One exception is NCSL's *Principles,* which takes a strong position on these subjects:

> The main purpose of a state tax system is to raise the revenue needed to finance government expenditures, not to promote social goals. The reason taxes are more appropriate as a means of discouraging than encouraging actions is that taxes are inherently a negative tool—taking away resources and income. . . .
>
> . . . On the other hand, taxes are sometimes a good mechanism for discouraging socially undesirable activity, such as air and water pollution, smoking, and consuming alcoholic beverages to excess. . . . Taxes are in some situations a better method of discouraging activity than outright prohibition because they preserve a degree of freedom of choice. Another benefit of levying heavy taxes on such activity is that it enables the state to recover a portion of the social costs incurred as a result of the problems this activity causes.

The Minnesota report takes a strong stand against exemptions of any kind other than those associated with the calculation of ability to pay. One of the report's "guiding principles" is, "Use of the state/local tax system to achieve social and economic goals should be minimized." However, the report comments that its objection is "practical, not philosophical"—based on concern that attempts by Minnesota to make substantial changes in income distribution or levels of output and prices would be overcome by competition from other states without similar policies.

The first Kansas report takes a particularly strong stand against building exemptions, exclusions, and deductions into tax structures. It urges the use of a tax expenditure budget to trigger periodic review of them. It also suggests, "Such measures should also be evaluated against the criterion of whether a program of direct public expenditure would be warranted and more effective in meeting perceived needs." (See Note 18.)

Equity by Geographic Breakdown

Equity by geographic areas usually does not enter into discussions of tax policy at the federal or state level. The general attitude is one of letting geographic chips fall where they may, given a distribution that is equitable among income groups and business types. For example, the federal income tax raises much more per capita in Connecticut than in Mississippi, and state income and sales taxes raise more from people in affluent suburbs than in inner cities or poor rural areas.

With highway legislation routinely requiring that federal highway receipts be allocated to produce a specified percentage return of taxes collected in each state, the national transportation tax picture will have at least some element of geographic equity cross-cutting the tax and spending decisions involved.

Some geographic redistribution has occurred historically in the federal highway program, which has emphasized "system needs" over geographic symmetry between revenues and receipts. A more compelling geographic equity issue arises when the fuel tax is used for deficit reduction. That to some suggests that the responsibility for the deficit is linked to fuel consumption. In most of the western states where distances are great and vehicle miles of travel (VMT) per capita is very high, this equity issue is given substantial weight.

Equity in Perception and in Fact

The perception of equity in a tax system has value in ensuring compliance and in keeping elected officials and voters satisfied over and above the benefits of equity itself. While *perceived* equity and equity are not necessarily congruent, a close enough relationship exists so that a system arguably should be equitable for compliance's sake, if not for equity's sake. As the Texas report handled this issue,

> Fairness is critical to a viable tax system. Taxpayers must believe that the tax system does not benefit some groups or individuals at the expense of others. Business taxpayers must believe that the tax system creates a level playing field for all industries.

Efficiency

Bringing About Better Decisions on Travel and Investment

The significance of user charges or prices for goods and services provided by the public sector, *public pricing,* is generally recognized in public policy as well as universally recognized in the public finance literature. The topic is often not addressed in academic terms in the tax studies reviewed for this report, primarily because the focus of the typical tax study is confined to taxes, not total revenues. One exception, the Louisiana report, reflects the conventional wisdom on the value of user charges

in providing signals of appropriate public service levels and investment and appropriate private consumption:

> The introduction of public pricing allows citizens to more directly signal their desires with regard to the level and quality of a public service. These signals become important in trying to determine the appropriate level and nature of public projects.

The most comprehensive approach to user charges, particularly on the impacts of charges to efficient functioning of economies, appears in a special category of tax studies associated with academic institutions. Discussions, too detailed for quotation here, appear in the Indiana[13] and Michigan[14] reports. They endorse user charges as appropriate signals for the levels of private consumption and public investment in services like transportation.

However, they recognize the major detailed issues of setting prices (charging marginal or average cost for a service that, like transit, often has decreasing marginal costs) and usually recognize the analogy to the more extensive discussions of these issues found in practical and academic treatment of public utility pricing.

The user charge rationale is extensively discussed and analyzed in a recent Congressional Budget Office report on paying for transportation investments.[15] It describes simply the standard definition of efficient pricing, a definition that is easier to formulate than to apply to most public investments:

> Economic efficiency is the second criterion by which financing mechanisms are evaluated. The standard definition of allocative efficiency is used here: does the price—the value consumers place on the product or service at the margin—equal the marginal cost—that is, the value of resources used in producing the last unit? If the price is less than the marginal cost, consumers tend to overuse the resource; if the price exceeds the marginal cost, they use it too little.

As noted in the introductory discussion of this chapter, there is general agreement in academic transportation literature that user charges should be based on efficiency—with particular emphasis on marginal costs of vehicles' contribution to congestion, pavement wear, and emissions. State highway cost allocation studies have not been influenced by this literature, largely because of the technical and political difficulty of implementing such an approach.

The 1982 Final Report on the Federal Highway Cost Allocation Study is the only known example in the United States of a government tax study on surface transportation that attempts to estimate the full marginal costs of the system by various classes of users. However, that report relegated the marginal cost analysis to secondary status behind the analysis based solely on equity (costs occasioned), and did not consider the efficiency criterion in its recommendations.

Paying Costs Imposed on Others

Economists recognize that only theoretically do market pricing systems capture the full costs of production and consumption. In practice, both have costs and benefits not captured in market price—externalities. It is possible to deal with these externalities by extreme forms of public intervention—prohibiting some production or consumption, like cocaine, because of negative externalities, and providing without charge some forms of consumption, like education in the primary grades, because of positive externalities. Short of prohibition and free goods, nonmarket ("command and control") regulation can be used. But this type of regulation has many well-known drawbacks, often leading to excessive costs and lack of accountability for causing costs.

Most externalities in transportation do not rise to the level at which command and control regulation, prohibitions, or free service are considered appropriate, but many rise above the level at which doing nothing is considered appropriate. In these circumstances, the economically appropriate remedy may be to add taxes to current prices to reflect negative externalities and to subtract from prices by providing subsidies to encourage consumption and production perceived as having positive externalities. Tax study commission reports generally avoid or downplay the technical term *externalities,* but reflect the principles summarized above. The New Hampshire report handles the subject this way:

> An important exception to this neutrality standard occurs where economic markets function poorly. For example, in the absence of some form of regulation or control, producers may employ production processes that degrade the environment or consumers may consume products such as alcohol that impose social costs on other parties. In such circumstances, a case can be made for corrective taxation that improves rather than impedes the function of markets. Aside from such cases of social externalities, neutral rather than corrective tax rules are to be preferred.

Charging for the marginal social costs of congestion and emission impacts is gaining support in contexts other than tax studies. Programmatic objectives, such as reducing VMT to achieve air quality standards and discouraging peak period travel to improve highway levels of service, have recently been the primary reasons for renewed interest in congestion pricing and emissions fees.

Creating Disincentives for Undesirable Activities

The Louisiana report also indicates the conventional approach to user charges associated with externalities, with examples from transportation:

> Many activities lead to social costs over and above the private costs borne by the individual. The use of a motor vehicle not only provides transportation to the driver, but it also leads to wear and tear on public streets and highways, can increase congestion, noise and air pollution. . . . Certain production processes not only create jobs, but may also generate air and water pollution and perhaps toxic wastes. The state in granting permission for these various activities should take into account these negative externalities. Through its fee structure, the state can limit to the extent it deems appropriate the negative consequences of these activities. . . .
>
> . . . It would not however be appropriate to measure the success of these fees and charges by the amount of revenue they created. In some cases the most successful fee might generate no revenue at all. For example, if careful licensing procedures and significant fines related to the improper transport or storage of hazardous wastes led firms to tighten their safety procedures with the result that wastes were safely handled, no revenues from fines would be generated for the state. At the same time, the goal of protecting the public's health and safety would have been successfully met.

Other examples of transportation-related environmental fees or tax incentives have been applied, or are being seriously considered. Penalties can become due if the manufacturer's fleet is not in compliance with the corporate average fuel economy standards for new car fuel efficiency. EPA regulations allow electric utilities and other stationary source polluters to take alternative actions to reduce emissions, such as purchasing and scrapping old "clunkers" that are heavy polluters. California air quality control agencies have been seriously considering the use of emissions fees on heavy polluters. Numerous studies of the impacts of other forms of tax incentives linked to environmental objectives have been performed, and some of them are reviewed in this report.

Considering Efficiency and Neutrality

While concepts of economic efficiency and tax neutrality normally are discussed in relation to private-sector activity, it is important to remember that in the context of altering methods of financing transportation, government activity is also a part of the environment. As a result, neutrality concepts sometimes need to be considered in relation to the impact of tax alternatives on the conduct of governments as well as of firms and consumers. In the Nevada study, which uses seven criteria, *intergovernmental neutrality* is listed as a separate criterion. It is defined as "to design a tax system that minimizes unintended interference with respect to Nevada's intergovernmental arrangements.

Encouraging Economic Growth and Competitiveness

Effects on overall economic growth and competitiveness are rarely discussed in connection with national or state transportation taxes, although growth and competitiveness are often important factors in discussions of appropriate levels of transportation investments.

Transportation taxes have several characteristics that discourage their consideration in terms of growth impacts. The first is that they are relatively small factors in total cost when compared with other aspects of transportation costs. The second is that they are rarely argued to be noncompetitive. At the national level, taxes affecting transportation in the United States are generally lower than those of competitor nations primarily because competitor nations typically impose much higher taxes on fuels used in transportation.

International competitive factors are sometimes considered in discussions of broader national tax policies, particularly among those encouraging the use of value-added taxes. But it is more common to consider national tax policy as it relates to domestic economic growth through investment, rather than competition with other nations. That was the approach reflected in the debates on taxes in the 1988 and 1992 presidential campaigns. It was also the thrust of the presidential recommendations that led to the last major federal tax reform in 1986.[16]

The factor of impacts on individual state growth is so important to many state decision makers that *competitiveness* or its equivalent often appears as a separate criterion in state tax studies. Nevada's studies are an example. A typical formulation of this criterion is the simple one used in Arizona: "Design the fiscal system so that it does not deter economic growth and prosperity."

The competitiveness question has been so significant in Massachusetts that a special tax commission report addressed the topic.[17] Before presenting its detailed measurement of Bay State tax burdens relative to those of other states, the report discussed why "this preoccupation with tax policy as a vehicle of economic competition persists despite massive evidence that interstate differences in tax burdens exert a minor effect on business location." The conclusions are relevant to transportation taxes that might be adopted at the state level, particularly those affecting trucking. The report points out that elected officials often ignore academic conclusions that business tax differentials don't matter because the academicians cannot rule out any effects and because their conclusions often conflict with the testimony of business officials. The elected officials tend to favor the counsel of business officials because "perhaps they know more than scholars."

There is ample evidence that states have actively competed with each other through the tax structure to attract trucking firms that have multistate operations to register their fleets in their states. This competition includes incentives such as favorable reciprocity agreements with other states, lower fuel taxes or registration fees, low-cost registration of trailers, or no charges for mileage traveled in non-International Registration Plan (IRP) states under the proration of registration fees. The Intermodal Surface Transportation Efficiency Act (ISTEA) incentives for states to join the IRP will reduce the incentive for states to compete in the future, insofar as registration fees are concerned.

Simplicity

Simplicity is related to holding down administrative costs, compliance costs, and evasion. Although not following the standard distinction between administrative and compliance costs, the second Kansas report[18] has an excellent discussion of these interrelated factors:

> Complexity in the tax code carries a number of undesirable attributes. Complex tax features and codes can impose significant and unreasonable compliance burdens on taxpayers. This burden may manifest itself in the maintenance of excessive records to qualify for various deductions or exclusions or the maintenance of multiple sets of accounts because of differing federal and state tax codes. It may also manifest itself through excessive time requirements for taxpayers and unnecessary uncertainty as to the correctness of the tax return. All are undesirable and costly to the taxpaying community.
>
> The mirror image of complexity for the taxpayer is increased enforcement and compliance costs for the state. Those provisions exacting the highest compliance price from taxpayers are also the most difficult to administer efficiently. Full compliance can only be insured at an unacceptable cost. . . . When perceived as excessive, complexity threatens the underpinnings of our voluntary compliance tax system. A tax system perceived as overly complex is often seen as inequitable and ripe with opportunities for evasion. It will begin to exact extraordinary enforcement costs and create growing noncompliance.
>
> Simplifying the tax structure can reduce compliance costs faced by both taxpayers and state government. Further, to the extent that simplification can change the perception of the tax system, long-term voluntary compliance can be enhanced.

In the Nevada report, the simplicity criterion appears as two separate criteria: (1) *administrative feasibility,* which seems to be minimizing cost, and (2) *simplicity,* which also has an element of minimizing cost that results from complexity. The Nevada report also notes, "Another result of complexity is that taxpayer understanding of the fiscal system decreases, a matter of serious concern in a democracy."

The New Hampshire report combines two concepts with the criterion of "simplicity and ease of administration." The South Dakota report lists as one of five principles that a tax system should be "simple, to minimize compliance costs for both taxpayers and tax collectors."

A similar perspective is found in the New Jersey report, which does not explicitly address cost except indirectly by considering ease of administration and compliance. The Minnesota report gives minimizing cost as the rationale for simplicity. Arizona's report has a short comment to explain its simplicity criterion: "Minimize fiscal compliance and administration costs. The system should be easily understood by affected individuals and businesses, and easily implemented by government agencies."

B.4 INFORMATION SOURCES

The review included assessments of tax study commission reports from 29 states, including most major tax study efforts in the states in the past 10 years.[19] It was supplemented by a sampling of academic literature, transportation revenue studies from the states, federal studies of both general revenue and transportation finance issues over the past decade, and tax policy material published by NCSL.

The much greater number of state than federal materials covered has two bases. The first is availability. Over the past 20 years, there has not been a major study of the overall federal tax system. Instead there have been major reviews of segments of that system, including the Federal Highway Cost Allocation Study of the early 1980s. Major general fund tax reviews by the federal executive branch, rather than citizen commissions, have focused separately upon individual income taxes (leading to the 1986 tax reform) and on corporate taxation (so far leading to no action). So there is simply less federal than state material on criteria for judging tax systems.[20]

While availability makes concentration on the state reports a necessity, diversity makes it a virtue. The states, as an often-cited Supreme Court opinion once put it, are "laboratories of democracy," and draw from diverse political cultures. While that diversity makes it more unlikely that a common approach will be discovered, it makes any commonality in state reports more valuable. Such commonality suggests potential widespread acceptance by individual states and local governments for the decision criteria that form a part of the national pattern of financing transportation.

ENDNOTES

1. Several other Minnesota reports were consulted in preparing this report. *Minnesota Tax Reform* (1987) was a report developed by the Minnesota Department of Revenue to embody the tax recommendations the then-governor made to the legislature. Its listing of criteria followed the patterns of state reports discussed in this report. *Financing Minnesota Government in the Decade Ahead* (Minnesota Wellspring, 1985) by Robert Ebel is a summary and popularization of the commission report.
2. The 1987 "Louisiana report" is actually a collection of reports published by Louisiana State University and the Council for a Better Louisiana. Neither endorsed the product, but the reports were the initial moves toward Louisiana tax reform. They were followed by endorsement by then-Governor Roemer and, with some modification, were the subject of a state constitutional convention being called for late in 1992. Criteria are addressed in question and answer format in *Paying for State Government in Louisiana: Considering the Alternatives.* User charges are discussed in Clarence Adams, *Louisiana's Fee Structure: Opportunities for Reform.*
3. Governor's Committee on Washington's Financial Future, *A Financial Plan for Washington,* 1989.
4. Among the general blue ribbon tax commissions, an occasional instance of making recommendations on spending levels appears along with revenue-raising recommendations to match that spending level. An example of such a report was the Levitan Commission in Maryland. Such results are rare, however, for two important reasons: (1) commission members and staff often view their influence and expertise as not extending beyond tax choices to the obviously non-technical subject of determining how much should be spent on schools, welfare, and other functions, and (2) truly representative blue ribbon commissions include such diverse membership that the unanimity for which most strive cannot be achieved on issues of spending levels.

   A willingness to establish adequacy targets based on spending at levels well in excess of current ones is much more common among commissions appointed to deal with a particular function such as financing health care for the indigent, transportation, public schools, libraries, or programs for children. Such commissions often are selected from among those with particular interest in the function being studied. They often exclude those with broad views on the overall levels of taxation or on the needs of activities that may compete for funds with the activity being studied.
5. Governor's Advisory Commission on Taxation, *South Dakota Taxation and Expenditure Structures,* 1988. This report has no explicit listing of criteria, though some criteria are implicit in the report's statements of problems. References to the South Dakota report are to a consultant report prepared about 1988 for the state's legislative research council, Public Sector Consultants, Inc., *The Personal and Corporate Income Tax: An Evaluation for South Dakota.* It uses about a half page to cite a 1985 NCSL assessment (*State Tax Study Commissions: An Overview of Four Approaches*) and to list five "traditional principles of taxation. They are that a tax system should be (1) balanced, (2) broadly based, (3) equitable, (4) adequate and efficient, and (5) simple."
6. The City of New York report is included along with the state tax studies because of the city's size (larger than all but a dozen states) and the fact that, nearly unique among American cities, it has a wide range of tax sources and spending responsibilities, making it close to state governments in the scope of its tax study. The *Tax Study Commis-*

sion Final Report was released in late 1989. Other than the adequacy discussion cited in this report, the discussion of criteria is so short that it can be quoted in its entirety:

> We must seek to insure that the tax system is fair, both in terms of vertical and horizontal equity. Like taxpayers should be taxed in like manner, and regressivity is to be avoided. We must also make sure the system is efficient, encouraging the growth of new industries and expansion of existing ones. It should be competitive, recognizing that a high tax burden can be implemented in ways that minimize the City's competitive disadvantages. It should be a system that can be understood by the taxpayers and administered in a way that is perceived as fair but is also cost efficient.

7. *Principles of a High-Quality State Revenue System* (undated) was published by the NCSL and the Lincoln Institute of Land Policy in the late 1980s in response to widespread demand in the states for prescriptive material on state and local taxes. While not officially endorsed as NCSL policy, the report was prepared by key NCSL staff members and legislators as well as the individual legislators and fiscal policy legislative staff members who formed the committee that developed it. The report is widely cited. For example, the New Hampshire report relied on it, calling it "a common reference for these evaluative criteria."
8. Robert Strauss, *A Study of Alternative Tax Structures for the State of Washington,* 1987.
9. Robert J. Kleine, *U.S. State-Local Tax Systems: How Do They Rate?,* Public Sector Consultants, Inc., 1992.
10. The Maryland study (Maryland General Assembly, *Joint Expenditure and Revenue Study Group, Final Report,* 1991) is more a compilation of materials than a complete study. The quoted comments come from materials submitted by the Department of Fiscal Services for the legislature as broad statements of tax policy principles.
11. Urban Institute and Sydec, Inc., *Rationalization of Procedures for Highway Cost Allocation Studies,* Trucking Research Institute, 1990.
12. Harold A. Hovey, *Tax Policy Options for Mississippi: A Report to the Governor* (1982) is a kind of "short form" tax study. As indicated in its preface, "In the hierarchy of tax policy analyses, it is more like a routine physical examination by a general practitioner than a one week visit to the Mayo Clinic for comprehensive tests."
13. James A. Papke, ed., *Indiana's Revenue Structure: Major Components and Issues,* 2 volumes, 1984, Purdue University. This report and the Michigan report can best be understood as gifts from state universities to decision makers in their states. The reports consist of introductory materials and central thrusts provided by leading lights in public finance (James A. Papke of Purdue and Harvey E. Brazer of the University of Michigan) and essays on individual taxes and related fiscal issues by academicians throughout the state university systems.
14. Harvey E. Brazer, ed., *Michigan's Fiscal and Economic Structure,* University of Michigan Press, 1982.
15. *Paying for Highways, Airways, and Waterways: How Can Users Be Charged?,* Congressional Budget Office, Washington, DC, 1992.
16. The basis for the 1986 tax reforms was the recommendations in *The President's Tax Proposals to the Congress for Fairness, Growth, and Simplicity,* 1985. As the title suggested, the report addressed three criteria, which were not explicitly stated. Instead they appeared in the form of the criticisms of the then-current tax system for being complex and unfair, and for retarding economic growth.
    The recent federal tax study, which received little attention in the press and Congress, was a study of corporate taxation required by the 1986 reform legislation. That study was presented by the Treasury Department in early 1992 as *Integration of Individual and Corporate Tax Systems.* That report is primarily oriented to economic efficiency, "to reduce tax distortions of important corporate financial decisions," as the Treasury Department expressed it in its transmittal letter to the Congress. The report itself includes international comparisons of the "tax wedge" between pretax and posttax returns on investment.
17. The Massachusetts Special Commission on Tax Reform, *The Competitiveness of the Massachusetts Tax System,* 1986.
18. The report of the Governor's Task Force on Tax Reform, *Kansas Tax Reform* (1988), is called the second Kansas report in this report. The long passage quoted in the text was undoubtedly written by the then-state tax commissioner, Harley Duncan, who has since been elevated by his peers to be the executive director of the Federation of Tax Administrators. The first Kansas report is the Kansas Tax Review Commission, *Final Report and Recommendations* (1985).
19. There is room for considerable difference of opinion in defining what constitutes a "state tax study." The major attempt to define, describe, and categorize the state studies is *State Tax Study Commissions: An Overview of Four Approaches* (Steven Gold, ed., National Conference of State Legislatures, 1985).
20. Tax alternatives for states include the three major tax bases of income, consumption, and wealth. With minor exceptions, federal taxes reach only income (and its subset, payroll), so the state studies are more comprehensive. . . . The transportation finance alternatives focus primarily on consumption, such as a gasoline tax, and wealth, such as a registration fee.

APPENDIX C

Impacts of Programs Affecting Alternative Fuels and Financing of U.S. Surface Transportation Programs

This appendix summarizes the most important aspects of the following programs in terms of their anticipated impacts on the use of both conventional and alternative fuels and, implicitly, on financing of U.S. surface transportation programs:

- The Alternative Motor Fuels Act (AMFA) of 1988
- California alternative-fuels programs
- The Clean Air Act Amendments (CAAA) of 1990
- Other Department of Energy (DOE) programs
- The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991
- The Energy Policy Act of 1992.

C.1 ALTERNATIVE MOTOR FUELS ACT OF 1988

The purpose of AMFA is to encourage (1) the development and widespread use of methanol, ethanol, and natural gas as transportation fuels by consumers; and (2) the production of methanol-, ethanol-, and natural gas-powered motor vehicles.[1] DOE is the lead agency responsible for implementing the act, working with other federal agencies, state and local governments, and industry. A total of $18.5 million was authorized by Congress for fiscal years 1990 through 1993 for six programs:

- Light-duty vehicle procurement
- Commercial truck applications
- Bus testing
- Studies and reports
- Interagency Commission on Alternative Motor Fuels
- Manufacturer Corporate Average Fuel Economy (CAFE) incentives.

The subsections that follow discuss the above programs.

Light-Duty Vehicle Procurement Program

This program is intended to ensure that the maximum practical number of autos and other light vehicles acquired by the federal government are alternative fuel vehicles (AFVs).[2] As of September 1991, almost $3 million had been transferred from DOE to GSA for such purchases, including 65 methanol vehicles, 50 compressed natural gas (CNG) vehicles, up to 200 ethanol vehicles, and others to be acquired. A total of 300 to 400 additional AFVs were expected to be purchased in fiscal year 1992, placing the program slightly ahead of schedule.[3]

An earlier AFV program failed in the 1970s primarily because of the lack of support systems. Aware of this past problem, DOE conducted a recent review to determine the locations and accessibility of alternative fuel dispensing facilities, focusing on air quality problem areas. The initial 65 methanol AFVs were being used by more than 20 agencies in the Los Angeles; San Diego; Washington, D.C.; and Detroit areas.

Commercial Truck Applications Program

The objective of this program is to encourage the use of alcohol and natural gas fuels by establishing and conducting heavy-duty vehicle commercial application projects, operating in "real world" environments.[4]

The program got off to a slow start because of the high cost of alternative fuel trucks and the initial reluctance of industry to participate in joint programs.[5] However, after passage of CAAA in November 1990, with its requirement of reducing truck emissions by 50 percent between model years 1994 and 1998, DOE entered into an agreement with the American Trucking Association's Trucking Research Institute to operate and test 80 alcohol and natural gas trucks along with conventional diesel trucks during 1991. That number was expected to double before the end of 1992.

Agreements for testing AFVs have also been entered into with the California Energy Commission (CEC) and the New York State Energy Research and Development Authority, both involving controlled tests of new CNG and conventional diesel trucks. A similar project was being initiated at the Illinois Department of Energy and Natural Resources involving comparative testing of ethanol and diesel trucks operated by two firms.

DOE is also developing a mobile emissions testing laboratory for trucks and buses, a set of testing requirements for trucks, and a national data center for alternative fuels that will analyze and store data on all types of AFVs.

Bus Testing Program

The objective of this program is to assist state and local governments in testing transit buses capable of operating on alcohol or natural gas.[6] This program has been integrated with the Federal Transit Administration's Clean Air Program, which includes 300 AFVs in 50 locations, a methanol bus demonstration program involving 60 buses in 7 locations, and a clean-diesel-system program, which will initially involve 400 buses with particulate traps.

The program involves monitoring emissions, durability, safety, fuel economy, and other factors in comparison with conventional buses.

Buses are being certified under the 1993 U.S. EPA Urban Bus Standards set forth in the CAAA of 1990 and the 1991

TABLE C.1. Lead and supporting agencies for studies and reports as of September 1991

Study	Lead Agency	Supporting Agency	Status
Light-Duty Vehicle Operations[a]	DOE	EPA/DOT	In Progress
Light-Duty Vehicle Disposal[a]	GSA/DOE	—	Complete
Electric Vehicles	DOT	DOE/EPA	Complete
Residential Energy Prices	DOE	DOT	Complete
Natural Gas-to-Methanol Plants	DOE	—	Complete
Environmental Study	EPA	DOE/DOT	Draft

[a] These studies are part of the Federal Light-Duty Vehicle Project.

California regulations. As of September 1991, only one manufacturer's engine had been certified (a Detroit Diesel Corporation's methanol engine) after more than 10 years of development with partial support from DOE.

Studies and Reports

The AMFA of 1988 mandated several studies and reports to Congress, all of which were scheduled to be completed by now. Table C.1 shows their status as of September 1991.[7]

An updated report on the effects of AFV programs on residential energy prices was due by December 1994. The report on environmental impact of alternative fuels was due in December 1990 (expected in April 1991) and every 2 years thereafter. The light-duty vehicle disposal report was expected in May 1991. The light-duty vehicle operations report was due in January 1992 and every year thereafter. A seventh report, a review of manufacturing incentives for automobiles, is due in the year 2000.[8]

In addition, DOE has established an Alternative Fuels Data Center (AFDC) at the Solar Energy Research Institute to collect, analyze, and disseminate information from all the programs.[9] The AFDC is intended to be an ongoing information service to government agencies, private industry, research institutions, and other interested organizations. Its services include a relational data base management system, statistical and graphics software, and remote accessibility.

Interagency Commission on Alternative Motor Fuels

The AMFA of 1988 required the establishment of an interagency commission with the following responsibilities:

- Coordinating federal agency efforts to develop and implement a national alternative motor fuel policy
- Ensuring the development of a long-term plan for the commercialization of alcohols, natural gas, and other potential alternative motor fuels
- Ensuring communication among representatives of all federal agencies that are involved in alternative motor fuel programs or that have an interest in such programs
- Providing for information exchange among persons working with, or interested in working with, the commercialization of alternative motor fuels.[10]

Members of the commission include representatives of the Departments of Energy (chair), Transportation, Labor, Defense, and Agriculture, EPA, GSA, and the Postal Service. Two interim reports have been prepared and submitted to Congress by the commission. A final report, due by September 1992, was to include a long-term plan to implement a national alternative motor fuels policy.

The chairman of the commission established a U.S. Alternative Fuels Council, composed of four members of Congress and 16 persons from outside of the federal government, to hold public meetings around the country and develop recommendations. Its principal recommendation was that the federal government should adopt a goal of having AFVs be 25 percent of all vehicle miles of travel (VMT) in 2005. This target year was later changed to 2010 after a review of a preliminary scenario that required an unrealistically high rate of AFV sales.[11]

Manufacturer Corporate Average Fuel Economy Incentives

The AMFA of 1988 provides auto manufacturers with CAFE credits to encourage the production of AFVs.[12] These incentives came into effect beginning with model year 1993.

The credits include a limit on the benefits provided to manufacturers building flexible fuel vehicles that operate on either conventional or alternative fuels, but the act has no limit on the credits for dedicated alcohol and natural gas vehicles. Whether these credits will have a significant influence depends on several factors such as the price of gasoline and alternative fuels, the cost of developing AFVs, consumer response to AFVs, the success of current efforts to meet emissions standards with reformulated conventional fuels, and perhaps most importantly, Congress's pending decision on raising CAFE standards.

Near-Term Prospects in Relation to the AMFA of 1988

DOE's strategy for implementing the AMFA of 1988 is to encourage the commercial production of methanol, ethanol, and natural gas vehicles and the widespread use of these fuels by consumers in the transportation sector. DOE has attempted to develop the plan from the perspective of the needs of the interested parties and to build upon other related programs. The aim is to achieve a self-sustaining alternative fuels industry that will continue to expand after the program has ended.[13]

Yet industry is having substantial difficulties in developing cost-competitive AFVs.[14] Although long-term forecasts and technological projections suggest that there likely will be future markets for AFVs, current regulations and programs and those scheduled to go into effect in the next few years will affect short-term markets.

Because of the long lead time required and the high cost of accelerating development of AFVs and their support systems, it appears likely that AFVs will penetrate the market slowly and be limited primarily to centrally fueled fleet vehicles over the next few years. Reformulated gasoline and diesel are the most economical options if they can meet emissions and other standards. If emissions characteristics of reformulated fuels prove to be closely comparable with those of alternative fuels, then

existing federal and state regulations probably will not result in material displacement of petroleum.[15] However, under certain conditions, CNG and methanol vehicles may be cost-competitive with reformulated gasoline by 2000.[16]

The principal uncertainty is government regulation. Congress may go further in mandating alternative fuels because reformulated conventional fuels frustrate the goals of developing domestic alternative fuels, reducing dependency on imported petroleum, and shifting to renewable energy sources.[17]

C.2 CALIFORNIA ALTERNATIVE FUELS PROGRAMS

Several California programs have potential national significance, including the following:

- The 1990 CAAA's California pilot test program
- California's low-emission vehicles (LEVs) and clean fuels program
- Reformulated gasoline activities
- California Clean Air Act (CCAA) transportation planning requirements
- CEC's demonstration program.

Each of these is discussed below.

The 1990 CAAA's California Pilot Test Program

The CAAA requires a California pilot test program involving the production and sale of clean fuel vehicles in California beginning with the 1996 model year.[18] In the first three years, 150,000 new clean fuel light-duty vehicles and light-duty trucks must be sold annually. Beginning in 1999, annual sales must reach 300,000.

The CAAA defines clean fuels in two phases. Phase I emission standards are applicable to the California Pilot Program only and begin in 1996. The Phase I standards apply to more types of pollutants than any previous legislation (nonmethanol organic gases (NMOG), CO, NO_x, and formaldehyde). Phase II emission standards are stricter for some pollutants (NMOG and NO_x) and begin to apply to the California Pilot Program in 2001. (Phase II standards also apply on a national basis to fleets that can be centrally refueled beginning in 1998.)

Vehicles able to meet the CAAA standards using reformulated gasoline are considered to be clean fuel vehicles. Discussions with experts in the field indicate that reformulated gasoline is likely to be the fuel used by the vast majority of vehicles designed to meet the Phase I emission standards.

AFVs are likely to become an increasing proportion of vehicles designed to meet the Phase II standards, but which type of vehicle will be dominant is quite uncertain at this time. If gasoline can be reformulated to meet these standards for most light-duty vehicles, it may remain the dominant fuel. However, its cost may be driven up to a point at which AFVs become quite competitive. Developing clean-burning gasoline and retooling refineries could cost $20 billion to $40 billion.[19] Pump prices may rise by about $0.10 per gallon.

California's Low-Emission Vehicles and Clean Fuels Program

The California Clean Air Act (CCAA) of 1991 is the only program that actually requires AFVs (other than the few hundred federal government fleet vehicles being purchased under the AMFA of 1988). Beginning in 1998, 2 percent of each manufacturer's light-duty vehicle sales in California must be "zero emission vehicles" (ZEVs)—i.e., electric vehicles (EVs) for all practical purposes. The required percentage for ZEVs jumps to 5 in 2001 and 10 in 2003.[20]

CCAA also mandates a set of standards for fleet average NMOG emissions for light-duty vehicles beginning in 1994 and becoming increasingly strict year by year through 2003. The act focuses on NMOG emissions (which include traditionally measured hydrocarbons as well as oxygenated hydrocarbons) because they are the source of ozone formation.

CCAA also defines emission standards for transitional low-emission vehicles (TLEVs), LEVs, and ultra-low-emission vehicles (ULEVs), with the first two categories equivalent to the Phase I and Phase II standards of CAAA. These standards are of no substantial importance for light-duty vehicles because manufacturers will be allowed to sell any mix of vehicles as long as the ZEV requirement and fleet average NMOG standards are achieved. The LEV and ULEV standards, however, are important for medium-duty vehicles of fewer than 14,000 pounds gross vehicle weight (GVW) which will have to meet these standards by specific deadlines.

California has also adopted regulations to ensure that clean fuel service stations are available at convenient locations when more than 20,000 AFVs are sold statewide.

Under CAAA, other states may adopt California's vehicle emissions standards and require the production of vehicles meeting these standards.

Reformulated Gasoline Activities

California is taking the lead in requiring cleaner gasoline. The first requirements went into effect in January 1992.[21] They included the following:

- A limit on sulfur content
- A ban on lead
- Detergents to control deposits
- A ceiling on vapor pressure in designated air basins during specified high-ozone periods.

The California Air Resources Board is expected to develop Phase II standards for reformulated gasoline that will go into effect in January 1996. These standards are expected to be similar to the federal requirements that will go into effect in 2000 under CAAA. Strict standards will be set for vapor pressure, sulfur and olefin content, and distillation points for the major components of gasoline.

Reformulated gasoline meeting these strict standards may become the dominant motor fuel by 2000. If all eligible regions choose to adopt the requirements, an estimated 55 percent of U.S. gasoline will be "clean." It is possible that the U.S. oil industry may find it preferable to reformulate all gasoline under this scenario, given the logistics of production and distribution.

As a result of recent give and take between government and industry, California has begun to emphasize early implementation of reformulated gasoline rather than large-scale, near-term requirements for AFVs because of the high payoff in the near term in emissions reduction. Cleaner gasolines will be used by all vehicles in the areas covered by the requirements. That contrasts with the alternative fuels programs that affect only new vehicle sales and that require long lead times to develop and produce both AFVs and their support systems.

Transportation Planning Requirements for Transportation Control Measures

CCAA required that air quality plans be prepared by July 1991 for areas of the state that have not met state air quality standards (which are generally stricter than federal standards).[22] The plans must include a wide range of control measures that, for most areas, include transportation control measures (TCMs). Performance standards are specified in the act and are more stringent for areas with the worst air quality problems.

One example of the act's ambitious standards is a goal of 1.5:1 worker to vehicle ratio in seriously polluted areas, which implies a 25 percent reduction in vehicular work trips.[23] Also, in these areas total emissions are not to increase after 1997.

In response to these requirements, the San Francisco Bay Area has adopted a TCM plan that is estimated to reduce VMT by about 11 percent from a projected 1997 baseline. It includes the following:

- Regionwide congestion pricing (to achieve LOS D/E), averaging $0.10–$0.15/mile
- Regionwide employee parking charge of $3/day
- Mileage- and smog-based registration fees, averaging $125/vehicle
- Gasoline tax increase of $2/gallon.

In addition, a regionwide nonemployee parking charge of $0.01/minute was seriously considered by the metropolitan planning organization but rejected as too difficult politically. It would further decrease VMT by about another 4 percent.

California Energy Commission (CEC) Programs

CEC has devoted considerable effort to developing a market for clean alternative fuels through demonstration programs and other activities.[24] Through CEC's initiatives, California has become a principal force in pushing for methanol as the leading alternative fuel.

CEC established a Methanol Task Force that developed a plan for reducing market barriers facing methanol. As a result of this effort, several methanol and petroleum industry leaders decided to enter into a public-private partnership to help move methanol closer to commercial status.

A CEC biennial report called for as much as 25 percent of all transportation energy demand to be met in methanol vehicles by the year 2000 in areas not meeting air quality standards.

Agreements with major oil companies resulted in a commitment to establish 50 methanol fueling stations in California. Government fleets will include several thousand methanol vehicles to help bring these vehicles closer to normal production runs.

TABLE C.2. CAAA provisions affecting VMT in CO and ozone nonattainment areas

Severity	Provisions[1]	Current Number of Areas[2]
Ozone Nonattainment Areas		
Moderate	Emissions from all sources to be reduced by 15% in six years	31
Serious	Above plus TCMs to offset emissions increase resulting from growth in VMT and vehicle trips	16
Severe	Above plus employers required to increase vehicle occupancy by their employees; stronger TCMs required	8
Extreme	Above plus possible restrictions on heavy vehicles	1
CO Nonattainment Areas		
Moderate	VMT forecasts are required, with contingency measures if forecasts are exceeded or attainment is not achieved	38
Serious	TCMs to offset emissions increase resulting from growth in VMT and vehicle trips; economic incentives to reduce VMT required by 1995 if attainment cannot be achieved without them	1

[1] Gary Hawthorn, "Transportation Provisions of the Clean Air Act Amendments of 1991," *ITE Journal*, April 1991, pages 17-24.

[2] Emission Control Technology Division, U.S. Environmental Protection Agency, Ann Arbor, MI, March and May 1992.

C.3 THE CLEAN AIR ACT AMENDMENTS OF 1990

The CAAA of 1990 is likely to affect transportation fuel use by reducing VMT and increasing the use of alternative fuels, though both effects are likely to be small. CAAA has varying requirements for implementing TCMs in all serious CO nonattainment areas and in all serious, severe, and extreme ozone nonattainment areas. (Severe and extreme CO nonattainment areas are not defined.) These provisions are succinctly summarized in Table C.2. This table also shows the number of affected nonattainment areas in each category as of May 1992.[25]

The use of TCMs in nonattainment areas can be expected to have some effect on VMT and on fuel-tax revenue. However, because TCMs primarily affect the home-to-work trips, which constitute only about 25 percent of urban weekday VMT, and they have only a modest effect on these trips, the overall reduction in VMT will be small. It has been estimated that a program of conventional TCMs in the San Francisco area will reduce emissions by 1 percent to 3 percent, and a comprehensive program that requires significant funding will decrease emissions by 5 to 8 percent.[26] The effects on VMT will be comparable.

In addition to the requirements for TCMs, the CAAA contains several provisions that affect motor vehicles and the fuels they use:[27]

1. Beginning in 1995, all gasoline sold throughout the year in the nine worst ozone nonattainment areas with a population in excess of 250,000 must meet several "reformulation" standards,

including an oxygen content of 2 percent. These nine areas contain about 23 percent of the country's population. The approximately 90 other ozone nonattainment areas may also opt into this requirement, though capacity problems may delay the introduction of reformulated gasoline in these areas by up to 3 years. In addition, all Northeast Ozone Transport Commission members have requested that this requirement be applied to all nonattainment areas in their states.[28] Other ozone nonattainment areas may also opt into this requirement, but EPA is expected to delay approval of such requests for several years because of supply limitations. The reformulated gasoline used in these areas is expected to reduce fuel economy 3 to 5 percent.

2. Beginning in November 1992, a somewhat different requirement was to apply to CO nonattainment areas whose CO source is not stationary. In these areas, all gasoline sold during the time of year when CO levels tend to be high were required to contain at least 2.7 percent oxygen by weight except in California (where ozone levels are of much greater concern than CO levels); in California the oxygen requirement is 2 percent oxygen by weight. As of May 1992, there were 39 CO nonattainment areas containing about 32 percent of the country's population. Twenty-three of these areas, containing about 7 percent of the country's population, are not ozone nonattainment areas. In 2001, the requirement may be raised to 3.1 percent in serious mobile-source CO nonattainment areas (currently the Los Angeles metropolitan area). In mobile-source CO nonattainment areas, oxygenated fuels must be used for at least 4 months per year.

3. Beginning in 1998, a variety of standards are set for new vehicles purchased for fleets of 10 or more vehicles that are capable of being centrally fueled and that operate in several (currently 21) ozone and CO nonattainment areas.

4. Beginning with the 1996 model year, a minimum of 150,000 clean-fuel automobiles and light-duty trucks must be sold annually in California, rising to 300,000 per year in model year 1999.

5. A particulate standard for new urban buses went into effect in model year 1994, but this standard was not expected to result in any change in fuel use.

6. More stringent emissions standards took effect in California in 1993 and nationally in 1994. A further halving of the standards for nonmethane hydrocarbons, CO, and NO_x may take effect in 2004 if EPA and the Office of Technology Assessment find that such "Phase II" standards are achievable.

7. Individual states may opt into the new California LEV/ZEV program described in Section C.2.

Of these provisions, only the ZEV requirement will necessarily increase the number of AFVs purchased. It has been estimated that the California ZEV requirement, by itself, would result in 1.6 million EVs operating by 2010.[29] In addition, Massachusetts and New York have recently adopted similar ZEV requirements[30] and the remaining six states belonging to the Northeast States for Coordinated Air Use Management (NESCAUM) group, as well as some of the Middle Atlantic states, have expressed varying degrees of interest in opting into the California program. If California is joined by the eight NESCAUM states, approximately four million ZEVs could be in operation by 2010, assuming such vehicles are marketable.

A second effect of the above provisions on highway tax revenue would be a probable increase in the use of gasohol, the only oxygen-containing gasoline fuel that enjoys a special tax status. Because ethanol blends tend to increase evaporative emissions (because of a resulting increase in Reid vapor pressure), ethanol is likely to be used only in the CO nonattainment areas that are not also ozone nonattainment areas. There are 23 such areas containing about 7 percent of the country's population. The oxygenation requirements for CO nonattainment areas can be met with a fuel containing only 8 percent or 9 percent ethanol by volume. However, assuming the continuation of the federal and/or state tax breaks for gasohol, it is expected that ethanol would be used exclusively in a 10 percent blend. Because oxygenated fuel would be required in CO nonattainment areas only during part of the year and concern about evaporative emissions is likely to limit the use of gasohol in ozone nonattainment areas, the above information suggests that the CAAA is unlikely to increase gasohol's share of the total gasoline/gasohol market by much more than 2 percentage points.

C.4 OTHER DEPARTMENT OF ENERGY PROGRAMS

In addition to initiatives required by the AMFA of 1988, DOE is involved in several other activities that are likely to influence consumption of conventional and alternative motor fuels:

- National Energy Strategy (NES)
- Research programs
- Cost-benefit study of alternative fuels
- Advanced battery consortium.

Each of these is discussed in the subsections that follow.

National Energy Strategy

The NES was developed by DOE to address three goals: (1) the increasing need for energy at reasonable prices, (2) the commitment to a safer, healthier environment, and (3) reduced dependence on unreliable energy sources.[31] The last goal implies development of renewable sources as well as independence from Persian Gulf and other petroleum sources.

The NES includes five major initiatives that are forecast to replace 2.2 million barrels per day of petroleum motor fuels—about 25 percent of the projected 2010 motor fuel consumption. The five initiatives are the following:

1. **Eliminate the Cap on CAFE Credits**—There is a cap of 1.2 MPG on credits that manufacturers can receive for flexible fuel and dual fuel vehicles. That reduces the incentive to produce these vehicles to no more than a few hundred thousand per year for at least 2 decades.
2. **Increase the Size of the Federal AFV Fleet**—The maximum feasible rate of increase of purchase of AFVs will achieve the target set for 1995 ahead of schedule.
3. **Require Use of AFVs for CAAA's Clean Fuel Fleets**—DOE proposes to modify the requirements of CAAA to ensure that AFVs are used to the extent feasible in the clean fuel fleets. Ten percent of the 1995 requirements would have to be AFVs and that would increase to 90 percent in 2000. The requirements also would be expanded from 21 nonattainment areas to all urban

areas, and would be expanded to cover heavy trucks except over-the-road class-eight trucks.

4. **Increase R&D on AFVs**—The effort devoted to clean diesel, gas turbines, fuel cells, and EVs would be increased. DOE proposes to invest in a public-private initiative on EVs with a consortium of manufacturers, battery developers, and utilities with specific performance objectives and a goal of advancing the commercialization of EVs to the mid-1990s.

5. **Accelerate Development of Advanced Biofuels Technology**—DOE proposes a goal of successfully commercializing the production of alcohol fuels from biomass by 2000 through planned improvements in crop yields (nonfood products) and conversion processes.

Research Programs

DOE has identified six broad areas of research and related activities to support a long-range program of AFV development.[32] One of the more challenging technical issues is the inherent difficulty in the use of fuels in a gaseous state in motor vehicle engines. The lower energy density of gaseous fuels is also a major challenge in designing vehicles and fuel-storage systems. Perhaps most important in the long term, each type of AFV must have a unique system design to achieve optimum performance and efficiency. This design has not been done yet for any alternative fuel. Current AFVs involve compromises that have been made to adapt current vehicle designs to operate on a flexible fuel basis—i.e., using either conventional or alternative fuels or a blend of the two.

The six areas of research needs identified by DOE for AFVs are the following:

1. Basic engine and combustion research for all fuel types to improve thermodynamic efficiency and reduce emissions
2. Gaseous fuel storage—breakthrough needed in optimizing energy quality, density, and cost tradeoffs
3. Alternative additives for alcohol fuels that maintain their full environmental and oil displacement benefits
4. Effects of specific emissions in the formation of ambient pollutants to focus attention on developing technologies that most effectively reduce pollutants
5. Effects of alternative fuels in reducing global warming
6. Expansion of education programs for scientists and engineers trained to conduct research on alternative fuels.

Cost-Benefit Study of Alternative Fuels

DOE has been conducting a multiyear Alternative Fuels Assessment that had its origins in a report to the president. The report concluded that the United States is likely to become increasingly dependent on oil supplies from the politically unstable Persian Gulf.[33] The report found that even with widespread use of more fuel-efficient vehicles this dependency cannot be reduced unless alternative fuel systems are developed.

A principal goal of the Alternative Fuels Assessment is to provide information and analytical tools so that government and industry will be in a better position to make decisions about the future course of alternative fuels development.

The study has been divided into three main research areas: fuel supplies, infrastructure, and environment. Each of these has been further divided into several tasks that have been underway concurrently. The interrelationships among the three main research areas and their constituent tasks are summarized in Figure C.1. Each of the three areas involves use of a major computer model: (1) the Alternative Fuels Trade Model, (2) David Greene's Vehicle Stock and Fuel Demand Model, and (3) the Transportation Energy and Emissions Modeling System. DOE has been publishing regular progress reports on the results of this research and on the development and application of these models, with the intent of helping to inform government and industry in their decision-making processes.

Advanced Battery Consortium

Chrysler, Ford, General Motors, and the Electric Power Research Institute have joined in a partnership to form the U.S. Advanced Battery Consortium (USABC). USABC will conduct R&D on advanced batteries to provide increased range, improved performance, and reduced cost, with specific objectives defined for the mid-term (to be proven by 1994) and long term (feasibility to be demonstrated by 1994).[35] DOE is matching the funding provided by industry for USABC, which is expected to total $262 million over 4 years.

The mid-term and long-term objectives for the advanced batteries include useful lives of 5 and 10 years, respectively, operating costs of less than $150 and $100 per kilowatt-hour, and recharge times of less than 6 hours and possibly as little as 3 hours. Faster recharge requirements could be extremely costly because of high energy inputs. Some of the quick recharge systems would require 440 volts or 100 amps, which would require the use of recharging stations instead of home refueling, thus eliminating most of the benefits of using low-cost off-peak electric power for recharging (but possibly making it feasible to meter and tax electricity use).

C.5 INTERMODAL SURFACE TRANSPORTATION EFFICIENCY ACT OF 1991

ISTEA has provisions that are likely to influence the consumption of conventional and alternative motor fuels and that could become very important factors in the long term. These include the following:

- The Congestion Mitigation and Air Quality Improvement Program (CMAQ)
- Requirements for conformity with Statewide Improvement Plans (SIPs)
- The Intelligent Vehicle Highway Systems (IVHS) program.

Each of these is discussed in the subsections that follow.

Congestion Mitigation and Air Quality Improvement Program

The CMAQ program directs funds toward transportation projects in CAAA nonattainment areas for ozone and CO.[36] These projects are intended to contribute to meeting the attainment of

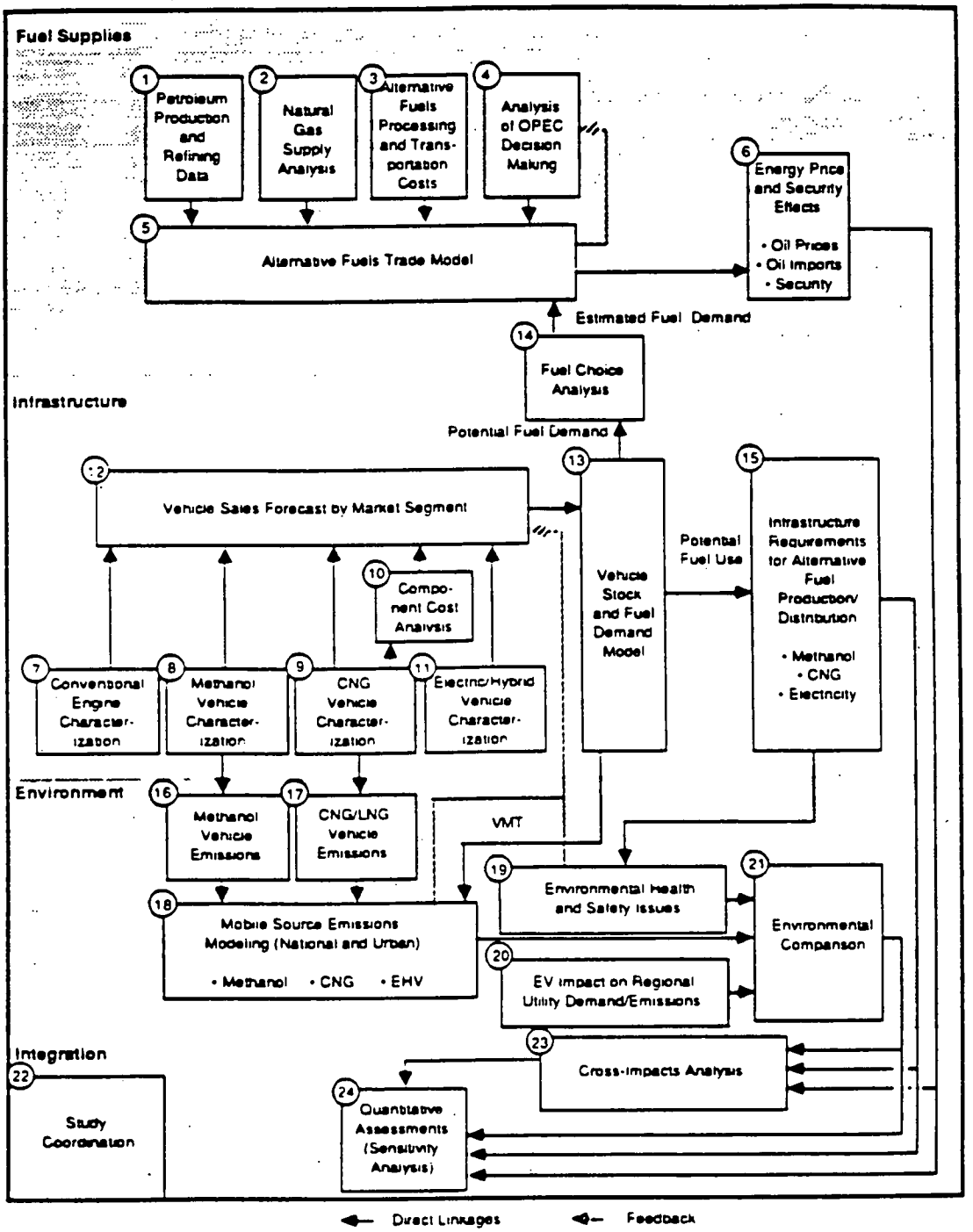

Figure C.1. Relationships among the elements of the DOE Alternative Fuels Assessment.[34]

national ambient area air quality standards. If a state has none of these nonattainment areas, the funds may be used as if they were Surface Transportation Program funds.

Total funding authorized for the program is $6 billion over 6 years. The funds are distributed based on each state's share of the population of air quality nonattainment areas weighted by degree of air pollution. A ½ percent minimum apportionment is guaranteed to each state.

The CMAQ program has a number of transit and transit-related applications. Eligible projects under the program include (but are not limited to) the following:

- Any transit or transit-related project or program contained in an approved State Implementation Plan (SIP)
- TCMs established by the CAAA of 1990

- The development of new traffic demand management programs
- The construction of pedestrian and bicycle facilities.

Other projects and programs may qualify if, after consultation with EPA, FHWA determines that they are likely to contribute to the attainment of a National Ambient Air Quality Standard.

Requirements for Conformity with State Implementation Plans

ISTEA and CAAA have mutually reinforcing provisions to ensure conformity of projects, programs, and long-range plans with air quality plans.[37] FHWA must undertake a substantive and detailed review of metropolitan plans to ensure compliance with both acts and other federal laws.

Both metropolitan (Section 1024) and statewide (Section 1025) transportation plans must conform with approved SIPs for air quality.[38] In metropolitan areas with more than 200,000 people that are classified as nonattainment areas for ozone or CO, federal funds may not be programmed for any highway project that will result in a significant increase in carrying capacity for single-occupant vehicles unless the project is part of an approved congestion management system. Nonimplementation of such systems by FY 1996 will result in a 10 percent penalty of apportioned highway funds and transit funds.

Intelligent Vehicle Highway Systems

An IVHS program is established under Title VI of ISTEA, with approximately $660 million authorized for 6 years.

ISTEA requires the promotion of compatible standards and protocols to promote widespread use of IVHS technologies, the establishment of evaluation guidelines for IVHS operational tests, and the establishment of an information clearinghouse.

A strategic plan must have been submitted to Congress no later than 1 year after the act became effective. The plan must have included the goals, milestones, and objectives of the IVHS program.

ISTEA also requires development of a completely automated highway and vehicle system that will serve as the prototype for future fully automated IVHS. The goal is to have the first fully automated roadway or test track in operation by the end of 1997. An IVHS Corridors program is established to provide for operational tests under "real world" conditions. Corridors that meet certain transportation and environmental criteria can participate in developing and implementing IVHS technologies.

C.6 ENERGY POLICY ACT OF 1992

The Energy Policy Act of 1992 added provisions pertaining to alternative fuels, EVs, automotive fuel economy, and global climate change. The act includes specific provisions requiring federal fleet procurement of AFVs increasing up to 75 percent or more by 1999 and thereafter. It also provides for assistance to state alternative fuel programs. It includes requirements for companies engaged in alternative fuel production to use such fuels for their fleets, and provides for assistance to demonstrations of EVs and infrastructure programs for AFVs. The act authorizes funding of advanced research to improve automotive fuel economy and to reduce emissions. The global climate change provision calls for a series of studies of alternatives to control or reduce greenhouse gas emissions.

ENDNOTES

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2. United States Department of Energy, *Second Interim Report of the Interagency Commission on Alternative Motor Fuels,* September 1991, pp. 7–8. Hereafter referred to as *Second Interim Report.*
3. According to the April 25, 1991, statement of Judy A. England-Joseph (*op. cit.,* pp. 12–14), the program was behind schedule because of unexpected problems of the manufacturers in terms of design, production, and cost.
4. *Second Interim Report, op. cit.,* pp. 8–9.
5. England-Joseph, *op. cit.,* pp. 9–11.
6. *Second Interim Report, op. cit.,* pp. 9–10.
7. *Ibid.,* pp. 11–12. The titles of the completed reports identified in the DOE report are *Federal Regulations Needing Amendment to Stimulate the Production of Electric/Solar Vehicles; Impacts on Home Heating Costs of Incentives for Alternative Vehicles,* November 1989; and *Assessment of Costs of Producing Methanol for Unutilized Domestic Natural Gas,* July 1991.
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9. *Second Interim Report, op. cit.,* p. 10.
10. *Ibid.,* pp. 10–11.
11. The revised scenario is included in the second report of the commission.
12. England-Joseph, *op. cit.,* pp. 8–9 and attachment I, p. 18.
13. *Second Interim Report, op. cit.,* pp. 12–13.
14. "The Greening of Detroit: A Push Is on to Make Gas More Environmentally Friendly," *Business Week,* April 8, 1991, pp. 54–60.
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16. *Ibid.,* pp. 5 and 26–30.
17. *Ibid.,* p. 10.
18. *Second Interim Report, op. cit.,* pp. 37–39.
19. "The Greening of Detroit," *op. cit.,* pp. 56 and 60.
20. *Second Interim Report, op. cit.,* p. 40.
21. *Ibid.,* pp. 40–44 and A–1—A–5.
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23. Grieg Harvey and Elizabeth Deakin, "Air Quality and Transportation Planning: An Assessment of Recent Developments," unpublished paper prepared for FHWA, pp. 2 and 10.
24. Kenneth Koyoma and Lisa Darling, "Methanol Supply and

Demand Issues from a California Perspective," *Transportation Research Record 1175,* pp. 15–21.
25. The number of CO nonattainment areas has been dropping over time as the EPA reviews the specific circumstances of individual nonattainment areas.
26. Grieg Harvey and Elizabeth Deakin, "Air Quality and Transportation Planning: An Assessment of Recent Developments," Deakin, Harvey and Skabardonis, Berkeley, CA, Revised Draft, February 27, 1992, p. 11.
27. *Second Interim Report, op. cit.,* pp. 37–40; and Charles L. Gray, Jr., "Clean Air Act and Future Transportation Fuels," *Transportation Impacts of the Clean Air Act,* Midwest Transportation Center, Ames, Iowa, 1991, pp. 1–15.
28. Margaret Singh, Argonne National Laboratories, Washington, D.C., personal communication, July 1992.
29. *Second Interim Report, op. cit.,* pp. 43–44.
30. Margaret Singh, personal communication, July 1992.
31. *Second Interim Report, op. cit.,* pp. 2–5.
32. *Second Interim Report, op. cit.,* pp. xiii–xiv.
33. United States Department of Energy, Office of Policy, Planning and Analysis, *Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector: Technical Report One: Study Objectives and Methodologies,* June 1988, pp. 2–5.
34. *Ibid,* p.5
35. *The Clean Fuels Report, op. cit.,* pp. 173–174.
36. United States Department of Transportation, *A Summary: Intermodal Surface Transportation Efficiency Act of 1991,* 1992, p. 9.
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38. *Intermodal Surface Transportation Efficiency Act of 1991,* Public Law 102-240, December 18, 1991.

APPENDIX D

REVIEW OF RECENT RELATED FORECASTS AND ANALYSES OF SCENARIOS

This appendix summarizes about 20 recent sources that involve either trend-based forecasts, policy-driven forecasts, or scenarios dealing with energy futures and related factors of interest to this project. The purpose of this review is to provide background for the development of the several scenarios as described in Chapter 2. An evaluation of the consequences of alternative financing programs under the scenarios is contained in Chapter 3.

D.1 ARGONNE'S COMPARISON OF FORECASTS TO 2010

The most comprehensive comparison of recent forecasts of highway travel and energy use is contained in Argonne's (ANL's) latest forecast report.[1] Figure D.1 shows a comparison of five recent forecasts of total highway vehicle miles of travel (VMT) and energy used in highway travel through 2010. The five forecasts are by the following:

- Argonne in 1990 (ANL-90N)
- Data Resources, Inc., (DRI) in 1989 (DRI-89/3)
- Gas Research Institute (GRI) in 1989 (GRI-89)
- Energy and Environmental Analysis (EEA) in 1988
- U.S. DOE's Energy Information Administration (EIA) in 1989 (EIA-89).

None of the forecasts reflects effects of the 1990 Clean Air Act Amendments (CAAA), the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), or other recent actions.

Table D.1 shows a comparison of forecasts for automobiles and personal vehicles from the five sources. They include forecasts of vehicle stocks, VMT, fuel consumption, fuel economy (on the road), and vehicle use (VMT/vehicle). Both ANL and EIA provide forecasts for all personal vehicles as well as for automobiles for most of these factors. Light trucks have recently accounted for more than 50 percent of the yearly additions to the total stock of personal vehicles.

ANL forecasts considerably faster growth in vehicle stocks, while auto VMT is quite similar for all forecasts. ANL forecasts a 2 percent decline by 2010 in annual VMT per auto while EEA expects a 4 percent increase, DRI a 26 percent increase, and GRI a 35 percent increase. The Argonne report notes that VMT/vehicle has been remarkably stable, varying by no more than 2 percent to 5 percent from the long-term trend over the past 40 years despite economic cycles, demographic shifts, and oil price shocks. We consider the Argonne or EEA forecasts of VMT/vehicle to be much more likely than the DRI or GRI forecasts.

The report notes that EIA forecasts lower energy use in the short term than ANL, primarily because of higher fuel efficiency assumptions, but higher energy use by 2010, because of somewhat higher VMT.

This source discusses other differences in these forecasts and also compares truck forecasts from the same forecasters and past forecasts by Argonne with the latest forecasts.

DOE's Alternative Fuels Scenarios

In response to a request by the Alternative Fuels Council, DOE developed an alternative fuels scenario, and a pathway for that scenario to 2010, that achieves a target of displacing 25 percent of projected U.S. petroleum fuel consumption.[2] This scenario is characterized as requiring an aggressive alternative fuels development program, but being technologically and financially feasible.

Figure D.2 shows the projected rate at which AFVs would penetrate the market for passenger car and light truck sales between now and 2010 by type of fuel. Note that there is a slow rate of penetration forecast for alternative fuel vehicles (AFVs) until 1997–1998, and then a rapid increase in AFV sales is forecast to continue for several years. For electric vehicles (EVs), the penetration increases until the end of the forecast period, while for other vehicles, it levels off around 2000. About 50 percent of all motor vehicle sales are forecast to be AFVs by 2010, and almost 60 percent of cars.

Table D.2 shows the mix of AFVs projected to be in use in 2010 broken down by fuel type and type of vehicle. Note that methanol vehicles make up the largest category — about one-third of all AFVs and about two-fifths of total personal alternative fuel cars. However, also note that each of the five categories of AFVs makes up a significant proportion of the total. The smallest category, ethanol, comprises 12 percent of the total. Not shown in these figures are the total vehicle stocks in 2010 including conventionally fueled vehicles. AFVs are projected to comprise 27, 28, 23, and 33 percent of all vehicles in use in 2010 for cars, light trucks, heavy trucks, and buses, respectively.

DOE characterizes this scenario as "one plausible scenario" among many that could be postulated to meet the 25 percent displacement goal. Discussion with DOE staff indicates that this scenario is actually somewhat of a political compromise scenario. The shares of AFVs were distributed more evenly among fuel types after the initial draft scenario produced by staff was reviewed by the Alternative Fuels Council, which includes representatives from the various industries concerned. In the original draft produced using David Greene's Alternative Motor Fuel Use (AMFU) Model, the shares of AFVs were less evenly distributed among fuel types — methanol being more dominant. One would expect that market forces would lead to dominance by one or two fuels once any alternative fuel became competitive.[3]

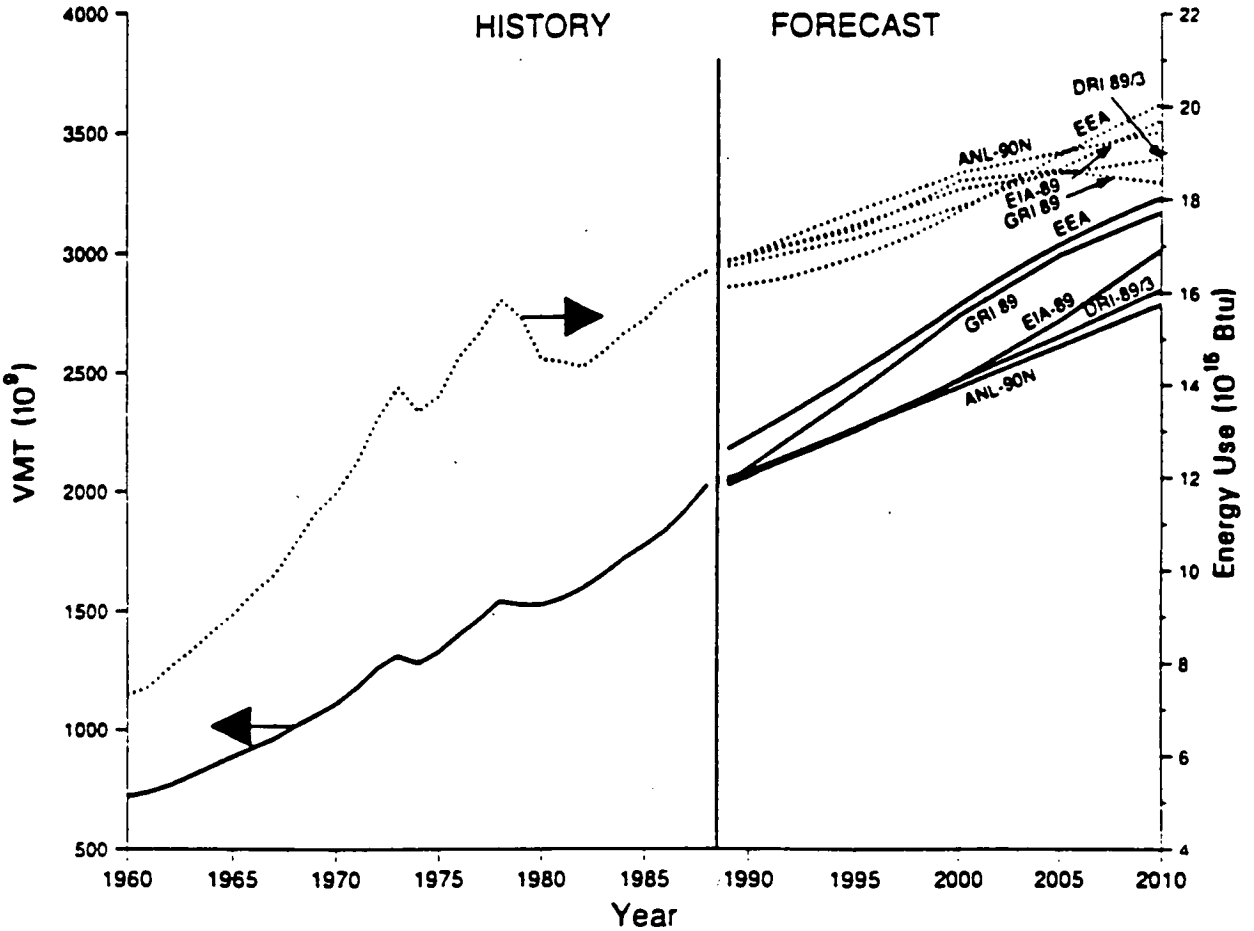


Figure D.1. Highway travel and energy use, 1960–2010.

Despite these shortcomings, the DOE scenario is a useful product in a technical sense, for the following reasons:

1. The scenario is based on a carefully developed pathway involving development of technology, infrastructure, productive capability, supply systems, and market penetration.
2. It was developed using David Greene's AMFU Model, which accounts for vehicle stocks, vehicle use, scrappage rates, fuel economy, and other factors.
3. It provides the basis for examining the potential impacts of the use of the several alternative fuels and their relative likely costs and benefits.

National Energy Strategy

The National Energy Strategy (NES) involves five major initiatives by DOE that are projected to displace 2.2 million barrels per day (MMBD) of gasoline and diesel by 2010—about 88 percent of the more ambitious goal of 25 percent of petroleum motor fuels displacement set by the Alternative Fuels Council as the basis for the scenario discussed above. (DOE's reports do not discuss the new policy initiatives that might be used to increase the level of petroleum fuels displacement targeted by the council.)

The NES could also have significant impacts on the use of petroleum fuels in sectors other than transportation, although that is not discussed in any of the available DOE reports. More efficient diesel and turbine engines could conserve significant petroleum fuels in other industrial sectors, and turbines could use alternative fuels efficiently. Fuel cells using alternative fuels could be used by utilities and other industries. Advanced biofuel technology also could result in widespread use of alcohol fuels by industry in the long run. DOE estimates that the displacement of petroleum fuels by alcohol from biomass could reach 2.5 to 4 million barrels per day by 2030.[4]

Daniel Sperling's Methanol Scenario

A scenario developed by Daniel Sperling is intended to represent "the upper limit of opportunities for introducing methanol fuel to this country," resulting in the production of 1.5 million barrels per day by the mid- to late-1990s, starting from a base year of 1980.[5] That compares with 1.1 million barrels per day of methanol in 2010, starting from a 1991 base (a slightly longer development period) in the scenario that DOE developed for the Alternative Fuels Council, as discussed above.

The scenario includes a staged development path requiring rapid, aggressive governmental action to overcome barriers and

TABLE D.1. Forecast comparisons: Personal vehicle stocks, vehicle miles, fuel consumption, fuel economy, and vehicle use

Source	Value by Year						Growth, 1985-2010 (%/Year)
	1985	1990	1995	2000	2005	2010	
On-Road Fuel Economy (mpg)							
Personal vehicles							
ANL	17.0	18.0	19.1	19.7	21.1	22.6	1.15
EIA	18.2[a]	18.7	19.9	21.0	22.1	23.1	1.10
All automobiles							
ANL	18.2	20.0	20.7	21.3	23.0	24.7	1.23
EIA	19.5[a]	20.2	22.0	23.8	25.5	27.2	1.52
DRI	20.0[a]	21.1	23.1	24.3	NA	27.2	1.41
GRI	18.4[b]	NA	23.1	24.6	26.2	27.9	1.75
EEA	19.3[b]	21.4	23.1	24.3	25.0	25.2	1.12
New automobiles							
EIA[d]	28.3[a]	28.6	30.7	32.8	34.8	36.9	1.21
DRI	24.1	24.3	25.5	27.0	NA	30.1	1.02
GRI	23.1[b]	NA	25.3	27.1	29.0	31.1	1.25
EEA	23.8[b]	24.3	25.1	26.5	26.5	26.5	0.45
Vehicle utilization (VMT/vehicle)							
Personal vehicles							
ANL	8,726	8,835	8,715	8,608	8,566	8,522	-0.09
Automobiles							
ANL	9,611	9,759	9,652	9,533	9,482	9,393	-0.09
DRI	9,870[a]	10,218	10,961	11,454	NA	12,478	1.07
GRI	9,318[b]	NA	10,649	11,148	11,393	12,612	1.27
EEA	11,739[b]	12,067	12,119	12,135	12,194	12,256	1.80

stimulate the development of methanol production, distribution systems, and vehicle production. The pathway includes the following elements:

- Use of methanol as an additive in gasoline and as a blend in early phases
- Development of an optimal methanol vehicle design, because conversion of current vehicles is expensive ($2,000±)
- Introduction initially as fleet vehicles with central refueling and servicing
- Development of natural gas conversion initially, with future transition to large-scale coal conversion plants, which offer major economies of scale
- Construction of a pipeline distribution system, which is far less costly than alternatives because of large plants and long distances to major markets.

The scenario includes government action to establish the methanol production industry, temporary removal of excise taxes on methanol and other assistance in penetrating markets, and development of an efficient distribution system.

Argonne's Electric Hybrid Vehicle Scenario

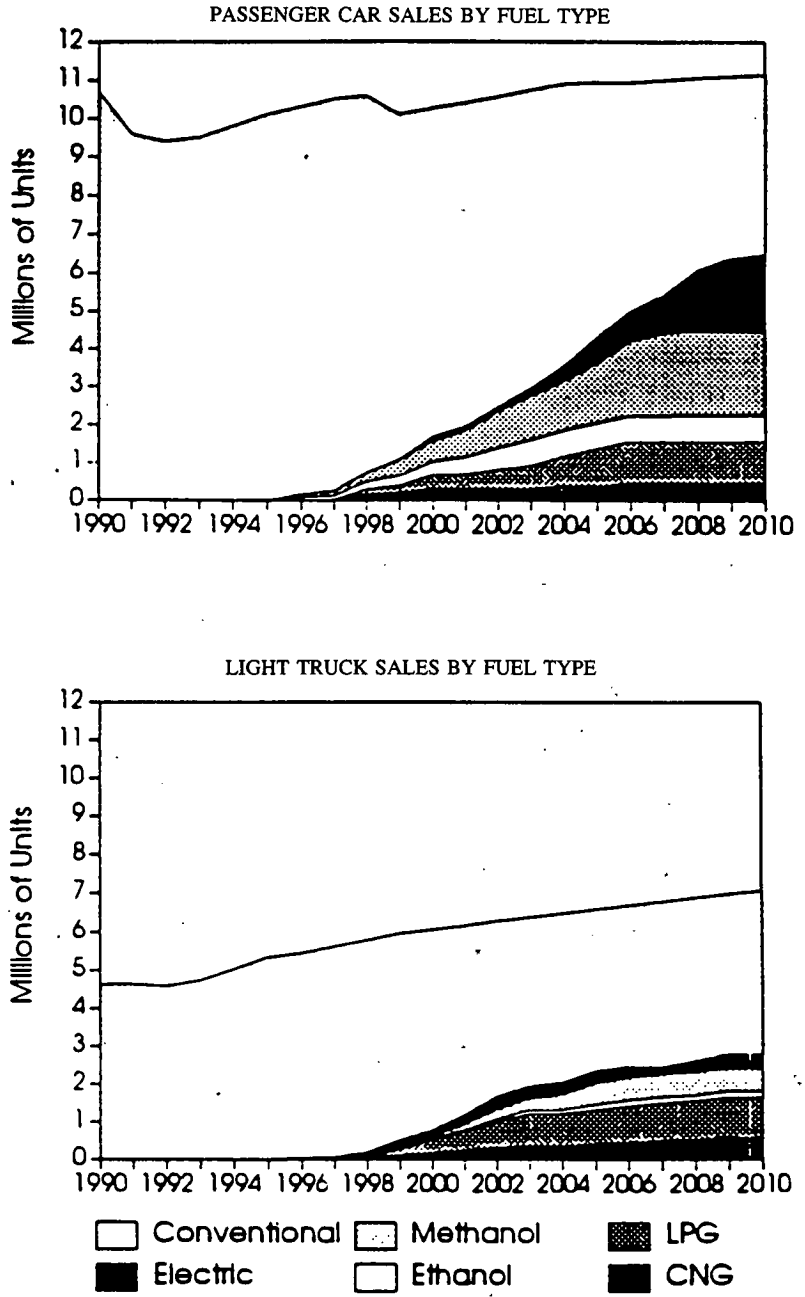
Electric hybrid vehicles (EHVs) are vehicles that can operate under either electric battery power or conventional fuels. Maximum EHV production by 2010 will be constrained by the rapidity with which battery technology evolves from the current lead-acid batteries to more advanced batteries that allow greater range on a single charge. Argonne has developed a scenario for DOE that postulates maximum feasible penetration of EHVs.[6]

TABLE D.1. Forecast comparisons: Personal vehicle stocks, vehicle miles, fuel consumption, fuel economy, and vehicle use (continued)

Source	Value by Year						Growth, 1985-2010 (%/Year)
	1985	1990	1995	2000	2005	2010	
Stocks (10^6)							
Personal vehicles							
ANL	145.2	170.0	186.0	201.2	214.8	229.4	1.85
Automobiles							
ANL	131.2	149.6	161.1	173.4	185.2	197.7	1.65
DRI	145.8[a]	147.1	148.8	150.6	NA	156.6	0.33
GRI	140.7[b]	NA	151.1	158.5	166.6	170.3	0.80
EEA	117.3[b]	125.3	135.0	145.7	155.0	163.1	1.38
Vehicle Miles (10^9)							
Personal vehicles							
ANL	1,267	1,502	1,602	1,732	1,840	1,955	1.75
EIA	1,511[a]	1,553	1,681	1,834	2,017	2,241	1.81
Automobiles							
ANL	1,261	1,460	1,555	1,653	1,756	1,857	1.56
DRI	1,439	1,503	1,631	1,725	NA	1,954	1.40
GRI	1,311[b]	NA	1,609	1,767	1,898	1,975	1.72
EEA	1,377[b]	1,512	1,636	1,768	1,890	1,999	1.56
Fuel Consumption (10^{15} Btu)							
Personal vehicles							
ANL	9.317	10.047	10.589	11.009	10.905	10.803	0.59
EIA	10.314[a]	10.431	10.616	10.962	11.469	12.158	0.75
Automobiles							
ANL	8.666	9.145	9.390	9.635	9.575	9.515	0.16
GRI	8.939[b]	NA	8.714	8.989	9.076	8.851	-0.04
EEA[c]	8.780	8.645	8.514	8.565	8.831	9.211	0.20

[a] 1988.
[b] 1986.
[c] Excludes oxygenates.
[d] EPA rated.

Source: Argonne National Laboratory, Forecast of Transportation Energy Demand through the Year 2010, April 1991, pages 67 and 68.



Note: **Sales are represented by distance between lines.**

Source: *Second Interim Report of the Interagency Commission on Alternative Motor Fuels,* Department of Energy, September 1991, page 29.

Figure D.2. Passenger car sales and light truck sales by fuel type.

TABLE D.2. U.S. DOE forecast of alternative fuel vehicle stocks in 2010 by fuel type, type of vehicle, and personal vs. fleet use (millions of vehicles)

Fuel Type	Total	School Buses	Transit Buses	Heavy-Duty Trucks	Fleet LT's	Fleet Cars	Personal LT's	Personal Cars	Total LT's	Total Cars	Total Fleet	Total Personal
EHV's	11.9	0	0	0	3.1	0.1	0	8.7	3.1	8.8	3.2	8.7
LPG	17.1	0.45	0	1.2	1.6	1.6	8.0	4.3	9.6	5.8	4.8	12.3
CNG	8.8	0.45	0.04	1.2	1.6	1.6	2.3	1.6	4.0	3.1	4.9	3.9
Ethanol	7.9	0	0	0	0	1.6	1.4	4.9	1.4	6.5	1.6	6.3
Methanol	21.9	0	0.04	0	0	1.6	5.6	14.7	5.6	16.3	1.6	20.4
Total	**67.6**	**0.89**	**0.08**	**2.4**	**6.3**	**6.3**	**17.4**	**34.1**	**23.8**	**40.5**	**16.1**	**51.6**

Source: *Second Interim Report of the Interagency Commission on Alternative Motor Fuels;* Department of Energy, September 1991, page 24.

Argonne's scenario envisions the introduction of nickel-iron batteries in the late 1990s, and large-scale production beginning in 2001. Advanced battery cars with a possible range of up to 200 miles are expected in volume production no sooner than 2005. A variety of possible technologies might achieve the assumed performance standards. Gradual buildup of advanced battery EHVs leads to a fleet total of 11.9 million EHVs in operation by 2010. That is about 5 percent of the total light-duty vehicles of all fuel types projected by DOE in the scenario developed for the Alternative Fuels Council, as described above.

Electric Vehicle Scenarios Developed for Los Angeles by Resources for the Future

Five scenarios were developed for EPA by Resources for the Future (RFF) to provide a more careful evaluation of the environmental impacts of large-scale introduction of EVs into the Los Angeles region.[7] The scenarios analyzed include a methanol-blend vehicle as a basis for comparing the other scenarios and the following four EV scenarios:

- Five percent EVs and in-basin power generation
- Fifteen percent EVs and in-basin power generation
- Fifteen percent EVs with full use of existing in-basin capacity plus out-of-basin power when needed
- Fifteen percent EVs with all power generated outside the basin.

Five and 15 percent penetration (500,000 and 1.5 million vehicles) are assumed to be achieved by 2010 and are assumed to be high-mileage nickel-iron battery vehicles. High capital cost and low operating costs will make EVs most suited for high-mileage light trucks. An average of 80 miles per day is assumed for them (compared with 30 for the average auto or light-duty truck). The authors state that these 5 and 15 percent scenarios should bound the range of changes in emissions and ozone concentrations likely to accompany EV penetration. Electric power for the 5 percent penetration scenario can be supplied by existing power plants, assuming that almost all recharging occurs during off-peak hours. Available off-peak capacity will be consumed at roughly double this level of penetration.

The 15 percent penetration scenario is estimated to result in reductions in pollutants that range from 9.3 percent for hydrocarbons to 36 percent for benzene. However, CO_2 emissions (the primary greenhouse gas) would be reduced only 3.3 percent, and acid rain would increase somewhat outside the basin.

Similar benefits would occur in other regions if EV requirements dictated such a high level of EV penetration, but greater negative impacts are likely in some areas for acid rain and ozone because of the types of fuel used for electric power generation (e.g., coal rather than hydro and natural gas) and other environmental conditions.

Although not stated in this report, a clear implication is that if greater reductions in emissions are required, a policy of promoting AFVs to these postulated levels will not be sufficient, because EVs are the least polluting of all AFVs. Further reductions in emissions, without greater EV or other AFV penetration, will require technological advances that reduce emissions of gasoline and diesel vehicles or reductions in VMT.

Southern California Air Quality Management District's EV Scenario

The Southern California Air Quality Management District has recently proposed a plan that would increase the EV requirements in the Clean Air Act Amendments of 1990 (2 percent of sales in 1998 and 10 percent by 2003, or about 40,000 and 200,000 EVs/year respectively) by about 65 percent to 200,000 by 2000 and to 1.3 million by 2007.[8] This plan would essentially achieve the 15 percent scenario for EVs in 2010 analyzed by RFF.

Purdue/DOT Fuel Economy Scenarios

Purdue University performed an analysis of four long-term fuel economy improvement scenarios for U.S. DOT several years ago.[9] Although some aspects of this analysis now appear dated (e.g., very high diesel penetration), the scenarios are of interest because they involved a careful examination of the long-term economics of pushing the technology of fuel economy far beyond current levels.

The scenarios analyzed were the following:

1. **Baseline**—No investments are made solely to improve fuel economy after 1985; new models are introduced more slowly than in the past, and new car fuel economy gradually improves, to an average of about 31 MPG in 2000 and 34 in 2020.
2. **A**—New car fuel economy reaches 40 MPG in 2000 and 43.3 in 2020.
3. **B**—Weight is reduced significantly after 1990 and average fuel economy reaches 50 MPG in 2000 and 55 in 2020.
4. **C**—Weight is reduced even further and an 80 MPG subcompact commuter car accounts for 15 percent of the market by 2020. Average fuel economy reaches 59 MPG in 2000 and 64 in 2020.

Consistent values for light trucks were also developed for each of these scenarios.

The study involved analysis of the investment requirements, frequency of retooling and new model introductions for several types of new light-weight technologies for cars and light trucks. The analysis showed that Scenario A resulted in the highest internal rate of return and the highest benefit-cost ratio of any of the three scenarios, and that this conclusion held up under a wide range of assumptions regarding fuel price increases, baseline assumptions, and discount rates.

OTA's Light-Duty Vehicle Fuels Scenarios

The Congressional Office of Technology Assessment (OTA) performed a comprehensive study of trends in energy consumption in the transportation sector, and long-term prospects for shifting consumption of petroleum fuels by light-duty vehicles to alternative fuels and/or increasing efficiency.[10] A major focus of the study involved an analysis of the following six scenarios:

1. **Baseline**—Negligible use of EVs and a very small increase in use of natural gas; transportation energy use increases at a slightly lower rate than industry as a whole. Average fuel economy reaches 36.6 MPG by 2015, but there is a substantial risk of global climate change by then. Total transportation energy use increases from 22.2 quadrillion Btus (quads) in 1989 to 28.2 quads in 2015 (0.9 percent/year).
2. **High Growth** (3 percent/year)—Transportation energy demand increases at 1.2 percent/year; synfuel use from coal becomes commercially significant (4 million barrels per day by 2015), as do several other alternative fuels: alcohol (0.5 quads), natural gas (1.5 quads), and electricity (0.7 quads of EV fuel use, requiring 2.4 quads of generation). Total transportation energy use increases to 35.3 quads in 2015 (1.8 percent/year).
3. **Moderate Emphasis on Efficiency**—Compared with the Baseline Scenario, 3.1 quads of transportation energy consumption is saved through a variety of measures ranging from improved transit (0.15 quads) to improved traffic flow (0.89 quads). New auto fuel economy increases to 39 MPG, contributing the second greatest amount to transportation energy savings (0.59 quads). Alternative fuels do not make a significant penetration and transportation energy use increases to only 25.5 quads in 2015 (0.5 percent/year).
4. **High Emphasis on Efficiency**—Transportation energy savings compared with the Baseline Scenario increase to 10.7 quads, with new auto efficiency contributing the most (2.7 quads), followed by improved transit (2.6), new light-truck efficiency (1.9), and new heavy trucks (1.8). Alternative fuels (including EVs) could play a substantial role in this scenario; if CO_2 emissions prove to be critical, gasoline might be replaced by methanol from biomass, but synthetic fuels from coal or oil shale would be counterproductive. Total transportation energy consumption is reduced to 18.5 quads in 2015 (-0.7 percent/year).
5. **High Emphasis on Renewable Energy**—A total of 1.2 quads of transportation energy is derived from renewable sources by 2015, most likely methanol from wood or herbaceous crops, or possibly ethanol technologies. The transition to substantial use of biomass is difficult, involving the establishment of new fuel processing and distribution industries in direct competition with existing systems. EVs remain a negligible share of all vehicles. Oil use grows only about one-fifth as much as in the Baseline Scenario, and total transportation energy consumption increases at the same reduced rate as in Scenario 3, Moderate Emphasis on Efficiency (0.5 percent/year).
6. **High Emphasis on Nuclear Power**—EV penetration becomes as large as the use of renewables (0.7 quads each). Although transportation is the most difficult sector to convert to electricity, it could power about four times as many vehicles as biomass by 2015, and could grow rapidly after that. Transportation oil consumption increases slightly less than in Scenario 5, High Emphasis on Renewable Energy—the least growth of all scenarios. Total transportation energy consumption increases at the same rate as in Scenarios 3 and 5 (0.5 percent/year).

OTA evaluated these six scenarios on a five-point scale in comparison with the Baseline Scenario (much better or easier, somewhat better or easier, about the same, somewhat worse or harder, or much worse or harder) in each of seven categories:

- Environmental
- Security
- Economic
- Resilience
- Implementability in terms of infrastructure
- Implementability in terms of public acceptance
- Sustainability.

Scenario 3, Moderate Emphasis on Efficiency, was assessed as having the highest total positive score and Scenario 6, High Emphasis on Nuclear Power, had the lowest total negative score. The worst was Scenario 2, High Growth, which had both the highest overall negative score and the lowest overall positive score.

On the basis of this evaluation, OTA concluded that the United States should combine elements of Scenarios 4, 5, and 6 (e.g., High Emphasis on Efficiency, Renewable Energy, and Nuclear Power) to ensure that a wide range of technologies became available in the future, and to provide the flexibility required to be able to cope effectively with different contingencies embodied in these scenarios. Table D.3 summarizes the policy options that OTA developed for each of the scenarios (other than the Baseline Scenario). Note that all scenarios except High Growth (which was rated worst) include substantial energy taxes.

TABLE D.3. Summary of OTA policy options

Scenario	Financial mechanisms	Taxes	Info management	RD&D	Standards	Federal programs
High growth	Credits, loans and payments for synfuels; tradable permits for coal emissions; incentives for electric vehicles.	No change from baseline scenario.	No change from baseline scenario. Improve public acceptance of nuclear power.	Clean coal technologies; advanced oil and gas recovery; synfuels; fluidized bed and IGCC; electric vehicles.	No changes needed in energy performance standards; emissions reductions in utility and transportation sectors probably necessary.	PURPA/PUHCA revisions to expand resource base, increase competition; eased plant siting to keep costs down; OCS/ANWR opened; SPR increased; improved nuclear licensing and waste disposal facility.
Moderate efficiency	Tax credits and accelerated depreciation for quicker equipment turnover; tradable permits for emissions reductions, (industry and utilities), coupled with tougher emissions standards.	Energy taxes; gasoline tax in the range of 50 cents; other energy taxes raised accordingly; carbon tax of at least $75 to $150/ton; added taxes on inefficient equipment.	Increase Government and utility efforts to impart life-cycle opportunities (retrofits & new equipment).	Vigorous for all sectors.	Raise building and equipment performance standards (NAECA, BEPS); CAFE to 39 mpg; tradable permits; 55-mph speed limit; HOVs and carpooling programs; and utility demand-side management programs.	Aggressive FEMP; increased funding for urban/intercity rail; Federal procurement and technology transfer are key.
Tough efficiency	Similar to moderate efficiency scenario, but at a higher level.	Energy taxes and especially carbon taxes of at least $150/ton; purchase taxes that levelize prices of equipment with varying efficiencies.	Same as moderate efficiency scenario.	Extremely aggressive; technologies available by 1999 implemented by 2015.	CAFE 55 mpg; most energy efficient design for buildings and equipment; stronger utility emissions reductions; ban new coal-fired generating plants.	Aggressive retirement of coal plants; natural gas cofiring; stronger DSM programs; aggressive FEMP; high national priority tied to infrastructure funding.
High renewable	Renewable investment tax credits for electricity generation & biomass fuels production; low-cost loans; accelerated capital depreciation for existing fossil-powered systems; same demand controls as moderate efficiency scenario.	Energy taxes on fossil fuel use only; carbon taxes as an alternative; same as moderate efficiency scenario.	Same as moderate efficiency scenario.	Especially for storage technologies.	Same as moderate efficiency plus standards for generating plants that favor renewables.	Favorable regulatory treatment encouraging renewables; fleet use of alternative fuels; extended and improved hydro (existing capacity).
High nuclear	Accelerated depreciation schedules for utilities committed to investing in nuclear plants; investment tax credits for new nuclear construction; same demand controls as moderate efficiency scenario.	Large carbon tax on utilities to encourage nuclear growth.	Same as moderate efficiency scenario. Improve public acceptance of nuclear power.	RD&D needed for advanced reactor designs; modular components; waste disposal technologies.	Same as moderate efficiency; also higher standards for non-nuclear plants.	Streamlined licensing; waste disposal facility.

ABBREVIATIONS: BEPS = Building Energy Performance Standards; CAFE = Corporate Average Fuel Economy Standards; DSM = Demand-Side Management; FEMP = Federal Energy Management Program; HOVs = High Occupancy Vehicle lanes; IGCC = Integrated Gasification Combined Cycle; NAECA = National Appliance Energy Conservation Act; OCS/ANWR = Outer Continental Shelf/Arctic National Wildlife Refuge; PURPA/PUHCA = Public Utility Regulatory Policies Act/Public Utility Holding Company Act; RD&D = Research, Development, and Demonstration; SPR = Strategic Petroleum Reserve

Source: *Energy Technology Choices: Shaping Our Future*; OTA; July 1991, page 148.

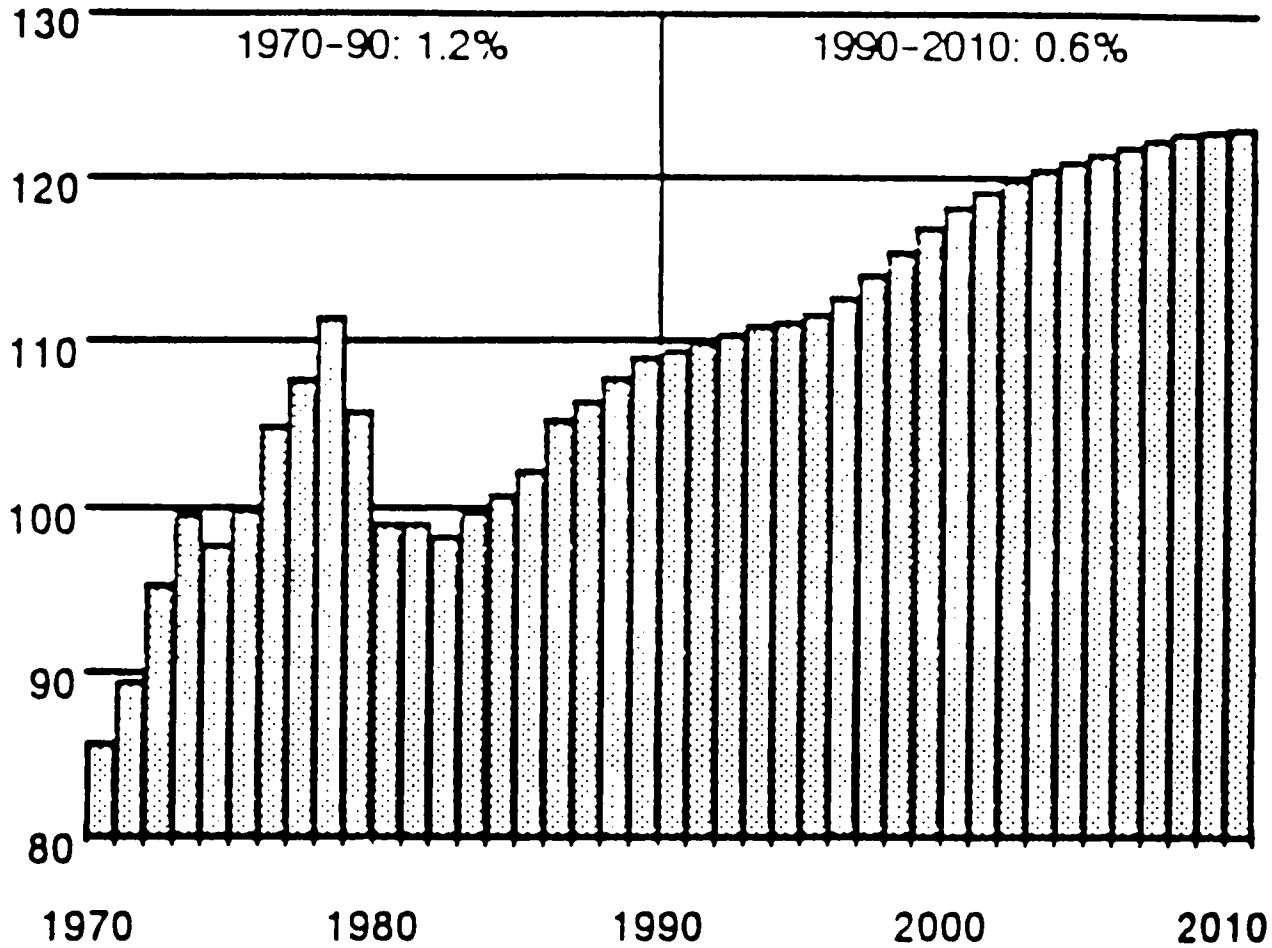


Figure D.3. DRI forecast of on-highway gasoline consumption, assuming no policy changes (billions of gallons).

DRI/EPA CO_2 Reduction Scenarios

DRI performed a detailed forecast for EPA of motor vehicle growth and analyzed various tax options designed to reduce CO_2 emissions, the principal greenhouse gas.[11]

Figure D.3 shows DRI's forecast of gasoline consumption assuming no policy changes other than fuel tax increases are required to keep current tax rates approximately constant in real terms, with some small growth. (Federal, and combined state and local tax rates would be $0.246 and $0.513, respectively, in 2010.) DRI assumed moderate rates of GNP growth (2.3 percent/year to 2000 and 1.9 percent/year from 2000 to 2010) and somewhat higher rates of oil price increases (3.6 percent and 3.4 percent/year for the two periods) in making this forecast. Note that the forecast averages only 0.6 percent/year growth from 1990 to 2010.

A detailed set of macroeconomic forecasts, vehicle sales by class, VMT, MPG, fuel consumption by type, fuel prices, vehicle stocks, and other factors are forecast by 5-year increments to 2010 for both the Base Case and the tax options analyzed.

DRI concluded that a gasoline tax option is the most effective of several taxes analyzed. A gas guzzler tax is somewhat less effective, but a gas guzzler tax coupled with a gas sipper rebate may be the most appealing option politically. An oil import fee is effective, but results in a significant natural gas price increase and is more harmful to the economy.

Despite the effectiveness of the tax options in achieving CO_2 emissions reductions, DRI finds that they are economically inefficient because the tax rates must be higher than the marginal social costs associated with higher fuel consumption to reach the goal of CO_2 emissions reductions.

DRI estimates that an oil import fee of $10/barrel would reduce emissions only 2.5 percent below baseline forecasts for 2000, and less afterward. The gasoline tax would have to be $0.40/gallon in 2000 and $0.58/gallon in 2010 to keep emissions at the 1990 level, assuming taxes were refunded via payroll tax reductions. To achieve 20 percent reduction of CO_2 below the 1990 level, the gas tax would have to be $1.53 and $1.73/gallon in 2000 and 2010, respectively. Both tax levels have a negative effect on GNP in 2000, but a positive effect by 2010.

An ideal policy, according to DRI, would combine a carbon reduction goal with a macroeconomic policy that would largely mitigate the negative effects of higher taxes.

DOE's Analysis of Energy Taxes

Energy Taxes: Various energy taxes have been proposed to provide an economic incentive to reduce energy consumption and our dependence on imported oil. These taxes could be implemented in revenue-neutral form or could fund transportation programs. However, many proponents of high energy taxes now advocate using the revenues generated by such taxes for deficit reduction. EIA has recently completed a study of the effects of several specified versions of the four most frequently proposed energy taxes:[12]

- **Motor Fuel Tax**—An increase in the federal tax on gasoline and highway diesel fuel of up to $0.50 per gallon.
- **Btu Tax**—A tax of up to $1 per million Btu on all energy sources applied at the point of production or import.
- **Carbon Tax**—A tax on all fossil fuel applied at rates that are (at least roughly) proportional to their carbon content. The rates would be designed to yield the same revenue as a corresponding Btu tax. The tax would be applied at the point of production.
- **Ad valorem Tax**—A tax of up to 15 percent on all energy products imposed at the point of final sale.

Although the basic purpose of the four taxes is to reduce energy consumption by increasing energy prices, only the Btu tax would apply to all energy sources in proportion to their energy content. The ad valorem tax would be greatest for high-cost energy, such as electricity.

The carbon tax would apply only to fossil fuels and would be based on the carbon content of the fuel. A carbon tax designed to collect the same amount of revenue as a $1 per-million-Btu tax would be imposed at average rates of $0.72 per million Btu of natural gas, $1.03 for petroleum products, and $1.24 for coal products. The purpose of making the tax rates proportional to carbon content is to provide an economic incentive for reducing consumption of high-carbon fuels, thus reducing production of carbon dioxide—the most common of the so-called "greenhouse gases" that are believed to be causing global warming. The EIA analysis exempts renewable fuels from this tax, presumably because the carbon in these fuels is obtained from carbon dioxide through photosynthesis so that production and consumption of renewable fuels do not result in any significant change in atmospheric carbon dioxide.

The motor fuel tax would apply only to highway fuels. The advocates of this tax believe that the portion of energy use that is nonessential is greater for highway energy use than it is for many other types of energy use, so that this form of energy tax could achieve its goals with fewer adverse economic effects.

All four of these taxes, and most particularly the motor fuel tax, would result in an increase in the tax rates applied to motor fuels, frequently with little thought given to using any portion of the resulting revenue for highway purposes. If none of the revenue were used for highway purposes, these taxes would reduce the productivity of existing dedicated motor fuel taxes (by both reducing vehicle use and promoting fuel efficiency) while reducing highway needs to a lesser extent (by reducing vehicle use). The resulting shortfall in highway revenue can be prevented or replaced by dedicating a portion of the new energy taxes to highway purposes, increasing motor fuels taxes further, or increasing other highway-user taxes.

Table D.4 presents a summary of some of the estimated effects in the year 2000 of implementing in 1991 the most aggressive forms of each of the above taxes studied by EIA.[13] The top portion of the figure presents EIA estimates of the direct effects of the taxes on total energy consumption, petroleum products consumption, and net oil imports. It is significant that, although the motor fuels tax is set at a rate that produces the least revenue, it has the greatest estimated effect on petroleum products consumption and on net oil imports.

The remainder of Table D.4 presents the estimates of the overall macroeconomic effects of the four taxes and their effects on the federal budget. These estimates were developed for EIA by DRI, using their U.S. Quarterly Model. Two sets of estimates are presented: one assuming that all new revenues are applied to deficit reduction; and a second assuming that the new taxes are combined with reductions in the federal payroll tax that are designed to approximately cancel the resulting effect on the deficit. As would be expected, the latter set of estimates shows a smaller effect on GNP (though the data presented in the EIA report indicate that this difference declines over time); however, it also shows a somewhat greater increase in consumer prices. Most significantly, the motor fuels tax produces the smallest macroeconomic effects in the year 2000 (though that is not the case in some of the earlier years). Thus, of the four taxes studied, in the long run, the motor fuel tax reduces petroleum products consumption the most with the least adverse economic effects.

ITE's Estimate of Fuel Savings Potential

A technical committee of the Institute of Traffic Engineers (ITE) performed a review of several forecasts, including work done by the National Transportation Policy Study Commission, the U.S. DOE and Argonne, and others, and concluded that transportation energy conditions will not change greatly by 2000.[14] Moderate improvements in fuel efficiency will be achieved; fuel prices will level off; the United States will increase its dependency on foreign oil; and government will have increasing involvement in energy. Alternative sources will have to be developed, and energy conservation will be needed.

The ITE technical committee described energy savings that can be achieved from a variety of TCM and TSM actions, and provided guidance for implementing them. The potential fuel savings impact of these "engineering tools," which include expanding transit, promoting ridesharing, and instituting parking management, as well as traffic engineering improvements, is estimated to be over four billion gallons/year. According to the committee, "This represents a minimum amount of energy savings that can be accomplished by urban traffic engineers."

Note that the savings are about 4 percent of DRI's forecast of 118 billion gallons of gasoline to be consumed on highways in 2000, as shown in Figure D.3.

SAIC's 2030 Forecasts

Science Applications International Corporation (SAIC) performed an analysis of the hurdles involved in developing a market for the various AFVs and prepared medium- to long-term forecasts of costs and AFV market penetration.[15]

TABLE D.4. Estimated effects of alternative energy taxes in 2000

	15 Percent Ad Valorem Tax	$1 Btu Tax	Carbon Tax*	50-Cent Motor Fuels Tax
Direct Effects				
Gross Collection for New Tax	136	91	81	68
Total Energy Consumption (quads)	-1.7	-1.4	-1.8	-1.4
Consumption of Petroleum Products (quads)	-460	-200	-280	-540
Overall Effects				
Deficit Production Case				
Deficit ($ billions)	-99	-73	-63	56
Real GNP ($ 1982 billions)	-51	-39	-43	-15
Real GNP (percent change)	-0.9%	-0.7%	0.8%	0.3%
Consumer Price Index (percent change)	+0.8%	+0.7%	+1.0%	-0.4%
"Deficit-Neutral" Case				
Deficit ($ billions)	+1	+6	+10	-2
Real GNP ($ 1982 billions)	-24	-35	-38	-16
Real GNP (percent change)	-0.4%	-0.6%	-0.7%	-0.3%
Consumer Price Index (percent change)	+1.0%	+0.7%	+1.7%	+0.2%

*Carbon tax implemented at $0.72 per million Btu for natural gas, $1.03 for petroleum products, and $1.24 for coal.

Source: Energy Information Administration, *Studies of Energy Taxes*, U.S. Department of Energy, 1991.

SAIC's analysis is characterized in a preface by DOE as being "fairly pessimistic" in terms of the "outlook for nonpetroleum fuel use" based on the "many legal, regulatory and technology-based uncertainties that exist." However, SAIC's analysis is probably the most careful consideration of factors affecting the market for AFVs and does not conflict in any significant way with the findings of any other literature reviewed in this project.

SAIC finds that forecasting market conditions for AFVs is fruitless, particularly for the 1990s, because whatever market exists for AFVs is created by government policies that are very uncertain. There is also considerable uncertainty about both near-term and long-term technological capabilities. Of particular importance is the uncertainty regarding the potential of "clean" petroleum fuels. If reformulated gasoline can achieve emissions reductions close to those of AFVs, then existing federal and state legislation will not result in material displacement of petroleum products. Even in the longer-term post-2000 period, estimates of AFVs are premature, according to SAIC, because there is no economic alternative to reformulated gasoline.

Light-duty Compressed Natural Gas (CNG) and LNG fleet vehicles could be cost-competitive with conventional vehicles by 2000 if their cost could be kept within 5 percent to 10 percent of conventional vehicles. Methanol vehicles must be 10 percent to 15 percent less costly than conventional vehicles to be competitive. SAIC forecasts that ethanol vehicles and EVs will not be competitive by 2000. Congress may go further in mandating AFVs because the reformulated gasoline solution frustrates the goals of developing domestic alternative fuels and renewable fuels, and of reducing dependence on Middle East petroleum. However, much depends on California, which is the de facto state leader in clean fuels and is empowered under CAAA to define many aspects of national standards.

The ultimate outcome, according to SAIC, cannot possibly be three large incompatible fuel production and distribution systems. Either CNG, methanol, or electric will emerge. The development of a refueling system may be the key factor in determining which type of AFV succeeds. Because of the many uncertainties involved, a cost advantage of 5 percent or more will have to be maintained for an AFV system for about 5 years before substantial investments will be made.

Long-term markets for clean fuel vehicles (CFVs) are forecast by SAIC under three types of standards and initiatives, by 5-year increments to 2030. Up to two million vehicles/year of an unstated mix of CFVs would be sold by 2020 (approximately the federal mandate of CFVs for all centrally refueled vehicles), or as low as about one-third of that amount in the low-case scenario (mostly transit vehicles). The Base Case, which involves several states' adopting California standards, would result in 1.6 million CFV sales per year by 2020.

Jack Faucett Associates' Analysis of Revenue Impacts of Nine Scenarios for FHWA

Jack Faucett Associates (JFA) has defined nine alternative fuels scenarios for FHWA and is evaluating their impacts on VMT, fuel consumption, and Highway Trust Fund revenue, by 5-year increments to 2014.[16] The nine scenarios are the following:

1. **Constant-MPG Base Case**—MPGs and AFV shares remain at their 1991 levels.
2. **Increasing MPG Base Case**—MPGs increase as forecast in David Greene's AMFU Model.
3. **Pre-CAAA Case**—These are very small shares of AFVs (5.1 percent of light-duty vehicle sales in 2020), based on a pre-CAAA forecast developed by EIA.
4. **CAAA Case**—Reformulated gasoline standards and clean fuel standards are achieved and eight states adopt California's zero emissions vehicle requirement (2 percent and 10 percent EV sales shares in 1998 and 2003, respectively).
5. **High Gasohol Case**—Same as #4 except that gasohol continues to grow, reaching 22 percent of combined gasoline/gasohol fuel in 2009, as forecast in the AMFU Model (compared with an increase from 6 percent to 8 percent in #4).
6. **Ten Percent Alternative Fuels Case**—Alternative fuels displace 10 percent of conventional highway motor fuel forecast to be consumed in 2004 under #2, Increasing MPG Base Case. This scenario approximately combines AFV assumptions of #2 and #3.
7. **Twenty-Five Percent Alternative Fuels Case**—Results of #6 were scaled upward to achieve 25 percent displacement, resulting in 100 percent AFV sales by the end of the forecast period.
8. **High CAFE Case**—CAFE standards are increased 20 percent and 40 percent by 1996 and 2001 from 1988 levels, as required by a bill introduced by Senator Bryan of Nevada.
9. **Most Likely Case**—As required by the National Energy Security Act, a minimum percentage of fleet vehicle purchases will have to be AFVs for the federal and state governments and other fleet operators according to a phased-in schedule.

Walsh's Global Forecast of Emissions

In a paper presented at the Society of Automotive Engineers, Michael Walsh forecast the levels of global emissions of the major pollutants by 5-year increments through 2010.[17] He estimated that the world's vehicle fleet will approximately double to 1.1 billion by 2010, but that CO, HC, and NO_x will remain fairly level for 10 years due to controls in developed countries.

However, Walsh estimates that CO_2 emissions will increase by about 75 percent by 2010, assuming the current lack of any regulation of CO_2 emissions continues. He urges emphasis on fuels with no CO_2 emissions—i.e., electricity (from nonfossil sources) and hydrogen.

Coalition of Environmental Groups' Scenarios

In a report prepared by a coalition of four environmental groups, four energy scenarios are analyzed through 2030:[18]

1. **Reference Case**—Current policies and trends
2. **Market Case**—Technologies that minimize the cost of energy services for consumers
3. **Environmental Case**—Monetary values assigned to environmental impacts of energy use
4. **Climate Stabilization Case**—Target reductions of CO_2 emissions.

The last case is estimated to cut energy use nearly to 50 percent of the Reference Case, with renewable energy sources supplying more than 50 percent of the total, and energy consumption for personal transportation dropping 57 percent. Petroleum consumption decreases to about 33 percent of the current level, and CO_2 emissions are reduced about 70 percent. The $2.7 trillion investment required to achieve the Climate Stabilization Case would save consumers $5 trillion in fuel and electricity costs, for a net national savings of $2.3 trillion.

The source does not provide a detailed description of the policies required to achieve these goals, but the emphasis is on promoting the development of alternative fuels and fuel-efficient technologies, rather than on reducing demand.

IVHS America's Strategic Plan

ISTEA includes $660 million for IVHS and challenges the states to compete for leadership in developing new systems in five areas:

- Advanced Traffic Management Systems (ATMS)
- Advanced Traveler Information Systems (ATIS)
- Advanced Vehicle Control Systems (AVCS)
- Commercial Vehicle Operations (CVO)
- Advanced Public Transportation Systems (APTS).

To guide implementation of IVHS, Congress asked U.S. DOT to prepare a strategic plan. U.S. DOT, in turn, asked IVHS America, a new organization created to develop public-private cooperation in leading this field, to prepare a strategic plan that would become the basis for the U.S. DOT report to Congress. IVHS America, anticipating the passage of ISTEA and its request, had already prepared a draft Strategic Plan.[19]

The IVHS Strategic Plan draws heavily on two documents that are major benchmarks in the short history of this field:

- *Proceedings of a National Workshop of IVHS,* sponsored by Mobility 2000, Dallas, TX, March 1990
- *Advanced Vehicle and Highway Technologies, Transportation Research Board (TRB) Special Report 232,* December 1991.

The Mobility 2000 group predicted that within 10 years computerized optimization of signals would be operational in most major urban areas and would include areawide, real-time monitoring systems and incident response systems that would reduce delay due to congestion and incidents by 10 to 25 percent. It also predicted that driver information systems would reduce delay in the most congested areas by 10 to 50 percent.

TRB Report 232 specifies more detailed objectives and milestones for the year 2001, most of which are amplifications of the Mobility 2000 predictions. Among the more important targets that are considered achievable are fuel savings of 2 percent for the entire highway system and an eventual (no time horizon) tripling of capacity of highway lanes, avoidance of thousands of fatalities, and substantial alteration of travel and land development patterns. Such an achievement would result in major reductions in fuel consumption, although no estimate has been made.

The IVHS America Strategic Plan builds on these two major benchmark documents, and proposes an ambitious 20-year "road map" that includes a much more detailed program of R&D projects, project costs, and objectives for the 20-year horizon. The plan lays out in considerable detail a program of R&D, testing, and step-by-step implementation in each of the five areas, with attention to the gradual integration of systems among the five areas. Among the most important benchmarks in the plan are the following:

1. Preliminary engineering would be completed by 1996 for advanced traffic management systems in 25 major corridors.
2. By 1997, a prototype automated freeway demonstration would be in operation (a goal of ISTEA).
3. Automated operation of transit vehicles would be achieved on specially equipped HOV lanes within 20 years.

If the IVHS program achieves its target goals, fully automated freeway and HOV lanes would be in operation in 20 years and could be expected to expand rapidly throughout the country in the 2010–2020 decade. As this technology is deployed beyond the test track environment into a mixed vehicle environment, systems will have to be developed for screening vehicles upon entry to automated lanes to ensure that they are properly equipped to operate in such lanes. Such systems can be expected to have the capability of keeping track of each vehicle's use of these lanes, both for fleet management purposes in the case of transit buses and other large fleets and for charging for the use of the system.

Another possible outcome of the IVHS program that is of interest, even though not recognized as a specific goal, is the development of a network of automated highways and/or HOV lanes with electrical power pickup from the roadway. The feasibility of using an electromagnetic inductive power pickup system for transit buses has been successfully demonstrated in Santa Barbara.[20] With such a system, transit buses or any properly equipped EHV can pick up electrical power while operating on electrified lanes, charge their batteries while operating on those lanes, and operate under battery power while on other routes (or other lanes of the same route). Such a system shows promise of being cost-effective in comparison with both conventional vehicles and conventional battery-operated vehicles when a high density of vehicles use the system.

ENDNOTES

1. Argonne National Laboratories *Forecasts of Transportation Energy Demand through the Year 2000,* April 1991, pages 2–13, 64–71, and 74–77.
2. United States Department of Energy, *Second Interim Report of the Interagency Commission on Alternative Motor Fuels,* September 1991, Chapter 3. Hereafter referred to as *Second Interim Report.* The goal of 25 percent displacement is about 14 percent greater than the 2.2 million barrels per day displacement forecast to be achieved by the National Energy Strategy.
3. After analyzing life-cycle costs of all AFVs, Science Applications International Corporation concluded that "the ultimate outcome cannot possibly be three large incompatible fuels and fuel systems (excluding diesel)," Science Applications International Corporation, *Identification and Analysis of Factors Affecting the Adoption of Alternative Transportation Fuels;* prepared for the Gas Research Institute and the Energy Information Administration, July 1990–December 1991, page 40.
4. *Second Interim Report, op. cit.,* page 5.
5. Daniel Sperling, "National Methanol Fuel Systems: A Transportation Fuel Pathway," *Transportation Research Record 870,* Transportation Research Board, Washington, DC 1982, pages 71–78.
6. *Second Interim Report, op. cit.,* page 19.
7. H. Dowlalabani, A. J. Krupnick, and A. Russell, *Electric Vehicles and the Environment: Consequences for Emissions and Air Quality in Los Angeles and U.S. Regions,* Resources for the Future, 1990, pages ix–xvii.
8. J. E. Sinor Consultants, *The Clean Fuels Report,* Volume 4, No. 1, February 1992, page 177.
9. R. K. Whitford and M. J. Doherty, "Motor-Vehicle Fuel Economy: Estimated Cost and Benefits from 1980 to 2020," *Transportation Research Record 870,* Transportation Research Board, Washington, DC 1982, pages 78–83.
10. Office of Technology Assessment, *Replacing Gasoline: Alternative Fuels for Light Duty Vehicles,* OTA-E-364, September 1990; and *Energy Technology Choices Shaping Our Future,* OTA-E-493, July 1991, pages 112–148.
11. DRI/McGraw-Hill, *An Analysis of Public Policy Measures to Reduce CO_2 Emissions from the U.S. Transportation Sector,* prepared for Office of Policy, Planning, and Evaluation, EPA, January 1991, pages 1–11, 23–28, 38–39, Appendices B and C.
12. Energy Information Administration, *Studies of Energy Taxes,* U.S. Department of Energy, 1991.
13. *Ibid.*
14. ITE Technical Committee 6F-25, "U.S. Transportation Energy Supply and Demand Forecasts to the Year 2000," Technical Council Informational Report, *ITE Journal,* June 1986, pages 21–22.
15. Science Applications International Corporation, *op. cit.,* pages 11, 26, 41–46, and 54–57.
16. Seven of the nine scenarios are defined in Jack Faucett Associates, *Identification and Evaluation of Alternative Highway Revenue Sources: Task A Report,* submitted to Office of Policy Development, FHWA, March 13, 1992, pages 12–19. Two additional scenarios and the forecasts of all the scenarios' impacts will be covered in subsequent reports.
17. *The Clean Fuels Report, op. cit.,* pages 2–5.
18. *Ibid.,* pages 5–7. The report referenced is titled *America's Energy Choices: Investing in a Strong Economy and a Clean Environment.* The coalition includes the Alliance to Save Energy, the American Council for an Energy-Efficient Economy, the Natural Resources Defense Council, and the Union of Concerned Scientists.

19. Intelligent Vehicle Highway Society of America, *Strategic Plan for Intelligent Vehicle Highway Systems in the United States,* Draft B, February 14, 1992.

20. Steven E. Shladover, "The Roadway-Powered Electric Transit Vehicle—Progress and Prospects," *Transportation Research Record 1155,* Transportation Research Board, Washington, DC 1987, pages 28–36.

APPENDIX E

ASSUMPTIONS USED IN DEVELOPING PROJECTED HIGHWAY USER RECEIPTS FOR THE SCENARIOS

The assumptions listed below were used in developing the projected highway user receipts for the year 2020 for each of the alternative scenarios, defined in Chapter 2, underlying the analysis in Chapter 3. The assumptions made for each scenario are intended to reflect the high end of the likely range of change for each factor that defines the scenario.

1. The proportion of Base Case receipts from each category of tax will be about the same as combined federal and state receipts in 1991, except that congestion pricing and emissions fee receipts will each become 1 percent of total highway user receipts available for surface transportation.

2. Base Case receipts will increase at a rate of 2 percent per year from 1991 to 2020.

3. The High Compressed Natural Gas (CNG) and Electric scenario will differ from the Base Case in the following ways:

   a. Conventional fuel consumption and fuel tax receipts from conventional fuels will decline by 40 percent.
   b. Receipts from taxes on CNG and electric energy consumption will be only half of what they would be on the conventional fuels they replace.
   c. Emissions fee receipts will become a negligible proportion of total receipts because CNG and electric vehicles (EVs) will become the dominant vehicles in areas that had the worst air quality problems.
   d. All other types of taxes and fees will be increased proportionally to make up for most of the revenue losses from fuel taxes and emissions fees.
   e. Total receipts will fall below the Base Case by about 6 percent—half of the amount of the loss in fuel tax receipts from conventional plus alternative fuels. The rationale is that the rate of increase in overall taxes and fees will be only half of what would be required to replace the loss in fuel tax receipts.

4. The High Fuel Economy scenario will differ from the Base Case in the following ways:

   a. Fuel tax receipts will decline by 5 percent if fuel tax rates increase at the same pace as in the Base Case; however, additional fuel tax rate increases will make up for half of the 5 percent loss of revenue.
   b. Emission fee receipts will become a negligible proportion of total receipts because the more fuel-efficient vehicles will be substantially cleaner burning.
   c. All other types of taxes and fees will be increased proportionally to make up for most of the revenue losses from fuel taxes and emissions fees.
   d. Total receipts will fall below the Base Case by about 1 percent—half of the amount of the loss in fuel tax receipts, the rationale being the same as in the High CNG and Electric scenario.

5. The Tax Diversion and Alternative Fuel Subsidy scenario will differ from the Base Case in the following ways:

   a. Fuel taxes will be increased by a much larger amount and will be used to provide both general revenues and special-purpose revenues, such as deficit reduction and funding for various programs related to externalities caused by motor vehicle use (e.g., air quality and safety impacts).
   b. Fuel taxes will no longer be dedicated to surface transportation funds at the federal level and in most states.
   c. The amount of funding for surface transportation provided from general revenues will make up 80 percent of all receipts made available for surface transportation. That will be substantially less than the total receipts from fuel taxes used for all purposes.
   d. Because of the increased receipts from fuel taxes and the greater amount of funds made available from general revenues for surface transportation, pressure to increase all other sources of highway user fees will be reduced and receipts from each type of other tax will be reduced to half of the proportion in the Base Case.
   e. Total receipts will increase above the Base Case level, but only half as much as in the Full VMT Measurement Capability scenario (i.e., 5 percent vs. 10 percent).

6. As in the High CNG and Electric scenario, the Full VMT Measurement Capability scenario will differ from the Base Case in the following ways:

   a. Conventional fuel consumption and fuel tax receipts from conventional fuels will decline by 40 percent because of the substitution of CNG and EVs.
   b. Receipts from taxes on CNG and EV energy consumption will be only half of what they would have been on the conventional fuels they replaced.
   c. A further reduction of 25 percent of Base Case fuel tax receipts will occur because of shifts of tax from conventional fuels to mileage-based taxes, tolls, and congestion pricing.
   d. Emissions fee receipts will become a negligible proportion of total receipts because CNG and electric vehicles will become the dominant vehicles in areas that had the worst air quality problems.

e. Congestion pricing will yield 10 percent of total receipts, up from about 1 percent in all other scenarios, as almost all major congested highways are managed with toll structures so that acceptable levels of congestion are maintained.
f. Because of increased receipts from mileage-related taxes, all other non-mileage-related taxes and fees (registration fees, sales and ad valorem taxes, driver's licenses, and other miscellaneous fees) are reduced to about half of the share of total receipts for the Base Case.
g. VMT fees, weight-distance taxes, and tolls will increase greatly (about sevenfold), as the technical and administrative problems associated with these types of taxes are overcome and they become politically acceptable. Collectively they will yield substantially greater receipts (41 percent versus 33 percent) than fuel taxes.
h. Total receipts will increase above the Base Case by 25 percent of the amount of increase in mileage-related taxes and tolls—i.e., about 10 percent of total receipts.

APPENDIX F

CRITERION-BY-CRITERION DISCUSSION OF MAJOR REVENUE SOURCES

F.1 TAXES ON CURRENT FUELS AS A BENCHMARK

Taxes on current fuels may be continued if other broad-based taxes are not implemented and if the use of fuels for highway travel does not change dramatically. Gasoline and diesel revenues now account for 75 percent of federal highway revenues and nearly 60 percent of all state highway expenditures (when federal and state fuel taxes are taken into account).

This section briefly evaluates stated criteria to compare the major revenue alternatives.

Adequacy

Consistency with the New Approach. Current fuel taxes are partially consistent with the new approach. They do not provide consistency between revenues and benefits that mileage-based taxes would provide.

Adequacy and Tax Rates. Tax rates on diesel and gasoline vary across the states. Although most tax rates are set at a fixed per-gallon figure, taxes are also indexed based on price (with a minimum and a maximum per gallon) or on a cost index. Diesel and gasohol rates sometimes vary from the rate for gasoline.

Inflation erodes the value of fixed rate per gallon fuel taxes and increasing fuel efficiency also reduces the revenue per mile of travel in current dollars. Unless the tax rate is adjusted, the fuel tax will become increasingly unable to produce adequate revenue.

Table F.1 illustrates fuel use, fuel efficiency, and vehicle miles of travel (VMT) for household-owned vehicles included in the 1988 DOE residential energy consumption survey. This data source for VMT may be more reliable than others such as the NPTS, because the vehicle mileages are based on odometer readings rather than on self-reported trips and mileage.

The leveling off of fuel efficiency in the early 1980s was the result of a flattening of the Corporate Average Fuel Economy (CAFE) standards for autos and light trucks, and a change in the mix of household vehicles. Light trucks, with lower than average fuel efficiency, have increased their share to around 50 percent of the net increase per year of household vehicle holdings.

Table F.1 indicates that fleet average fuel efficiency will rise as older, less fuel-efficient vehicles are retired throughout the 1990s. These retirements will reduce motor fuel revenues per mile of travel. Increased VMT is not likely to compensate for the decline in tax revenue per mile.

Future changes in fuel efficiency will depend on energy prices, technological changes, and regulatory policies. Because motor fuel prices are so low in the United States, and because the fuel efficiency of autos in other countries with much higher energy prices is about equal to U.S. passenger car fuel efficiency, it is unlikely that increased fuel prices will have any impact on U.S. auto fuel efficiency. However, higher fuel prices may have an impact upon the relative sales of autos and light trucks, leading to slightly better fuel efficiency for the overall light-vehicle fleet in future years.

Because U.S. light-vehicle fuel efficiency is now determined by regulatory policies, changes in those policies are the key determinants of future fuel efficiency.

Taxes on current fuels (gasoline, diesel, gasohol) could be altered to make them responsive to inflation or to indexed revenue needs under the recommended new approach.

Stability. Taxes on current fuels require rate revisions periodically to respond to inflation or needs. In addition, the potential for changes in fuel efficiency will further decrease the stability of fuel taxes. Fuel taxes recently have been less stable than taxes on VMT would have been or than taxes on vehicle registrations have been.

Appropriateness for Dedication. Taxes on current fuels are clearly appropriate for dedication.

Simplicity

Point of Taxation. Gasoline taxes are collected fairly high up the distribution chain, on refiners or major distributors. Diesel fuel taxes are collected from distributors and users. Even if rates were indexed, taxes on fuels dispensed through gasoline service stations would continue to be collected through means similar to those for gasoline or diesel fuels today, and preferably always as far up the chain of distribution as feasible.

Compliance Costs. Compliance costs should continue to be similar to those for gasoline or diesel fuels today. Compliance costs for the eventual consumer of gasoline dispensed from the pump are very low. Costs paid simply include the tax, and no filings or paperwork are necessary. Compliance costs for energy companies that are the major taxpayers of gasoline taxes are also low; taxes are paid on a large volume of product.

Compliance costs for motor carrier fuel taxes are significant to the taxpayers. However, all states are to join the International Fuel Tax Agreement (IFTA), which will substantially reduce carriers' filings with regard to motor fuel tax accounts in various states.

TABLE F.1. Variations in VMT and fuel consumption per vehicle by model year

		Average per Vehicle			
Model Year	Number of Vehicles (million)	VMT	Fuel Consumed (gallons)	Fuel Expenses (dollars)	Miles per Gallon
1988 or 1989	7.1	12,920	583	589	22.1
1987	12.0	13,408	584	585	22.9
1986	15.5	12,570	573	575	21.9
1985	13.2	12,074	569	572	21.2
1984	13.3	11,506	552	548	20.9
1983	8.1	10,610	504	503	21.1
1982	8.1	10,752	506	506	21.2
1981	8.4	10,021	499	596	20.1
1979 or 1980	17.0	9,480	572	565	16.6
1977 or 1978	15.7	8,715	600	584	14.5
1975 or 1976	9.9	7,706	594	571	13.0
1974 or Earlier	19.3	6,271	528	489	11.9

Source: Energy Information Administration, *Household Vehicles Energy Consumption, 1988*, Department of Energy, Washington, D.C., 1988, pg. 34.

Potential for Evasion. Evasion of motor fuel taxes has become a topic of serious concern, after a long period of neglect. Evasion of any existing tax is difficult to estimate, because revenue figures are the most carefully collected data, and other data must be analyzed to refute the estimates of fuel consumption based on the revenue figures. However, estimates have been made of $1 billion per year in lost gasoline tax revenues and an equal amount of lost diesel revenues. If estimates of diesel evasion are correct, from 15 percent to 25 percent of current diesel taxes are being evaded. FHWA has initiated a cooperative effort with the IRS and the states to curtail motor fuel tax evasion.

All previous estimates indicate that the evasion rate for diesel fuel taxes exceeds that of gasoline taxes. That is generally attributed to several major factors:

1. Diesel fuel is similar to number 2 heating oil, and very large quantities of this product are available on a nontaxed basis.
2. Diesel fuel is taxed lower down the distribution chain, primarily because of the first factor, resulting in more taxpayers responsible for remitting diesel fuel taxes than gasoline taxes.
3. Where diesel fuel is taxed at a higher rate than gasoline, as at the federal level and in some states, added incentives are created because more can be saved by evading higher rather than lower per-gallon taxes.

Table F.2 illustrates estimates of the evasion of motor fuel taxes, as part of the AASHTO Study of Motor Carrier Taxation and Registration Issues.[1] Evasion rates for regular gasoline taxes were estimated to be much lower than evasion rates for carrier fuel use taxes. The rates were estimated before FHWA began to encourage more attention to fuel tax evasion.

Over the last several years there has been growing recognition of the magnitude of the problem of fuel tax avoidance and evasion and several initiatives have been taken to address the problem, including the following:

1. The NCHRP performed a synthesis of current practice on measures to curtail evasion.[2]
2. IRS has undertaken a nationwide effort to expose organized tax evasion schemes and has uncovered several large evasion operations in Texas, Virginia, New York, and other states.
3. Congress has funded a program for IRS and the states to improve the level of enforcement of fuel tax collection. The state assistance program is administered by FHWA.
4. Training courses have been conducted by the Federation of Tax Administrators and member state agencies on fuel tax evasion, auditing, and investigation techniques.
5. Fuel dyeing of diesel fuels has been implemented.

Two other initiatives hold out the possibility of substantially reducing avoidance and evasion in the next few years as a result of ISTEA: (1) the requirement that all states, in effect, will have to become members of IFTA or a similar multistate agreement; and (2) the commercial vehicle operations (CVO) component of the Intelligent Vehicle Highway Systems (IVHS) program, which could lead to the development of systems designed to reduce evasion of fuel and other taxes.

TABLE F.2. State estimates of evasion of motor fuel taxes

State	Regular Motor Fuel	Carrier Fuel Use
Arizona	Very Small	Very Small
Arkansas	Less than 1% at pump	Less than 1% for decals; 10% to 15% overall
Colorado	Difficult to evade	1% to 5%
Iowa	Not a problem	0.4%
Maine	Less than 1% at pump	15% to 20% prior to supplier law
Maryland	Minimal	Indiscernible
Nevada	0% to 3%	5%
New Hampshire	1% to 3%	1% to 3% for New Hampshire; 15% to 20% for out-of-state
Ohio	Almost none	Not applicable
Virginia		30%

The IFTA effort has been driven by a desire to reduce the burden of fuel tax registration and reporting on motor carriers. Congress has appropriated funds to help states develop the necessary mechanisms to administer and enforce fuel tax collection under a base state system. If this effort succeeds, fuel tax collection and enforcement programs will be greatly improved.

The IVHS/CVO program provides an opportunity to further this objective if it is effectively coordinated with the NGA program and the other tax enforcement initiatives. There are various ways this coordination might be accomplished, and we are just in the process of conceptualizing possible approaches under a separate contract with FHWA.[3] One possible system being considered is developing a national database on all carriers and vehicles covered by IFTA, which states could access to determine the base state of any vehicle covered by the program.

A national database for IFTA carriers and vehicles could be accessed routinely by state fuel tax administrators, auditors, investigators, and possibly by weighmasters at weigh stations and inspectors at ports of entry. To minimize the regulatory burden on carriers and state inspectors, various IVHS/CVO projects are underway involving the use of AVI transponders to clear trucks with proper credentials so that they do not have to stop at these weigh stations and ports of entry. Vehicles could be screened by checking the national database, either on a sample basis, selectively based on the judgment of officials in the field, or possibly for every interstate carrier's truck.

Once such a system is fully operational on a national basis, there would probably be sufficient incentive for most interstate carriers to use the AVI transponder system, and tax enforcement would be greatly improved. Most interstate carriers' trucks would be cleared beforehand and only those trucks without AVI transponders would normally have to be stopped for inspection of credentials and tax status.

Administrative Issues and Costs. They will not change. Fuel products have to be monitored and subjected to taxation at an appropriate point in the distribution chain as high up as possible. Federal fuel taxes are highly productive revenue sources, with low administrative costs.

Total state spending is only $200 million to administer motor fuel taxes. Table F.3, taken from the AASHTO study, shows that motor fuel tax accounts are generally more expensive to administer than gasoline taxes. For states reporting both regular motor fuel and carrier fuel use, it is clear that the carrier fuel use taxes are far more costly to administer, particularly when compared with yield. Table F.3 also includes three responses by weight-distance tax states, indicating that the administrative costs of weight-distance taxes are also high, comparable with some carrier fuel use taxes.

Equity

Motor fuel taxes do not achieve equity by vehicle class, and must be augmented by other fees, generally fees that place high relative rates on heavier vehicles. However, not all the types of alternative fees look better. VMT fees weighted by cost responsibility will achieve vehicle class equity. Vehicle sales taxes will have less equity by vehicle class than fuel taxes.

Efficiency

Fuel taxes do not lead to more efficient use of transportation facilities.

Other

Ease of Implementation. Taxes on current fuels are relatively easy to implement compared with major changes in the revenue structures of the federal government and the states. Fuel taxes

TABLE F.3. State breakdowns of administrative costs of regular motor fuel and carrier fuel use taxes (see Endote 1)

State	Regular Motor Fuel	Carrier Fuel Use	Weight Distance
California	$483,000 (0.1%)	$2,854,000 (3.7%)	
Florida	$1,520,811 (0.4%)	$627,847 (18.0%)	
Iowa	NA	$442,500 (53.7%)	
Kentucky		$769,247 (10.9%)	
Maine	$35,000 (less than 1%)	$315,000 (11%)	
Maryland	$2,811,496 (1.2%)	$1,104,229 (9%)	
Mississippi	$450,000 (3%)(diesel)	$360,000 (3%)	
Nevada	(15%)	(14%)	(12%)
Oregon	$1,897,000 (0.3%)		$7,810,537 (12.4%)
Tennessee	$1,258,000 (less than 1%)	See Regular Motor Fuel	
Virginia	$716,372 (0.2%)	$4,394,684 (25.7%)	
Wisconsin	$800,000 (2%)	$80,000 (no net receipts due to Wisconsin's requirements)	
Wyoming	$55,000 (less than 1%)		$3,408,825 (14%)

at the local and regional levels are not widespread and should be assumed to be relatively difficult to implement.

F.2 TAXES ON ALTERNATIVE FUELS

Taxes on alternative fuels may become necessary if other broad-based taxes are not implemented and if the use of fuels for highway travel changes dramatically. Gasoline and diesel taxes now account for 75 percent of federal highway revenues. Transportation energy analysts expect ethanol, methanol, blends (such as gasohol), liquefied petroleum gas (LPG), compressed natural gas (CNG), and electric batteries to become more widely used. More exotic fuels such as hydrogen may also emerge in the future.

Procedures for distributing, dispensing, and taxing alternative fuels will differ by fuel type. Dispensing of liquid fuels including ethanol, methanol, blends such as gasohol, and perhaps LPG, may take place at service stations as occurs today for gasoline, diesel, and gasohol. For these fuels, major differences will depend upon how far up the distribution chain the fuels can be taxed and what administrative procedures and costs, compliance costs, and evasion will be likely in comparison with current fuels.

Distribution and dispensing procedures may differ for electric or natural gas vehicles. Electricity will be available at many places outside service stations. CNG can be distributed at service stations, or potentially at homes or businesses, using compressors. Meters with coded seals can be used in electric or natural gas vehicles to monitor fuel input. Alternatively, meters that measure VMT can be used, eliminating the need for separate types of meters for different fuels.

Adequacy

Consistency with the New Approach. Fuel taxes are generally consistent with the new approach although not as directly related to benefit categories as are mileage taxes.

Adequacy and Tax Rates. Tax rates on alternative fuels could be set to yield revenue equivalent to gasoline or diesel taxes, and could also provide one-to-one replacement of revenues per VMT or energy content. Subsidies of alternative fuels through tax exemptions would, of course, result in inadequate revenue yields.

Stability. Taxes on alternative fuels would be as stable as current fuel taxes, and would require periodic revisions in rates

to respond to inflation or needs. Changes in fuel efficiency, probably in response to technological changes, would render revenues less stable.

Appropriateness for Dedication. Taxes on alternative fuels would be appropriate for dedication.

Simplicity

Point of Taxation. Collection of taxes on fuels dispensed through service stations would be similar to that for gasoline or diesel fuels, and as far up the distribution chain as feasible. Taxes on electric vehicles (EVs) would be collected from individual vehicle owners. Most CNG could be dispensed by service stations, but some might be transferred to the vehicle at home. Thus, monitoring of individual owners might also be necessary for CNG.

Compliance Costs. Compliance costs would be similar to those for gasoline (e.g., minimal) for liquid fuels, much higher for electric, and potentially much higher for CNG. Electric or CNG would entail reporting and compliance costs for the individual household or business that are similar on a per vehicle basis to those for registration and user fees or VMT fees. For states, the fuel use taxes for electric or for those loading CNG at home would be paid through registration fees. An additional income tax form would be needed to report federal fuel taxes due on electric or CNG vehicles.

Taxpayer compliance costs for state fees include 5 to 15 min per quarter to pay such fees, at an average of 10 min per quarter (to read meters and remit forms). These costs will entail 20 to 60 min per taxpayer per year at $10.00 per hour, or $3.33 to $10.00 per year, plus postage of $1.28, or about $4.61 ($5) to $11.28 ($11) per year. Meters are assumed to be required on the vehicle, and to cost $30 to $40. Total compliance costs are estimated to be $35 to $51 per year in the first year, and $5 to $11 per year thereafter.

Federal compliance costs for electric or CNG vehicles are assumed to involve an annual filing of vehicle energy usage (or mileage). At an estimated 30 to 40 min to record all information, and fill out and reproduce the form, including state-related registration information, the federal filing is estimated to cost $5.00 to $7.50 per taxpayer per year.

Evasion. Evasion is a serious concern for all alternative fuels, particularly electricity and CNG, and is likely to be a greater problem than gasoline tax evasion. Evasion rates are likely to be similar to those of diesel fuel taxes because of the multiple uses of alternative fuels within the economy.

Administrative Issues and Costs. The multiple fuel types will increase administrative costs because more types of product will have to be monitored and subjected to taxation at an appropriate point in the distribution chain.

Administrative costs per vehicle are estimated to be approximately the same as for VMT fees because meters will be needed on electric and perhaps CNG vehicles, and reports of fuel use or miles of travel or both would be provided by the vehicle owner. The meters would be subject to spot checking by state or local personnel, who would transmit the information to the state registration database for cross-checking against state or federal filings by the taxpayer. Annual administrative costs are estimated to be about $2.00 to $2.50 per vehicle.

Equity

Vehicle and income group equity will be similar to that for current fuel taxes. Vehicle use fees can be indexed by vehicle class to achieve greater equity among vehicle classes than fuel taxes alone can achieve. Vehicle sales taxes will be less equitable by vehicle class than fuel taxes.

Efficiency

Taxes on alternative fuels will not contribute to more efficient use of transportation facilities.

Other

Ease of Implementation. Taxes on fuels delivered through stations may be relatively easy to implement. Others, such as CNG or electricity, may be difficult due to the lack of precedent for the federal government to deal with a minority of individual vehicle owners.

F.3 STATE REGISTRATION FEES OR FEDERAL VEHICLE USE TAXES

State. States now collect differentiated registration fees from all vehicle types based on parameters such as weight or value. For registration fees to be able to replace the revenues from motor fuel taxes, states need only adjust the rates and basis of the tax. For heavy vehicles the only real issue is the setting of rates by vehicle type because fees are already based on weight and higher weight-related fees could be apportioned through the International Registration Plan (IRP) using established procedures. For light vehicles, rates set on the basis of value would generally result in lower tax burdens for lower-income vehicle owners because the value of light vehicles tends to vary directly with household income level.

Federal. A federal heavy-vehicle use tax (HVUT) is now levied on trucks registered in the United States at gross vehicle weights (GVWs) or gross combination weights (GCWs) of more than 55,000 pounds. The tax for vehicles between 55,000 and 75,000 pounds is $100 plus $22 for every 1,000 pounds more than 55,000 pounds. Vehicles of more than 75,000 pounds pay $550 per year. In fiscal year 1991, the HVUT yielded $575 million to the highway trust fund.[4]

Although the federal use tax now applies only to heavy vehicles, such taxes have been applied to light vehicles in the past. A federal automobile use tax of $10 for seven or fewer passengers and $20 for more than seven passengers was applied from January 1, 1919, to June 30, 1926.[5] A federal use tax of $5 per vehicle was applied to all vehicles from February 1, 1942, to

June 30, 1946. A federal vehicle use tax set on the basis of value for smaller vehicles and weight for larger vehicles would tend to promote equity among vehicle classes and among income classes for household vehicle owners.

Appropriateness of Dedication. A vehicle use tax is clearly an appropriate revenue source to dedicate and place into the trust funds.

Adequacy

Consistency with the New Approach. Vehicle use taxes are moderately consistent with the new approach. Economic, mobility, and environmental benefits are more difficult to link to vehicle registrations than to vehicle use.

Adequacy and Tax Rate. Registration or vehicle use tax rates could be set at virtually any level, limited only by political feasibility. A rate averaging $100 per vehicle would yield around $18 billion per year on a national basis, based on about 180 million registrations.[6] Rates should be graduated for the various vehicle classes.

Stability. Registration fees or vehicle use taxes could provide a very stable revenue base, as well as one that grew with the vehicle fleet. It would be responsive to inflation if based on value. Very high registration fees, however, would be expected to lead to more intensive vehicle use with fewer registered vehicles producing the same or increasing levels of VMT. That would reduce revenue yield and weaken the link between growth in registrations and growth in VMT. Over time a new equilibrium level of vehicle use would be expected to result, and stability around that new level would follow.

Simplicity

Point of Taxation. Registration fees or a federal vehicle use tax would be collected from all vehicle owners. Because states now collect registration fees, changing those fees to another basis or to different rates would not alter the states' point of taxation.

At the federal level, a mechanism such as that now used for the HVUT, requiring that such tax be paid before registering a vehicle in a state, would be a desirable cooperative federal/state administrative arrangement. Federal income tax forms could include a place to report a tax on vehicles. That would be far simpler and more cost-effective than a separate mailing of forms to all vehicle owners by the federal government, which would require an additional filing process for most households. There may be cross-benefits for collecting each tax by reminding some of those who do not now file federal income tax forms of their obligations.

Collection of a federal use tax by the states, in conjunction with vehicle registration, is another potential administrative option. Currently, the IRS has no direct contact with perhaps millions of vehicle owners who do not file federal tax returns. States may not wish to assume this burden, but coordinating federal and state tax collection and enforcement efforts seems to be highly feasible, based on recent FHWA efforts to promote cooperation on curtailing fuel tax evasion.

There are more than 94 million households in the United States. More than 80 million households own nearly 150 million vehicles[7] and more than 113 million individual income tax returns are filed.[8] Filings for the other 30 million vehicles would be accomplished by businesses, almost all of which would already be filing federal tax forms. We estimate there are 90 million to 100 million total vehicle-owning entities (households and businesses).

Vehicle owners not filing federal income taxes would have to be made aware of their obligations to pay a federal vehicle use tax or VMT tax. This notification would most logically be done by having state agencies supply a brief memo to all persons registering motor vehicles, noting that as of a certain date, proof that the federal use tax had been paid was a condition of registration. A precedent for this tactic has been set with the HVUT, enhancing compliance. Once the vehicle use tax was in effect, proof of payment would be required to register a vehicle.

Because of the changes in the numbers of vehicles that taxpayers possess, and the turnover of vehicles, registration will lead to the taxes' being paid on more vehicles than the number of vehicles in use at any time. Evidence of sales or trade-ins could be used to avoid duplicate payments if the number of a household's or business' vehicles does not change over the year. States allow the transfer of registrations when vehicles are traded and the federal government can do likewise.

Compliance Costs

State. Taxpayers already incur compliance costs to pay registration fees. We estimate that compliance costs for current vehicle registration fees include about 5 to 15 min of time per vehicle per year to file the reregistration and to fill out a check and mail it to the state. Up to 5 more min might be required for the taxpayer to deal with a more complex tax, based on value or some other variable. However, because the state would provide the estimate of value and taxes due for all reregistrations, the extra time should be less than 5 minutes. Thus, a maximum of 10 to 20 min is estimated for enhanced registration fees.

At a time cost of $10 per hour, the compliance costs for 180 million vehicles range from $300 million to $600 million per year. Postage at $0.32 adds $57.6 million per year. Registration fees are generally due on anniversary dates of initial vehicle registrations, so separate mailings are made by multiple vehicle-owning households. Because the majority of the estimated $350 million to $650 million in compliance costs already have been incurred, or are likely to be incurred, state registration fee changes will have little added compliance cost.

Federal. A separate schedule (form) might be required to be filed with the IRS by all taxpayers who owe the tax. The compliance cost estimate assumes all taxpayers will be obligated to supply a vehicle identification number (VIN) or other identifier for each vehicle registered, to identify the state of registration and the state license number, to supply the dates during which the vehicle has been registered, and to identify the names of the vehicle owners as they appear on the state vehicle registration or title. The owners would also supply a copy of the vehicle use

tax form to the state for each vehicle registered. When registering for the first time, the vehicle use tax form and the payment of the federal fee could be sent to the state, for resubmittal to the federal government.

For those who do not file income taxes, there will be a new compliance burden, unless those not required to file because of limited income are exempted from the vehicle use tax. We believe such an exemption is undesirable because a person with the resources to own and operate a vehicle should share in funding surface transportation.

By extrapolating the estimates of time requirements given by IRS for other tax forms, we have estimated that recordkeeping, learning about the law or the form, preparing the form, and copying, assembling, and sending the form to the IRS will require an estimated 20 to 40 min, with a midpoint of 30 min.[9] That is fairly low, because the understanding required is not complex, and needed information generally can be gathered from vehicle registration cards or by noting the VIN through the windshield. IRS estimates of average times for other typical income tax forms are shown in Table F.4. These time estimates are substantially higher than 20 to 40 minutes.

With an assumption of a time value of $10.00 per hour, the time cost per filer to comply with the vehicle use tax averages around $5.00, with a range of $3.75 to $6.25. With an assumption of no more than 100 million such filers, the compliance cost would be around $375 million to $625 million per year. The filer will need another 10 minutes to understand the law and find the correct value of tax to pay from a table of values for vehicle types that graduates the fee with the value of the vehicle. Compliance costs would thus be about $500 million to $750 million per year for a value-based fee. We assume no additional postage costs.

Compliance costs for the existing HVUT were estimated by FHWA in 1986 to be between $5 and $10 per vehicle.[10] That compares with the costs that are estimated for all filers for all vehicle types. (Those with large truck fleets will be on the lower end of costs per vehicle.)

It would be logical for the taxpayer to pay this year's vehicle use tax on the basis of vehicles owned over the last 12 months as of the filing date (April 15) for last year's income tax returns. Provisions will have to be made for those who file for an extension to ensure that vehicles registered just after filing are properly taxed. Prior year registrations will need to be reconciled. Withholding rates for federal income taxes could be adjusted to take account of average vehicle holdings and to ensure that the average filer is meeting all tax obligations timely.

Potential for Evasion

State. Previous estimates indicate that evasion of registration fees is generally modest, although evasion is of concern for heavier vehicles that are assessed high registration fees. Table F.5 shows estimates of registration fee evasion for both in-state vehicles and IRP vehicles, compiled through a survey of the states during the AASHTO Study of Motor Carrier Taxation and Registration Issues.[11] States do not consider in-state registration fees to be subject to much evasion, but misreporting of mileages and fees due under the IRP is a major concern.

TABLE F.4. Estimated preparation time for individual income tax forms[9]

Form	Record keeping	Learning about the Law or the Form	Preparing the Form	Copying, Assembling, & Sending the Form to the IRS
1040	3 hr., 8 min.	2 hr., 42 min.	3 hr., 37 min.	49 min.
Schedule A (1040)	2 hr., 32 min.	24 min.	1 hr., 9 min.	27 min.
Schedule B (1040)	33 min.	10 min.	17 min.	20 min.
Schedule C (1040)	6 hr., 13 min.	1 hr., 5 min.	1 hr., 57 min.	25 min.
Schedule C-EZ (1040)	46 min.	4 min.	20 min.	20 min.
Schedule D (1040)	51 min.	55 min.	1 hr., 8 min.	42 min.
Schedule D-1 (1040)	13 min.	1 min.	13 min.	35 min.
Schedule E (1040)	2 hr., 52 min.	1 hr., 6 min.	1 hr., 16 min.	35 min.
Schedule EIC (1040)	39 min.	18 min.	48 min.	54 min.
Schedule F (1040):				
Cash Method	4 hr., 2 min.	34 min.	1 hr., 14 min.	20 min.
Accrual Method	4 hr., 22 min.	25 min.	1 hr., 19 min.	20 min.
Schedule R (1040)	20 min.	15 min.	22 min.	35 min.
Schedule SE (1040):				
Short	20 min.	13 min.	10 min.	14 min.
Long	26 min.	22 min.	38 min.	20 min.

TABLE F.5. Evasion of state registration fees: Regular and IRP[11]

State	Regular Registration	IRP
Arizona	Very Small	Up to 25%
Arkansas	Less than 1%	Up to 25%
Iowa	1%	
Maryland	10% to 70% for fleets due to 5% excise tax	10% to 70% for fleets due to 5% excise tax
New Hampshire	0%	5% to 10%
Virginia		30%

Federal. The very large number of taxpayers from whom a new federal tax would be due would place an extra administrative burden on the federal government and the states, and would require careful cross-checking of state registrations and federal use tax payments. Filing for a lower number of vehicles owned than are registered would be difficult to trace because registrations might be in different names from filers of federal tax forms.

We estimate that evasion levels could reach 15 percent to 25 percent unless administrative efforts, as recommended below, are made to cross-tabulate vehicle use tax files and state registration files. With extensive cross-checking, evasion levels could approximate current evasion levels for state registration fees—around 2 percent per year or less for autos and light trucks.[12] The inability to record and trace vehicle holdings rapidly, because of changes in vehicle holdings, suggests a potential average evasion rate of more than twice as much—up to 5 percent.

Administrative Costs and Issues. The states already administer registration fees. Registration fees are relatively costly to administer. States' administrative costs are about $2 billion per year, about 10 times greater than the estimated $200 million to administer fuel taxes, while the tax yield is less for registration fees than for fuel taxes. However, because we believe that the states will continue to register vehicles under all future scenarios, there are few marginal administrative costs incurred by states from greater reliance on registration fees.

The federal situation differs. Administration of a new tax to be collected from individuals is costlier and more difficult than most business-related taxes that are typically collected from fewer taxpayers. Federal administrative costs would include the recording of additional data items and programs to cross-tabulate vehicle use information with state registration records. A time of 3 to 5 minutes per federal tax return for coding VIN, state ID, or state registration information is estimated for each of 100 million returns. At $20 per hour, that would total $100 to $167 million per year. Audit and enforcement efforts are estimated to cost another $50 million per year.

Administering a federal use tax would require two-way cross-checking of information between states and the IRS, to determine if the vehicle use tax was paid on vehicles being registered, and to determine if vehicle use information and registration information was accurate. That is currently done for the federal HVUT. An estimated 2 minutes would be added to process each registration, at a cost of $20 per hour. With approximately 180 million state registration activities per year, states would incur additional annual administrative costs of around $120 million. That would increase state expenses for collecting motor vehicle and motor carrier taxes, which totaled $1.9 billion in 1991,[13] by about 6 percent.[13]

Total state and federal administrative costs for a federal use tax are estimated at around $270 to $337 million per year. Current federal use tax administrative and enforcement costs were estimated at $11.9 million in 1986, and state costs to verify payments were estimated at $2.7 million.[14]

Equity

Vehicle Class. A registration fee or use tax might or might not be equitable among vehicle classes depending on how it is defined and graduated. A use tax could be designed around state or federal highway cost allocation study results so as to match cost responsibility among vehicle classes.

Within vehicle classes, a registration fee would not be as equitable as fuel taxes or VMT fees, because it would not be sensitive to the amount of use. A set of mileage categories would in fact end up as a VMT (mileage-based) tax, with the same issues as described below for mileage-based taxes in terms of administrative costs and evasion.

Income Group. Equity by household income group could be served by a use tax based on vehicle value, if the equity goal was to minimize impacts on lower-income groups. States that levy use taxes based on value, such as Washington and Minnesota, have schedules for depreciated value applicable to all model years and vehicles, applying a consistent set of depreciation assumptions. Applications of value-based fees by other states would be straightforward; they could borrow the schedules for value-based fees and apply them in their own states.

The federal government does not levy the HVUT based on value, nor does it levy property taxes or taxes on personal property based on value. There may be objections to a value-based use tax on the federal level, despite the existence of value-based registration fees in many states.

Efficiency

The use tax would not promote efficiency in terms of pricing of transportation.

Other

Ease of Implementation. Registration fees could be adjusted or a federal use tax implemented, but it might be difficult to tie such fees as closely to benefits or objectives of the programs as might be possible with VMT or fuel taxes.

The HVUT was to have been set at higher levels, but the trucking industry preferred an additional diesel fuel tax, in cents per gallon over the gasoline tax, as a way to pay for some of the cost responsibilities of heavy trucks that were not adequately covered by other federal taxes incident on heavy trucks. The trucking industry likely would be adamantly opposed to reliance on higher vehicle use taxes in lieu of fuel taxes, because the industry believes that use taxes would be increased more rapidly in the future instead of across-the-board increases in vehicle value taxes.

F.4 VMT Fees

A VMT tax could be assessed for travel within the nation, within a state, or within regions based on the reading of a vehicle odometer or hubodometer or upon vehicle roadway use recorded by AVI equipment. VMT fees could be graduated based on vehicle size and weight or other vehicle characteristics, including emissions, equivalent single-axle loads, vehicle value, energy consumption, or energy type.

A VMT fee would be an appropriate state fee that could be adjusted to achieve equity among vehicle classes and vehicles based on their relative cost responsibility. A VMT fee would also be an appropriate federal fee, with or without parallel state and local VMT fees, but it would be much easier to administer jointly if state or local programs existed that involved monitoring and checking of mileages traveled or mileages accumulated by the vehicle.

Much of the discussion in the previous section of point of taxation, compliance costs, administrative costs, and evasion levels for registration fees or vehicle use taxes applies to VMT fees. Therefore, the following discussion does not repeat all relevant estimates covered above. Where the VMT fee provides for different issues, they are discussed below.

VMT fees could be administered through periodic readings of odometers, hubodometers, or other meters on the vehicle itself. That might be accomplished electronically, if all vehicles were required to have transponders or smartcards, or could be accomplished manually if representatives of enforcement agencies read the meters.

VMT fees also could be administered in the same manner as congestion fees, with estimates of the mileage of each vehicle built up from a series of interrogations of a transponder or smartcard as the vehicle traveled the road system. A VMT fee administered in this manner would incur the same administrative, compliance, and enforcement costs as the congestion fees discussed below.

Adequacy

Consistency with the New Approach. VMT fees are very consistent with the new approach. Economic, mobility, and environmental benefits are strongly linked with vehicle use.

Adequacy and Tax Rate. VMT fees could yield almost any desired level of revenues. With annual VMT exceeding 2 trillion miles in the United States, VMT fees need to average less than $0.01 per mile to yield current federal tax revenues, and only $0.04 to yield revenues to fund all current state and federal surface transportation programs.

VMT fees should logically be based on the relative cost responsibility of vehicle classes. If VMT fees were proportional to the results of the 1982 FHCAS, the federal fees per mile for the heaviest trucks would be more than 16 times those for autos. For states, whose expenditures are tilted more heavily toward common cost items (and allocated in cost allocation procedures by VMT), the heaviest trucks typically have per mile cost responsibilities three to seven times greater than autos.

Stability. The VMT fee follows vehicle usage by definition. VMT is a reasonable parameter to reflect some aspects of need. VMT fees are not responsive to inflation, although they can be indexed or adjusted periodically in response to changes in revenue requirements.

Appropriateness of Dedication. Because VMT is highly related to the needs for capacity expansion and system preservation, a VMT fee will tend to mirror needs better than current taxes. VMT fees are highly appropriate for dedication to trust funds.

Simplicity

Point of Taxation. The point of taxation and incidence would be similar to that of the registration fee or vehicle use tax. VMT fees would be collected from the individual vehicle or fleet owner and would be incident upon vehicle use. For the states (or for regions if applied on a regional basis), VMT fees could be collected as part of registration fee submittals. Impacts of the fees on VMT would be less if the fees were collected annually than if they were collected more frequently. VMT reductions in response to a VMT fee would be greater if the driver could see a running VMT fee meter inside the vehicle, which would be a reminder of the costs being incurred.

For the federal government, VMT fees could be paid as part of the federal income tax return, with about 90 to 100 million filers anticipated. Cross-checking with state registration infor-

mation, and with state and local observations of mileages, would be desirable for federal fees.

Compliance Costs. Compliance costs include costs estimated for registration and vehicle use fees, plus the costs associated with basing the tax paid on miles of travel. These extra compliance costs will include reading a meter and recording mileage. We have assumed that mileages can be voluntarily read by the taxpayers at the time vehicle license, VIN, and ownership information is recorded on state registration forms or federal tax forms.

Filing VMT reports with state registration forms should require no more than 5 to 15 min per taxpayer if done annually. This cost would apply each time a registration form is filed. Including used vehicle purchases, about 200 million forms might be submitted each year to the states, indicating a compliance cost of $167 to $500 million at $10 per hour.

The costs of filing federal VMT forms are estimated at $500 to $750 million per year, the same as for vehicle use taxes, which require recording the vehicle's age and model year. These costs are higher than the state costs because this filing requires a new form and new activities to comply.

Either state or federal VMT fees would probably require the taxpayer to read a table that indicated the tax due based on miles of travel. For vehicles scrapped or sold during the year, the mileage would have to be recorded at the time of transfer and also reported. That would be facilitated by having reports filed of mileage readings (of the meters) by those who had just purchased a vehicle and by those businesses that scrapped vehicles.

The added compliance costs for VMT fees assume that a "tamper-proof" odometer, hubodometer, or other meter is installed into each vehicle, new or old. While no technology is fully "tamper-proof," using coded seals and imposing very high fines for tampering could discourage tampering by making detection relatively easy and penalties severe.

Technologies to consider include any type of meter, or smartcards or transponders. Meters could also include transponders or smartcards in them, to be read electronically by roadside interrogators or at inspections stations.

Hubodometers are available for $30 to $40[15] for heavy vehicles, and at the same price for lighter vehicles, although they are not widely used in lighter vehicles. Costs are estimated to decline under universal application. An estimate of $30 to $40 per vehicle (equipment plus installation) is used as the basis for compliance costs. It is also assumed that the hubodometer includes a transponder or smartcard that provides for electronic interrogation.

The cost for hubodometers is in addition to those compliance costs listed for the vehicle use fee. This cost assumes that mass market savings are partially offset by the costs to make hubodometers or other meters more tamper-proof and capable of being read electronically. Hubodometers currently break if opened, but can be removed from the wheel.

A fleet of 180 million vehicles would incur $5.4 billion to $7.2 billion, at $30 to $40 per meter, in first-year compliance costs. Costs within a state or region would be proportional to the number of vehicles. Assuming an average meter life of 10 years (similar to vehicle lives) and 17 million new and 3 million replacement meters per year at a cost of $30 to $40, the total annual cost of the meters, on a national basis, would average $600 million to $800 million per year after the first year. (These costs would be in addition to the $167 million to $500 million annual costs estimated for state and/or $500 million to $750 million annual costs estimated for state plus federal paperwork filing costs.) Nationwide compliance costs would thus range from $6.1 billion to $8.5 billion in the first year (startup) and $1.3 billion to $2.1 billion annually thereafter.

Although it would reduce compliance costs, reliance on self-reporting without an opportunity for backup information would not be a wise course of action, because it would create incentives for underreporting and consequent equity issues between honest and less than honest taxpayers.

Evasion. Evasion is a major concern, because the VMT fee is paid on an individual vehicle basis, and more complex recordkeeping is required than that of knowing whether a vehicle exists.

Estimates of evasion of state weight-distance taxes range from a few percent to 30 percent. We have assumed that highway agency and FHWA estimates, which are at 10 percent or fewer, have more credibility than other estimates and, consequently, we estimate evasion at about 10 percent.[16]

Administrative Issues and Costs. VMT fee enforcement would require reading odometers or other meters, or monitoring vehicle movements. That could be accomplished visually or electronically during vehicle inspections at centrally administered inspection stations, or during highway patrol or parking enforcement activities by state or local personnel. Odometer reading by private service station personnel operating under a decentralized inspection system likely would not be a valid enforcement approach.

For areas that do not have government-administered vehicle inspections, additional costs would be necessary to ensure some level of monitoring of compliance with VMT fees, such as a required periodic reading by a government agent, with the paperwork signed as to the accuracy of the reading and the lack of tampering. That monitoring implies a very large cost, and random inspections should be considered as an enforcement procedure. Random inspections, in association with other enforcement by states, are estimated to cost $1 million per state per year (based on average 20 full-time equivalents at $50,000 per year each). We assume this cost would be borne by the federal government, as with the use tax.

Assuming random inspections at parking lots, meters, etc., state and local personnel could provide a significant deterrent to evasion. Federal checking of odometers or hubodometers is probably an unlikely administrative approach.

If mileage readings were included in state registration and titling information, there would be additional state recordkeeping costs. We estimate these at another 2 minutes per vehicle per year, or $120 million per year (180 million vehicles at 2 minutes per vehicle at $20 per hour). That would add another $120 million in state costs to the $120 million estimated for state cross-checking with regard to any federal vehicle use fees. Total state costs would thus be around $240 million per year.

Federal costs are assumed to be the same as for the vehicle use tax, or $150 to $217 million per year. We assume the federal government would reimburse state costs if states were not ad-

ministering VMT fees. Total administrative costs are estimated at $390 to $457 million per year.

Equity

Both federal and state cost allocation studies could be used to set highly equitable VMT fees among vehicle classes. VMT fees could be graduated based on cost responsibility, vehicle size and weight, equivalent single-axle loads, value, emissions, or other characteristics.

Efficiency

VMT fees encourage efficiency by pricing travel. However, because the rate per mile does not vary with the time of day or facility, it cannot reflect the true social cost of travel.

Other

Ease of Implementation. There are no VMT fees currently being applied to all vehicles and they are not likely to be greeted warmly unless justified as part of a new approach and contract between the transportation agency and its customers. New administrative procedures would be needed. For states, expanding existing registration procedures would be reasonable.

A federal VMT fee that relies heavily on state enforcement is unlikely to be implemented. FHWA examined but rejected the possibility that the states would enforce a federal weight-distance tax.[17] If, however, states themselves implement VMT fees, then a federal VMT fee will be enforced in parallel with state enforcement efforts, similar to the situation today with enhanced state-federal cooperation on fuel tax enforcement.

F.5 PAVEMENT DAMAGE FEES OR WEIGHT-DISTANCE TAXES

A pavement damage fee would be implemented to assess and to increase the economic efficiency of impacts on pavement wear and tear, in a manner similar to a congestion fee's impact on the use of capacity. Because a weight-distance tax is often intended by states that use such a tax to charge trucks for the extra pavement costs they cause, these two related options are discussed together. A pavement damage fee could be applied through an axle weight-distance tax, because it is the axle load that is related to pavement damage.

States now levy weight-distance taxes, and elements of weight-distance taxes are present in the apportionment of fees for heavy vehicles under the IRP, although the apportionment of registration fees to states under the IRP depends only on the percentage of miles traveled in the states.

The possibility for a federal weight-distance tax and axle weight-distance tax was examined in detail in the cited 1988 FHWA study *The Feasibility of a National Weight-Distance Tax.* We use the estimates in that report for all relevant portions of the analysis of a federal weight-distance tax.

A weight-distance tax would certainly be implemented if a state or federal VMT fee were implemented, because it would be impossible to achieve equity among vehicle classes without steeply graduated VMT fees based on weight to reflect relative cost responsibility. If VMT fees were implemented, the administrative and compliance costs of applying weight-distance taxes virtually would be subsumed in the overall costs of the VMT fees.

Adequacy

Consistency with the New Approach. VMT fees, including weight-distance and pavement damage fees, are very consistent with the new approach. Economic, mobility, and environmental benefits link well with vehicle use.

Adequacy and Tax Rate. Rates could be set at almost any level and could be based on registered weight and distance, as are some current state weight-distance taxes, or on axle weights, which are better indicators of likely pavement damage. Oregon imposes a tax of $0.005 per mile for each equivalent single-axle load on very heavy vehicles (more than 80,000 pounds). An equivalent single-axle load is the axle load imposed on pavements by a single axle of 18,000 pounds. Procedures for calculating equivalent single-axle loads are used by highway agencies to relate the pavement damage caused by axles of different weights to the 18,000-pound single axle.

Weight-distance taxes can be collected based on either registered weights or actual recorded or reported vehicle weights. In practice, registered weights are used. Weight-distance taxes will apply only to heavier vehicles. The FHWA study analyzed applications to vehicles of more than 55,000 pounds and of more than 26,000 pounds.

Stability. Pavement damage fees and weight-distance fees are likely to be highly stable, and will be relatively easier to adjust than other taxes because not as many taxpayers are involved. Oregon has been able to adjust weight-distance fees regularly after conducting cost-responsibility studies or updates. However, unless indexed, they will not be responsive to inflation.

Appropriateness of Dedication. Weight-distance taxes or pavement damage fees are appropriate as a dedicated source of trust funds.

Simplicity

Point of Taxation and Incidence. Pavement damage fees or weight-distance taxes will be incident upon trucks, at the level of the vehicle or fleet owner or operator. If applied to vehicles of more than 55,000 pounds, the number of taxpaying entities will be the same for the weight-distance tax as for the current HVUT.

Compliance Costs. There has been considerable debate over the compliance costs for weight-distance taxes. FHWA's 1986 estimates were that net additional compliance costs for a national weight-distance tax (above what carriers were already incurring for the HVUT) applied to gross registered weight for vehicles

TABLE F.6. Levels of compliance with state weight-distance taxes

State	Percent Compliance
Arizona	92.5
Arkansas	95.0
Colorado	89.5
Idaho	84.0
Kentucky	85.0
Nevada	98.0
New Mexico	90.0 to 95.0
New York	90.0
Ohio	90.0
Oregon	96.0
Wyoming	85.0
Average	90.7

Source: National Governors' Association, "Briefing Paper on Mileage Taxes (Weight-Distance Taxes, Ton-Mile Taxes, and Axle-Mile Taxes)," 1985.

of more than 55,000 pounds would range from $2.4 million to $9.4 million, and would range from $6.2 million to $31.8 million for a tax applied to registered axle weights.[18] Higher compliance costs were estimated if the tax was applied at more than 26,000 pounds.

Tax Evasion. Evasion of pavement damage fees and weight-distance taxes is highly dependent on enforcement activities. A Jack Faucett Associates study in 1984[19] estimated federal weight-distance tax evasion under different administrative options:

- Weight-distance, administered same as (then) existing HVUT (17 percent)
- Weight-distance, with use of hubodometers (10 percent)
- Weight-distance, with use of state weigh stations (15 percent)
- Axle weight-distance (12 percent).

In the study, hubodometers were estimated to cost $50 with a $25 cost of attachment.

Evasion of current state weight-distance taxes was estimated in the AASHTO study, and a followup estimate was prepared for a National Governors' Association briefing paper. As shown in Table F.6, evasion levels were estimated to average around 10 percent for the 1985 weight-distance taxes.

Administrative Issues and Costs. Administrative costs for a national weight-distance tax have been estimated by FHWA for different administrative structures and different levels of application (more than 26,000 pounds and more than 55,000 pounds). Costs range from $26 million to $114 million for fees applied to all vehicles of more than 26,000 pounds, and from $12 million to $53 million for fees applied to all vehicles of more than 55,000 pounds, depending on the type of enforcement and the frequency of payments (annually or quarterly). These results indicate that administrative costs, even though higher than for HVUT, would be modest for a fee structure that could yield $3 billion or more per year. While the FHWA estimates were in 1986 dollars, we do not believe they should be adjusted for inflation, because reduced costs of electronic filing and data processing have offset the cost impacts of inflation.

Administrative costs for state weight-distance taxes were estimated in the FHWA study as shown in Table F.7. Average costs per account ranged from less than $20 to more than $120. The mean cost was calculated at nearly $50 per account. A wider range of variations in costs and numbers of accounts should be used: $20 to $150 per account and 10,000 to 80,000 accounts per state.

Equity

Pavement damage fees and weight-distance taxes could be highly equitable sources of revenue. In addition, pavement damage fees may contribute to more productive use of pavement resources.

The establishment of pavement damage fees or weight-distance taxes raises concerns by the trucking industry that a convenient tax source will be created that can be raised without public outcry. The most recent federal highway cost allocation study indicated that heavier trucks were underpaying their federal cost responsibility rather than overpaying.

Efficiency

Pavement damage fees or weight-distance taxes can be efficient. The fees encourage decisions about axle configurations of trucks to be based on more complete consideration of pavement costs. Small modal shifts to rail may also occur if heavy trucks are taxed more heavily.

Other

Ease of Implementation. Neither weight-distance taxes nor pavement damage fees are likely to be very easy to implement politically. Weight-distance taxes have been eliminated in several states recently. Only Oregon has a pavement damage fee, applicable only to vehicles registered at more than 80,000 pounds GVW (i.e., the very largest truck-trailer, tractor-semitrailer, and tractor-semitrailer-trailer or triples combinations). The possibility of a federal weight-distance tax has been debated for many years. The political ease of implementation may not be great.

F.6 CONGESTION PRICING

Congestion pricing would involve fitting every on-road vehicle with an AVI or smartcard that would allow either a debit or a charge for the use of a particular road at a particular time. Congestion prices would be set to raise revenue and to shift

TABLE F.7. Administrative costs for state weight-distance taxes

State	Number of Accounts	Total Processing and Enforcement Cost	Cost Per Account
Arizona	24,000	$453,000	$18.88
Arkansas	16,234	$570,000	$35.11
Colorado	18,300	$1,683,000	$91.97
Idaho	17,300	$670,000	$38.73
Kentucky	32,000	$960,000	$30.00
Nevada	13,246	Not Available	Not Available
New Mexico	14,000	$601,000	$42.93
New York	62,500	$1,845,000	$29.52
Oregon	35,954	$4,385,500	$121.98
Wyoming	20,000	$1,554,000	$77.70
Mean			$48.69

travel to different modes or time periods, so as to reduce the overall costs of travel, including the costs imposed by users on others.

It is extremely difficult to construct a scenario in which the federal government might levy congestion fees except as an add-on to regional or state applications of such fees. However, the potential for such fees to encourage economic efficiency in the transportation sector provides a rationale for federal encouragement. In addition, if federal funding flexibility remains greater than the funding flexibility of many states (as it has become under ISTEA), then passing some funds from congestion pricing back and forth through the federal revenue system may provide a more flexible means to fund regional or state transportation improvements. We have not analyzed how that might be accomplished.

Adequacy

Consistency with the New Approach. Congestion pricing is very consistent with the new approach. Economic, mobility, and environmental benefits link well with taxing vehicle use at peak periods.

Adequacy and Tax Rate. Tax rates are assumed to be set at or below a level that represents the total costs imposed by the vehicle's use on all of society, including the user. This rate-setting applies the principle of marginal cost pricing. Potential economic benefits can be achieved from pricing roadway travel under congested conditions at higher levels than today's prices, as long as prices do not exceed the costs imposed by the particular trip on society. Higher than marginal cost prices will curtail travel in a manner that has negative impacts on the economy.

Virtually any level of revenues could be realized through congestion pricing. A calculation of the national level revenues from congestion pricing, accomplished by consultant team members for a previous study, indicated that 1989 revenues of more than $200 billion might accrue from congestion pricing applied to all the nation's federal aid highways.[29] The study assessed fees ranging from $.002 per mile on the least congested federal aid highways to $0.50 per mile on the most congested. Similar analyses for both the Los Angeles area and the Portland, Oregon, area by consultant team members indicated that congestion prices averaging up to $0.15 per mile seemed to have net economic benefits if applied to those areas.[21] Such fees would increase costs per mile to auto and light truck users by about one-third and by more than $1,000 per year, a substantial economic change. Similar prices applied to other urban areas might also have net economic benefits and yield very substantial revenues.

Setting congestion fee rates below marginal social cost could be justified because revenues could be used to enhance mobility through investments and thus yield lower congestion levels in the future.

Congestion pricing should be highly flexible, so rates could respond to changes in demand.

Stability. Congestion fees are not responsive to inflation. While they usually increase in response along with VMT, they are collected on a facility basis and are thus not responsive to overall VMT.

Appropriateness of Dedication. Although some economists argue that congestion fee revenues should not be used for road capacity expansion, their point of view is incorrect. The current highway system may not be the most cost-effective and efficient size. To assume that the economic goal is to price the use of the existing capital plant more efficiently is both suboptimal and a wrong definition of the transportation efficiency problem. Rather, the goal should be to raise revenues and make investments that have positive payoffs, whether those investments are in the form of new capacity (highway or transit) or of some other type. The use of congestion fee revenues for capacity expansion can be both appropriate and desirable.

Simplicity

Point of Taxation. Fees would be imposed on all users of particular facilities at particular times of day. A mechanism for assessing fees on all vehicles would be necessary, and the point of taxation would be the individual vehicle and its owner. The number of taxpayers would be equal to the number of vehicle owners in all areas implementing congestion pricing.

It would appear to be necessary to tie congestion pricing into vehicle registration. A collection procedure that processes fees more frequently than annually would be desirable to administer the fees, track vehicles and owners, and make the users responsive in terms of travel behavior to the fees they were being assessed. A display of fees within the vehicle would be an appropriate reminder of the link between travel and costs.

If applied throughout the United States, congestion pricing might range from very low fees per mile for travel on relatively uncongested roads, to fees at levels that would strongly affect travel choices in the most congested corridors. With congestion pricing applied throughout the nation, about 180 million vehicles would be equipped with transponders, and all households and businesses would have accounts with some level of government.

Compliance Costs. The costs of compliance include not only the costs of activities necessary to pay the fees but also the costs of on-vehicle and roadside equipment needed to determine the fees. The application of congestion pricing is assumed to include an on-vehicle transponder or smartcard that tracks and verifies fees due as well as provides an indicator of vehicle location.

We have assumed a cost of $20 to $50 for the transponder or smartcard on the vehicle (in mass production).[22] Nationwide application to 180 million vehicles would cost $3.6 billion to $9 billion for the cards or transponders in the first year. Continuing costs for 20 million additional cards or transponders would be $400 million to $1 billion per year, if applied to all vehicles across the nation.

As with other fees, additional reporting costs would also be incurred. There would be slightly different compliance activities, however, because the taxpayer's major responsibility would be to decide whether to contest the accuracy of the bill, rather than to supply information, and to remit payment. It is assumed that responding to the bill would take about 15 min per quarter, or 60 min per year, for a total of $10 per year at $10 per hour. Adding postage costs of $1.28 would bring the reporting compliance cost to approximately $11 per vehicle per year.

For the national total of 180 million vehicles, transaction costs would amount to $2 billion per year. Total costs would be $5.6 billion to $11.0 billion the first year and $2.4 billion to $3.2 billion per year after the first year. The compliance costs would be highly dependent on how frequently bills had to be paid. Monthly transactions would impose yet higher costs.

Transaction costs for electronic road pricing using currently available technologies have been estimated by Hau at $0.066 for AVI and $0.125 for smartcards.[23] Rooney estimates $0.08 to $0.12 per transaction for automated toll collection.[24] Costs include all those for the AVI transponders and the administrative costs incurred by the agencies. A denser network than the kind of single facility or ring road applications already in place could reduce transaction costs substantially.

Assuming costs could decline to $0.003 per transaction and congestion pricing estimates could be reliable at 10 transactions per vehicle per day, an annual cost of $78 per vehicle would be incurred for 260 days per year of application. That would yield more than $14 billion per year if applied to all vehicles in the nation. Of course, fees of $78 per year would be incurred only in places where there could be very significant benefits from congestion pricing applications.

Fewer recorded observations of each vehicle over a period of time may provide statistical reliability, without compiling such detailed information. A statistical approach would reduce the opportunity to protest bills but would resolve many privacy issues. Assuming that 500 to 1,000 observations would suffice to establish statistical reliability, costs could potentially be reduced to $15 to $30 per vehicle, assuming the same cost per transaction. The methods that will lead to the most cost-effective applications of IVHS technologies to systemwide congestion pricing are speculative at this time. It is probably incorrect however, to assume that records must be kept with 100 percent accuracy 100 percent of the time.

Evasion. The evasion potential of congestion fees is uncertain. A complex monitoring system must be set up that automatically checks the status of each vehicle using the roadway system. High levels of vehicles without transponders or of nonfunctioning transponders on vehicles will present enforcement personnel with substantial difficulties.

Congestion pricing is fairly dependent on virtual universal use of electronic transponders. It is conceivable that they can be justified on other grounds: checking the status of registrations or insurance, tracing stolen vehicles, or assessing personal property taxes.

If there is universal use of transponders, evasion can be limited by the following:

- Equipping of enforcement personnel with interrogating transmitters that tie into comprehensive databases that allow an immediate status report on the functioning of a transponder or smartcard on a particular vehicle and the identity and status of the vehicle
- Inspection of transponders or smartcards during vehicle inspections
- Cross-tabulation of congestion fee records and motor vehicle registration records for vehicles listed as registered
- Substantial penalties for operating a vehicle without a working transponder or smartcard or for tampering in any manner with a transponder or smartcard.

The closest analogies to attempting to curtail evasion under congestion pricing are the enforcement procedures used for weight-distance taxes. An analogous estimate to the weight-distance tax estimate of evasion is 10 percent using smartcards or transponders.

Administrative Issues and Costs. Substantial administrative issues exist. Congestion pricing would have to be applied jointly to state and other facilities to ensure that pricing one facility did not simply shift traffic to other facilities that could not handle it as efficiently. Cooperation between state, regional, and local

jurisdictions would be necessary to administer the congestion fees. Revenue distribution would be a political issue similar to that for all other potential new taxes or fees.

Rough cost estimates made previously for Los Angeles applications indicate administrative and enforcement costs would be in the range of $150 million to $300 million for implementing a system of pricing applicable to all freeways in the Los Angeles area and about 8 million vehicles.[25] That would amount to about $20 to $40 per vehicle, or about $3.6 billion to $7.2 billion if applied to 180 million vehicles in the United States. Congestion pricing is very unlikely to be applied to all vehicular travel, so the ratios per vehicle should be used for places employing congestion pricing.

Equity

Beneficiaries of congestion pricing would include those who remained on the roads and paid the fees, because the fees would be scheduled to reduce the total operating, travel time, and safety costs of the remaining road users. Those who changed their travel would not benefit unless compensatory actions (such as new modes) were funded with a portion of the proceeds of the congestion prices.

Vehicle Class. A previous assessment of the application of congestion pricing to all U.S. federal aid highways provided an estimate of the relative fees per mile for congestion pricing that would be due from various vehicle classes. The results were presented in terms of ratios of fees per mile relative to the fees per mile to be paid by autos. The heaviest trucks would pay only about three times as much per mile as autos, under a system that combined both congestion charges and pavement damage fees.[26]

Income Group. Lower-income persons would find the burdens of congestion pricing greater than would higher-income persons, as is the case with motor fuel taxes, registration fees, or VMT fees.

If congestion pricing revenues were used for programs that benefited those who no longer used the roads at peak periods, congestion pricing might result in a very close correspondence between those who paid and those who benefited. An analysis by Kane and DeCorla-Souza indicates that regionwide pricing combined with carpool improvements (assuming HOV-2) could benefit single-occupant vehicle users, carpoolers, and bus users in terms of reduced total average costs for each mode in the corridor.[27] Of course, some individuals within a group may still not benefit.

Efficiency

Congestion pricing implements the efficiency approach to highway taxation by charging the traveler a price of the marginal social cost of the trip. As noted, some smaller economic efficiency gains could also be made by charging below the marginal social cost.

Other

Ease of Implementation. This type of tax has never been imposed in the United States, and has not been technologically feasible until recently. FHWA's Congestion Pricing Pilot Program should provide evidence as to the level of interest in this topic. Substantial opposition may be expected from interest groups such as automobile users as well as from those who will oppose all taxes no matter what the net benefits to themselves and society.

The technological means of implementing congestion pricing on a wide scale are also not yet proven, although experiments with the use of AVI for toll roads and ports of entry (for trucks) have indicated that the technology is workable on specific facilities.

F.7 TOLLS

Tolls refer to traditional toll collection procedures on specific new or existing roads. Tolls can differ by time of day and (as usual) by type of vehicle. If they differ by time of day, tolls have some potential attributes of congestion pricing.

As with congestion pricing, it is difficult to construct a plausible scenario in which the federal government will be collecting tolls. Existing provisions of ISTEA allow tolls to be used as a "soft match" for federal funds, and thus tolls can be a part of state strategies to use ISTEA funding mechanisms in a flexible manner.

Adequacy

Consistency with the New Approach. If administered electronically, tolls can be very consistent with the new approach, particularly if tolling is widespread enough to resemble VMT fees or congestion pricing.

Adequacy and Tax Rate. Toll rates can be set at almost any level. However, tolls are more likely to be used to supplement other state and local agency revenues than to fund all expenditures.

Toll roads can have yields only from those users willing to pay the price to avoid an alternative free route. That strictly limits the yield potential except if tolls are widely applied or if there is no alternative free route. Toll roads, if not covering an entire system, will also tend to distort travel patterns. In addition, productivity losses for persons and businesses will occur if they have to stop at toll booths. AVI or smartcard technology can reduce the latter loss of productivity.

Appropriateness of Dedication. Tolls are an appropriate source of revenue for transportation, and toll revenues would be appropriate for trust funds for any level of government imposing the tolls.

Simplicity

Point of Taxation and Incidence. Tolls are trip based and apply only to those who use a specific facility. Automated toll

collection offers the opportunity to reduce administrative costs significantly. In many cases, toll road users also pay general transportation taxes and fees (fuel use taxes and registration) in addition to the tolls. Tolls on one facility may be perceived as inequitable, particularly if users in other corridors are not subject to tolls.

Compliance Costs. Toll collections in which the vehicle must stop and the driver hands over the toll impose high compliance costs on users. It costs auto and light-truck drivers from $0.25 to $0.40 in operating and travel time to stop and pay a toll, even if there is no line at a toll booth. Lines at toll booths can result in delay costs of many times these amounts. Some toll facilities collect very low tolls, in the range of $0.25 to $0.50, and have more than minimal delay times, thus imposing more in compliance costs than they impose in tolls. New toll roads with collections made in this manner impose too high a compliance cost to be considered viable options. Existing toll roads, tunnels, and bridges should be converted to maximize use of AVI transponders or smartcards as rapidly as possible.

Evasion. If administered electronically for many roads, evasion rates should be at or slightly below those for congestion pricing, for example, 10 percent or less.

Administrative Issues and Costs. Standard toll collection procedures are extremely costly administratively, and impose high delay costs on motorists. Transaction cost estimates by Hau ($0.066 to $0.125 per transaction) and Rooney ($0.08 to $0.12) are probably good indicators of likely total costs of AVI or smartcard toll collection.[28]

Equity

Toll roads have a close correspondence between those who benefit and those who pay, although beneficiaries include bondholders, consulting engineers, toll collectors, and financial advisors to toll road authorities who are guaranteed income from the toll facility, in addition to users of the road.

Tolls can be set to achieve a close correspondence between cost responsibility and tolls paid by vehicle classes, and thus can be highly equitable among vehicle classes.

Efficiency

Tolls contribute to efficient use of transportation facilities if and only if the tolls allow various alternative routes to be priced correctly. Analyses have indicated that tolls should be higher on arterials than on expressways because the marginal social costs of an additional vehicle on a parallel arterial may be greater than the marginal costs of that vehicle on a tolled expressway.

With more comprehensive and widespread tolling schemes, toll rates can be set to differentiate by time of day and facility and can be managed to promote more efficient use of entire systems.

If tolls are collected manually, additional disadvantages of delays and stopping are created that reduce efficiency. Automated toll collection is necessary to reduce or eliminate these impacts.

Other

Ease of Implementation. While there has been much interest in toll facilities, very few have been implemented since the advent of the Interstate Highway System, in part because the availability of 90 percent or higher federal matches made the toll option unattractive to states. Objections to toll roads include the inequity of drivers' paying tolls in one corridor while all others use free roads.

This situation may change because of ISTEA's providing much greater flexibility in matching federal aid and toll financing. If toll arrangements can add dollars to improvement packages and programs, and the toll facilities themselves do not have to be 100 percent or more self-supporting, more agencies may become interested in using toll revenues as an additional source.

F.8 TAXES ON NEW VEHICLE SALES AND PARTS SALES TAX

Federal. A sales tax equal to 12 percent of the retail price is now applied to sales of new vehicles of more than 33,000 pounds and trailers of more than 26,000 pounds. Before April 1, 1983, this tax was set at 10 percent of the manufacturer's sales price of trucks and trailers.

A sales tax on the manufacturer's sales price of automobiles was in effect from October 4, 1917, to August 16, 1971, and was last levied at a rate of 7 percent. A tax on truck parts and accessories was repealed effective January 7, 1983.

State. Many states impose sales taxes on all items, and some provide for vehicle sales taxes to be allocated to transportation programs.

Adequacy

Consistency with the New Approach. A sales tax is only moderately consistent with the new approach, because it applies to so few of those who benefit from meeting mobility, economic, and environmental objectives.

Adequacy and Tax Rate. In a reasonable year in which 12 million units of autos and light trucks are sold[29] in the United States, at a manufacturer's sales price of about $13,000 per unit in 1992 dollars, each 1 percent of sales tax on new light vehicles will yield $1.5 billion; a 7 percent tax will yield $11 billion. A tax on retail sales of vehicles at the state or federal level will yield about 10 percent to 15 percent more per unit at a similar rate as a manufacturers' sales tax. Either the sales tax at the manufacturer's price or at the retail price could yield very substantial revenues.

A vehicle sales tax could clearly produce much revenue. If applied to used vehicles also, a sales tax could yield substantial additional revenues. Applying a tax on used vehicle sales would, however, increase administrative difficulties and be double taxation on the vehicle whose ownership was transferred.

A sales tax on new vehicles would be highly responsive to inflation and to important price contingencies. In particular, percentages of the increases in the cost of vehicles due to higher

vehicle quality or lower emissions (or higher-cost power plants for alternative fuel vehicles) would be captured by this tax.

Sales taxes on vehicle parts and accessories would pose significant administrative difficulties because there are many automotive-related products manufactured by a wide range of businesses, and sold in such a wide variety of outlets. It would be difficult to separate out the sales of parts and accessories from other sales. In most states imposing sales taxes, these items are simply combined with other taxable goods, and the overall sales tax receipts go to general revenues.

Stability. Vehicle sales tax revenue will fluctuate substantially in response to economic cycles. Purchases of new vehicles drop substantially during recessions and increase substantially during recovery periods. New vehicle sales of autos and light trucks ranged from 11 million to 16 million during the 1980s. This type of variation far exceeds in percentage terms the variations of any other major revenue alternative based on vehicles, fuels, or VMT. If the balance in the trust funds is allowed to stay positive, and if spending patterns are stable, the year-by-year fluctuations in the yield of vehicle sales taxes may not be of great concern.

Appropriateness of Dedication. A vehicle sales tax is clearly appropriate for dedication to the trust fund accounts. A vehicle sales tax on autos was dedicated to the highway trust fund until 1971.

Simplicity

Point of Taxation and Incidence. The tax could be levied at the retail level or the manufacturers' (wholesale) level, and would directly apply to buyers of new vehicles. The tax would also have the indirect effect of increasing the value of all old vehicles.

A tax levied on original vehicle manufacturers' sales would involve a modest number of companies, and represent a highly favorable point of federal taxation. The manufacturers' level and type of application would reduce administrative and compliance costs and opportunities for evasion. A somewhat higher rate would be needed to obtain a given revenue yield because the wholesale price represents a lower tax base than the retail price.

There will be many more taxpayers for a tax applied to vehicle parts and accessories. The United States Department of Commerce's *Census of Wholesale Trade for 1987* included 45,848 establishments engaged as wholesalers of new autos, motorcycles, buses, recreational vehicles and trucks; new and used motor vehicle supplies and parts; petroleum products marketing equipment; and tires and tubes. The *Census of Service Industries for 1987* included 151,218 automotive selected services establishments, including automotive repair shops, auto rental and leasing without drivers, auto parking, and automotive services except repair. A slightly redundant list of retail automotive businesses for the *Census of Retail Trade for 1987* showed 204,223 establishments including new and used car dealers, used car-only dealers, auto and home supply stores, and gasoline service stations. Even considering some redundancies among these establishments, there are clearly many establishments engaged in retail sales of auto and truck parts and accessories that could be subject to a parts and accessories tax. If applied at the wholesale level, around 45,848 establishments could be taxpayers, considerably more than the number of major vehicle manufacturers.

Compliance Costs. Compliance costs would be relatively minimal for a vehicle sales tax levied at the manufacturer's sales price level, and not very onerous for a vehicle sales tax at a retail level or for a parts and accessories tax at the manufacturers' level. There would be no extra burden of time or paperwork for the vehicle purchaser.

By contrast, businesses' compliance costs could be substantial for a retail parts and accessories tax that would differ from a general sales tax. Separating sales by taxable versus nontaxable items would present a major compliance burden to establishments selling both automotive and nonautomotive items. We estimate compliance costs would be at least $1,400 to $2,800 per establishment per year for separating sales and accumulating records and filing tax forms.[30] At an average of $2,000 per filing firm, assuming 200,000 filers, compliance costs for the parts and accessories taxes would be around $400 million per year at the national level, and proportional to the number of such establishments at the state level. The parts and accessories yield of revenues, should it be dedicated to transportation, would not be large enough to make compliance costs acceptable.

Evasion. Evasion at the manufacturers' level should be a relatively minor issue, because the movement and initial distribution of new vehicles is well documented. We estimate that evasion of manufacturers' sales tax would be very low for vehicles, perhaps 1 percent to 2 percent.

Retail level vehicle sales tax evasion is a greater concern, because a large number of vehicle dealers exist, many of whom could have financial problems. A major issue is also whether the tax is paid by a corporation that stays in operation, given the uncertainties faced by such businesses as well as the opportunities to create "daisy chain" companies and phony records, under which tax is supposedly paid by a firm that later cannot be found when it is apparent the tax has not been paid.

Evasion at the retail level will present another major problem. Many outlets for automotive parts will be selling both taxable and nontaxable items. We estimate that without a very large effort to monitor and audit these establishments, the evasion of the sales tax on parts is likely to approximate 15 percent to 25 percent (the same estimate in percentage terms by FHWA for diesel fuel, for which very similar issues are faced—more than 200,000 taxpayers, both taxable and untaxable product or products being sold by the same establishments, and extreme pressures of competition on price). On the basis of previous experience with IRS and the states, the chances of developing a major auditing and enforcement program for minor (to IRS and state tax offices) tax sources are slim to none. Evasion, in addition to compliance costs, provides a major reason to target only an original vehicle sales tax at the manufacturers' level.

Administrative Cost and Issues. Sales taxes on new vehicles, if administered at the manufacturers' level, could require reporting and administration by fewer than 100 significant taxpayers. The administrative costs of such a tax would be almost

negligible. A retail sales tax, such as is collected on truck sales, could entail some major costs due to the larger number of selling entities.

Sales taxes on vehicle parts would present major administrative problems. First, in both legislating and administering such a tax, a determination must be made of what is taxable. Tracing and administering all items from all industries that produce products for automotive and nonautomotive uses would be complex. We estimate that administrative costs would be similar on a per taxpayer basis to the costs incurred to administer existing vehicle sales taxes, with similar evasion problems. For the federal government, that would imply around $200 million in administrative costs.[31] Because of the complexity of administration and the problems of evasion and compliance, parts and accessories taxes should rank very low on the list of potential sources.

Equity

Vehicle Class. A vehicle sales tax could be set at different rates for different classes of vehicles and to reflect cost responsibilities. However, there is little prospect of such vastly different rates to mirror the relative cost responsibilities of the different vehicle classes.

Income group. A vehicle sales tax places a lower proportionate burden on lower-income classes than motor fuel taxes or VMT or flat per vehicle use taxes.

Efficiency

Vehicle sales taxes provide no incentive for more efficient use of the transportation system.

Other

Ease of Implementation. A sales tax applied to autos and light trucks will be perceived as a new federal tax, despite its use in the past. Other fees and taxes could be reduced in return. The issue of additional taxes for heavier vehicles needs to be addressed in conjunction with greater reliance on sales taxes for federal revenues from lighter vehicles.

F.9 EMISSIONS FEES

Fees can be assessed on vehicles based on their emissions characteristics or their emissions characteristics adjusted by their miles of travel. An emissions fee can have a regulatory purpose in addition to raising revenue. The potential yields from emissions fees are substantial, therefore making these fees reasonable candidate sources of revenues for states or regions.

Emissions fees could be collected annually, which would reduce compliance costs, or collected on a nearly pay-as-you-go basis. The latter would involve a VMT meter being read by roadside or by using other transponders, with resulting emissions fees collected as a VMT fee would be collected, through a weekly, monthly, or quarterly payment.

Emissions fees could be assessed based on the manufacturer's certification information for a vehicle's engine family, or could be based on other inspection data for the engine family, possibly including an inspection of the individual vehicle.

It is likely that inspections of individual vehicles would occur only in air quality nonattainment areas. That would make a consistent federal emissions fee collected on the basis of the actual emissions experience of individual vehicles difficult if not impossible to enact.

A federal emissions fee is unlikely, because the emissions damages apply at regional or local levels. The federal government has provided for emissions reductions primarily through regulating new vehicles. CAAA and EPA also have an overview and approval concern with regard to other emissions strategies that states and localities develop. While it is likely that the federal government would approve the use of emissions fees as a control measure, direct federal fees would be considered as unlikely as direct federal implementation of other control measures.

Fees could also be limited to new vehicles, but that is an inappropriate strategy. New vehicles emit less than older vehicles, and fees on new vehicles would slow the retirement of older vehicles, thus delaying the improvement in air quality. A fee applied to all vehicles each year would, by contrast, provide an incentive to remove higher emitting vehicles from operation.

Adequacy

Consistency with the New Approach. Emissions fees will be highly consistent with the environmental objectives in the new approach. However, emissions fees are not as consistent with the mobility and economic objectives.

Adequacy and Tax Rate. Tax rates could be chosen along a very broad continuum, and emissions fees could yield very high revenues at the higher rates. There is no firm agreement as to the public health costs of emissions, as a way of setting a price on the externalities imposed by emissions. Costs vary substantially by area; areas with good air quality would have very low or insignificant costs of auto emissions; nonattainment areas could have very high emissions costs. One estimate of fee levels set on the basis of health and damage costs per unit of emissions suggests that fees per vehicle might range from $5 to $1,000, with an average of $125.[32] An average of $100 per vehicle would yield $18 billion, equivalent to all current revenues, if applied to 180 million vehicles.

Stability. Emissions fees will not be responsive to inflation or to VMT. As a result of continued tightening of standards, emissions have been declining, a process that could be accelerated by an emissions fee. Emissions fees could be adjusted annually to maintain revenues, but at some point the fees might exceed the costs of the health impacts of the pollutants.

Appropriateness of Dedication. Emissions fees are less appropriate for dedication than other fees.

Simplicity

Point of Taxation and Incidence. Emissions fees would be paid by vehicle owners, preferably annually. Commercial vehicle owners would pass on the costs. Lower-income vehicle owners would be hit harder than higher-income vehicle owners, both because of income availability issues and because lower-income persons are more likely to own older vehicles with higher emissions and to own light trucks, which for any model year typically emit significantly more than autos of the same age. Federal emissions standards through the 1980s have been more lenient for light trucks than for autos, despite the fact that 90 percent of light trucks are used for personal travel.

Compliance Costs. The emissions fee will require at least an annual inspection, requiring significant time for compliance. Two hours of taxpayer time per vehicle is an estimate for inspections. If applied to 180 million vehicles, at $10 per hour, or $20 per vehicle, compliance costs could total $3.6 billion per year. If administered as a federal vehicle or VMT weighted fee, the additional compliance costs estimated for those fees would also be incurred: $0.4 billion to $0.6 billion for user fees; and $5.9 billion to $8.0 billion in the first year (startup) and $1.1 billion to $1.6 billion annually thereafter for VMT fees. Total costs if applied to all vehicles would be $4.0 billion to $4.2 billion for emissions/user fees. For VMT/emissions fees, costs would be $9.5 billion to $11.6 billion in the first year, and thereafter $4.7 billion to $5.2 billion, if applied to all vehicles.

Evasion. Evasion will be highly dependent on the geographic breadth of application, and on the level of the highest fees. If all vehicles in a large state are subject to the fee and to inspection, and if fees per vehicle are low, evasion levels may also be low, similar to state registration fees (2 percent). If fees are steeply graduated, based on VMT, and applied locally, evasion due to misstating the place of registration, misstating VMT, or avoiding testing may exceed 10 percent.

Administrative Issues and Costs. Administration of emissions fees would require centralized inspection and testing of emissions at least annually. The current outcome of rule making by the Environmental Protection Agency on testing procedures is uncertain, although rules continue to be promulgated. If emissions testing were required for Clean Air Act implementation in nonattainment areas, there would be little additional administrative burden for collecting fees based on vehicles' emissions characteristics. If mileages are also to be used to collect fees, attention must be given to ensuring enforcement against tampering with vehicle odometers.

Equity

Beneficiaries of emissions fees include persons in areas where air quality is undesirable, those who benefit from expenditure of the fees, emissions-testing businesses, and manufacturers of lower-emissions vehicles. Emissions fees would be higher for those owning higher-emitting (older) vehicles, likely to include lower-income groups disproportionately. Among the income groups, lower-income households would probably be affected by emissions fees to a greater extent than for other vehicle use, fuel, sales, or VMT fees.

Emissions fees would raise the cost of travel and the revenues might be used for providing alternative travel modes for those who could not afford additional fees. However, if emissions fees were used for other purposes, there might be little correspondence between those who pay and those who benefit, except for the general assertion that clean air benefits the entire society.

Efficiency

Vehicle emissions fees could be set at levels that would discourage emissions up to the point at which the charges would equal net health benefits. Emissions fees could contribute to some aspects of economic efficiency, although they would not be directly related to other major efficiency concerns of pricing travel: congestion fees or pavement damage fees.

Other

Ease of Implementation. Emissions fees have difficulties for federal implementation, due to the local nature of air quality issues. There are few if any technical barriers to implementation. There are no state or regional emissions fees in place, although there is interest in several regions, including Los Angeles, which has the most dramatic emissions problems.

F.10 MAJOR TAXES WITH LITTLE PROSPECT OF DEDICATION TO TRANSPORTATION

A few potential taxes could provide large amounts of revenue, but have little likelihood of being dedicated to transportation programs. They are therefore treated here in much less detail than the major sources that could be adequate and are likely candidates for dedication to transportation.

F.10.1 Value-Added Tax on Vehicles and Parts

A value-added tax is collected at each stage of production or sale. Because the tax due is based on the amounts of the firms' product for which value-added taxes have not yet been paid, the purchaser of goods or services has an interest in determining that value-added taxes have been paid by suppliers. It would be very difficult to separate value-added taxes for transportation activities from all other value-added taxes and deposited into transportation funds at any level of government.

Although value-added taxes could be imposed by states, it is highly unlikely because of their highly innovative nature and the interrelationships of the national economy.

Adequacy

Consistency with the New Approach. Value-added taxes are not consistent with the new approach.

Adequacy and Tax Rate. Value-added tax rates can be set at almost any level. They are unlikely to be dedicated to transportation and thus may not provide for an adequate revenue source.

Stability. This tax will be relatively stable and will likely fluctuate with VMT. If set as a percentage, it will respond directly to inflation.

Appropriateness of Dedication. It is unlikely that any portion of a federal value-added tax would be separated and devoted to surface transportation.

Simplicity

Point of Taxation and Incidence. The value-added tax is paid by all businesses on the differences in prices for the businesses between what they buy and what they sell. The incidence of the value-added tax on automotive and truck-related products is approximately similar to that of the sales taxes on both vehicles and parts taken together.

Compliance Costs. Compliance costs to businesses will be substantial and will be somewhat greater than the costs of retail sales taxes, once experience has been gained by U.S. businesses in dealing with these tax sources.

Evasion. The United States has no experience with this tax.

Administrative Issues and Costs. The United States has no experience with this tax.

Equity

Value-added taxes will not be equitable among vehicle types. They will be fairly similar to vehicle and parts sales taxes, which are relatively flat on a per mile basis among vehicle types, ignoring the fact that cost responsibility per mile is much higher for heavier vehicles. Value-added taxes will apply less to lower-income groups than other taxes such as fuel, vehicle use, or VMT taxes.

Efficiency

A value-added tax will not provide incentives to use transportation facilities more efficiently.

Other

Ease of Implementation. A broad-based tax such as a value-added tax will be perceived to apply to all businesses, and substantial opposition can be anticipated.

F.10.2 Carbon Tax or Btu Tax or Ad Valorem Energy Tax

These taxes would be set on the carbon content, energy content, or value of fuels used. A tax on Btus was proposed by the Clinton administration, with a level of $0.599 per million Btus for oil and $0.257 per million Btus for coal, natural gas, and nuclear power. Hydroelectric power would be taxed according to the average Btu content of fossil fuels used in conventional power plants to produce equivalent power. Estimates presented by the Energy Information Administration, Citizen Action, and the *Washington Post* were that this tax would cause average family expenditures for gasoline to rise by $73 per year, and average family expenditures for household heating to rise by $71 for oil, $44 for natural gas, and $40 for electric heat.[33] Of course, prices for other goods also would increase because of the impact of energy costs.

The Clinton administration proposal did not allocate any of the proceeds of this tax to the transportation trust fund accounts, and we do not anticipate that such a tax, if enacted, would dedicate any revenues to surface transportation.

F.10.3 General Sales, Income, and Property Taxes

These sources provide very large amounts of revenues, and are currently used, with or without dedication, for highway and transit purposes. Applications of these taxes at the local level are too widespread to document fully. Most local governments support both highway and transit programs with property taxes mixed with a variety of other revenue sources. State and local general funds rely substantially on sales taxes. Income taxes are used in most states for general revenue purposes.

Variations are, of course, substantial, although it is very noteworthy that motor vehicle and motor fuel taxes are among the few universally applied taxes, in addition to property taxes.

For either highways or public transit, dedication of sales, income, or property taxes will depend largely on making effective arguments on traditional public finance grounds: i.e., that highways and/or transit are more deserving than other public needs. These tax sources are targets of local or state opportunity, unrelated to their relationship to surface transportation.

Adequacy

Consistency with the New Approach. These taxes are not consistent with the new approach.

Adequacy and Tax Rate. These taxes can be set at almost any level and can yield very high revenues.

Stability. Overall revenues from sales, income, or property taxes will not be responsive to vehicle activity but will be responsive to inflation.

Appropriateness of Dedication. It is unusual for portions of such taxes to be separated and devoted to surface transportation accounts, although such dedication would be appropriate and has been achieved.

Simplicity

Point of Taxation and Incidence. Each of these taxes applies to the individual household or business.

Compliance Costs. Compliance costs to households and businesses will be fairly nominal because they already pay these taxes.

Evasion. These taxes should have fairly low opportunities for evasion, except for income taxes.

Administrative Issues and Costs. Administrative costs are likely to be similar to those incurred today.

Equity

These taxes will not be equitable among vehicle types. Their incidence on income groups will be the same as today.

Efficiency

These taxes are not related to efficient use of facilities.

Other

Ease of Implementation. A broad-based tax will be perceived to apply to all households and businesses, and substantial opposition can be anticipated.

ENDNOTES

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29. MVMA Statistics, 1991, indicates that total U.S. new auto and light-truck sales ranged from around 11 million to around 16 million per year during the 1980s.
30. Estimate is based on the compliance cost estimate of this amount in 1986 for the existing federal vehicle sales tax on heavy trucks, as contained in *The Feasibility of a National Weight-Distance Tax, op cit.,* 1988. The 1986 figures have not been adjusted for inflation, because rapid computerization of private, state, and federal recordkeeping is assumed to have held down costs of compliance and administration.
31. Estimate is based on the United States Department of Transportation estimate in *The Feasibility of a National Weight-Distance Tax* (1988) of $2 million in 1986 to administer the heavy-vehicle sales tax, with 2,000 to 4,000 filers, and assuming 100 times as many filers.
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