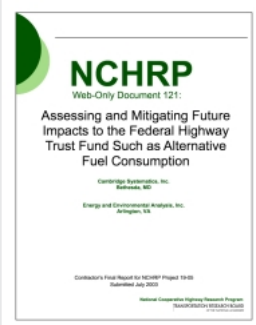


# Assessing and Mitigating Future Impacts to the Federal Highway Trust Fund Such as Alternative Fuel Consumption

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# ACKNOWLEDGMENTS

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# SUMMARY

The Federal Highway Trust Fund provides funding for transportation improvements, including 100 percent of Federal funding for highway improvements and about 60 to 70 percent of Federal funding for transit improvements. The major funding source for the Highway Trust Fund is the Federal tax on motor fuels. In FY 2000, Federal taxes on motor fuels provided about $24.5 billion in revenue out of the total $30.3 billion deposited into the Highway Trust Fund.

There are a number of initiatives that might affect future Highway Trust Fund revenues. These include:

- Restoring the lost revenues from the Federal subsidy for the use of gasohol in the place of petroleum-based motor fuels (5.3 cents per gallon);
- Redirecting the 2.5 cents of the tax on gasohol that is currently deposited into the Federal General Fund to the Highway Trust Fund;
- Examining the legal prohibition in some states against using methyl tertiary butyl ether (MTBE) as an additive to petroleum motor fuels; and
- Studying hybrid vehicles that use a combination of electric and traditional motor fuel propulsion systems that are now in production with a significant number of vehicle models planned in the near term.

Usage of alternative fuels for transportation, including gasohol, is generally encouraged, and current tax mechanisms and other subsidies provide incentives for alternative fuel use. The Highway Trust Fund, however, is dependent upon use of petroleum-based motor fuels. For each increment of 1.0 billion gallons in the consumption of gasohol (usually 10 percent ethanol and 90 percent gasoline), the Highway Trust Fund will forego $78 million in revenue. The impact of alternative fuels has already created a major threat to the primary funding source for transportation improvements by the Federal government under the current revenue structure.

According to the U.S. Department of Energy's (DOE) official forecast, the Alternative Energy Outlook (AEO):

- Fuel consumption is forecast to increase for all types of fuels. The increases in fuel consumption will be associated with increased revenues associated with each fuel type. This is true through the reauthorization period (2004 – 2009) and through 2020.
- Continued increases in fuel consumption will translate directly into higher amounts of revenue going into the highway and mass transit accounts of the Federal Highway Trust Fund through the reauthorization period and 2020.

- In the case of ethanol or gasohol, increased consumption could reduce revenues by reducing the taxes that would be paid on the gasoline portion of the blend if it were marketed as pure gasoline.

The AEO represents the base-case forecast from which scenarios of future fuel use and corresponding revenues are derived. Scenarios for future fuel use were developed by Energy and Environmental Analysis (EEA) based on expert analysis of potential issues. The scenarios screened in this study include those of high, medium, and low probability. Each high probability scenario was analyzed in detail with regard to the impacts on fuel consumption and fuel tax revenues in comparison to the base case by 2010 and 2020. Medium and low probability scenarios were analyzed in less detail.

The scenario analysis for this study has shown that, while there are serious threats to the continued usefulness and stability of motor fuel taxes, those threats are not unlimited, nor are they likely to have major impacts over the reauthorization period. There are, however, several potential factors of concern to transportation agencies. Agencies need to be prepared to respond to all factors, and will need to refine and manage revenue sources and revenue collection programs to avoid adverse impacts on highway and transit revenues.

- Increases in ethanol consumption could degrade the Highway Trust Fund by as much as $4.0 billion per year. Changing the existing treatment of ethanol/gasohol to eliminate subsidies out of transportation revenues could add a significant amount of $1.0 billion to $2.0 billion per year.

- Because the impacts on revenues due to fuel efficiency changes will require changes in the vehicle fleet, which has average useful lifetimes of more than 10 years, fuel efficiency impacts on revenues will be low in early years and cumulative over time. However, because there is no reasonable way for transportation agencies themselves to be against improved fuel efficiency, the long-term goal for revenue programs should be to move away from reliance on fuel consumption, if that can be done without negatively impacting revenues.

- Alternative fueled vehicles that are powered by fuels such as hydrogen, pure electric (battery only), natural gas, and other currently uncommon fuels have very low or extremely low probabilities of entering the vehicle fleets during the reauthorization period or by 2020. As a consequence, there is no current pressing need to develop procedures and methods to assure that fees are collected from such vehicles. An eventual change to a different tax source from motor fuels would render this issue moot. Fees collected (based on roadway system usage) have several advantages over motor fuel taxes, and should be considered as a long-term approach to financing transportation.

**CHAPTER 1**

# INTRODUCTION AND RESEARCH APPROACH

## PROJECT STATEMENT 19-05, FY 2003

The Federal Highway Trust Fund provides funding for transportation improvements, including 100 percent of Federal funding for highway improvements and about 60 to 70 percent of Federal funding for transit improvements. The major funding source for the Highway Trust Fund is the Federal tax on motor fuels. In FY 2000, Federal taxes on motor fuels provided about $24.5 billion in revenue out of the total $30.3 billion deposited into the Highway Trust Fund.

There are a number of initiatives that could affect future Highway Trust Fund revenue. These include:

- Restoring the lost revenues from the Federal subsidy for the use of gasohol in the place of petroleum-based motor fuels (5.3 cents per gallon).
- Redirecting the 2.5 cents of the tax on gasohol that is currently deposited into the Federal General Fund to the Highway Trust Fund.
- Examining the legal prohibition in some states against using methyl tertiary butyl ether (MTBE) as an additive to petroleum motor fuels – MTBE is an additive to petroleum motor fuels used to meet Clean Air Act standards; MTBE is taxed as petroleum-based motor fuels. The only current alternative to MTBE is gasohol, which includes a Federal subsidy as noted in the previous bullet.
- Studying hybrid vehicles that use a combination of electric and traditional motor fuel propulsion systems that are now in production, with a significant number of vehicle models planned in the near term. These vehicles can average in excess of 50 miles per gallon, which will reduce the consumption of petroleum-based motor fuels. While not in mass production, these vehicles are beginning to appear on the nations' highways and could grow to become a significant portion of the market in the future.

Usage of alternative fuels for transportation, including gasohol, is generally encouraged, and current tax mechanisms and other subsidies provide incentives for use. The Highway Trust Fund, however, is dependent upon use of petroleum-based motor fuels. In 1999, 14.3 billion gallons of gasohol were consumed out of a total of 162.9 billion gallons of all types of motor fuels. The "diversion" from the subsidy and the lower tax rates on gasohol, was about $1.0 billion in

2000. For each increment of 1.0 billion gallons in the consumption of gasohol, the Highway Trust Fund will forego $78 million in revenue. The Federal Highway Administration (FHWA) has reported the actual consumption in comparison to the U.S. Treasury forecast in Federal FY 2001 was 28 percent more than the forecast for gasohol and nine percent less than the forecast for petroleum-based motor fuels. This was a contributing factor in the reported drop of the collections in the Highway Trust Fund by more than 10 percent for Federal FY 2001 in comparison to 2000. The impact of alternative fuels has thus already created a major threat to the primary funding source for transportation improvements by the Federal government under the current revenue structure.

The objectives of this research project are to:

- Define the impact of the use of alternative fuels and other products that resulted in the reduced consumption of petroleum-based motor fuels;
- Assess the extent of increased use of alternative fuels and the reasons for the increased use where present;
- Identify and apply procedures to forecast use of alternative fuels in FY 2002 through FY 2009 and beyond; and
- Prepare a report presenting findings and recommendations for agency staff.

Recent data reflect that increased use of alternative fuels is occurring much faster than forecasted in previous years. This increase has created a significant negative impact on revenue levels deposited in the Federal Highway Trust Fund. This results in the reduction of funds available for transportation improvements in Federal FY 2003 and in years beyond. It also sets a new lower baseline for Highway Trust Fund revenue estimates just one year prior to beginning the debate on the reauthorization of TEA-21. It is essential that options be researched and prepared in a timely manner to be debated as part of the reauthorization of TEA-21 in 2003 to help ensure a solid level of funding is provided for transportation improvements in relationship to the use of the transportation system.

# RESEARCH APPROACH

Research for this study was divided into five tasks:

1. Assemble current information on the factors influencing motor fuel tax revenues.
2. Identify and analyze factors influencing increased use of alternative fuels and other factors impacting revenues.
3. Forecast future use of alternative fuels and fuel consumption impacts of other factors.

4. Develop recommendations.

5. Prepare draft and final reports.

## Task 1 – Assemble Current Needed Information

Current sources of information on alternative fuels and fuel efficiency and other threats or potential developments were surveyed and assessed with regard to the potential revenue impacts. The research team updated their sources of currently available information through a literature search and through contacts with other experts in the field of alternative fuels and factors impacting revenues. Team member Energy and Environmental Analysis, Inc. (EEA) led this task based upon their involvement in the very latest research sponsored by the Department of Energy (DOE) and the automotive industry on alternative fuels and other factors impacting on future fuel efficiency. The state of knowledge was summarized by EEA with regard to the current usage of alternative fuels and important legislation and market forces that are underway, emerging, or being considered. An initial memo covering these items and Task 2 was circulated in October 2002, and the substantive findings of that memo are summarized in Chapter 2 of this report.

## Task 2 – Identify and Analyze Factors Influencing Increased Use of Alternative Fuels and Other Factors Impacting Revenues

Research published by DOE documents the factors influencing the use of alternative fuels as mainly regulatory and economic. Use of alternative fuels and subsequent revenues from alternative fuels may be impacted through subsidy policies and/or or voluntary or mandated implementation of fuel economy technology. To identify and analyze factors influencing increased use of alternative fuels and other factors impacting revenues, both regulatory and economic forces were considered, and expertise was applied on forecasting and estimating the probabilities of the possible outcomes. EEA supplied the expertise required to estimate the probabilities of particular possible futures in terms of fuel efficiency and fuel types. EEA based these probabilities on research performed for the National Academy of Sciences (NAS) on its recent fuel economy study, and on their recent support to the U.S. Department of Transportation (DOT) on its congressionally mandated review of Corporate Average Fuel Economy (CAFÉ). EEA utilized its detailed knowledge of alternative fuel vehicle characteristics in terms of their price, fuel economy, and attributes in determining the likely probabilities of outcomes in the near term and through 2020. The potential factors qualitatively analyzed included a number of alternative fuels, the primary factors influencing fuel economy, and potential legislative, regulatory, and market factors.

The team utilized its previous work on the analysis of revenue alternatives to organize the information necessary to transform the estimated impacts into quantitative forecasts of fuel consumption and forecasts of Federal revenues. The team evaluated the use of the FHWA and DOE models for potential use in Task 3. DOE models were determined to be significantly more sophisticated and up-to-date. After the review of the models in this task, the research team determined that DOE models would be used to quantify the fuel usage forecasts of potential scenarios. Project resources were reallocated to allow EEA to utilize the range of DOE models that were determined to be most useful.

## Task 3 – Forecast Future Use of Alternative Fuels and Fuel Consumption Impacts of Other Factors

The team utilized the available DOE model systems to evaluate the scenarios as described qualitatively in the first two tasks, and identify them as medium to high probability. The focus was on evaluating the parameters that will matter the most to the estimates of revenues as a result of alternative fuel use and of overall motor fuel consumption. Fuel consumption forecasts for light and heavy-duty vehicles utilized the models or procedures developed for the DOE, the auto industry, and DOT CAFÉ analyses.

Potential changes were evaluated and are included in an overall forecast for 2010 and 2020 for alternative fuels, alternative fueled vehicles, and fuel efficiencies. The forecasts identify the probabilities of outcomes, rather than presenting simply a single mean or best estimate forecast. There is considerable uncertainty over the potential factors, including not only the future legislative background and state of technologies, but also over the more mundane determinants of markets such as the prices of petroleum fuels and of alternative fuels. These uncertainties were ranked and forecast quantitatively accordingly.

## Task 4 – Develop Recommendations

In this task, the team identified draft recommendations to deal with the potential impacts of alternative fuels use and subsequent impacts on revenues. Fortunately, those potential impacts with the greatest adverse consequences for revenue streams are longer-term due to the nature of the vehicle system, in which fleets turn over very slowly. Thus, changes in fuel efficiencies or fuel types that have impacts on revenues are cumulative over time rather than immediate. The findings, elaborated upon below, also indicate that the most serious potential threats to revenues are very low probability in the next decade, such as from widespread use of fuel types (fuel cells, natural gas, and pure electric) that are outside of the current revenue collection system.

## Task 5 – Prepare Draft and Final Report

For this task, the draft final report was prepared, the reviewed by the panel, and the final report was published based on panel feedback.

**CHAPTER 2**

# FINDINGS

## U.S. DOE's BASE-CASE PROJECTIONS

Table 1 shows the observed and projected consumption of current fuel types, from the U.S. DOE's official forecast, the Alternative Energy Outlook (AEO). This constitutes the base-case forecast from which scenarios of various probabilities are derived. The current estimates and future forecasts shown in Table 1 provide the overall national context or what is currently anticipated with regard to motor fuel consumption and motor fuel revenues.

### Table 1 2000 and AEO Projected 2010 and 2020 Fuel Consumption by Fuel Type

| Type of Fuel | 2000 Fuel Use (Billion Gallons per Year) | 2010 Fuel Use (Billion Gallons per Year) | Percent Change (2000 – 2010) | 2020 Fuel Use (Billion Gallons per Year) | Percent Change (2000 – 2020) |
|---|---|---|---|---|---|
| Diesel Fuel (Distillate) | 29 | 44 | 52% | 54 | 86% |
| Motor Gasoline (includes gasohol) | 120 | 143 | 19 | 164 | 37 |
| Liquefied Petroleum Gas | 0.5 | 1 | 100 | 1.1 | 120 |
| Ethanol (E85) | 0.5 | 1.2 | 140 | 1.4 | 180 |
| (Adjusted Case) | 1.4 | 5.0 | 257 | 5.0 | 0 |
| Methanol | 0.1 | 0.4 | 300 | 0.4 | 0 |
| Hydrogen | 0 | 0 | – | <0.01 | 0 |

A key finding is that in the base case, fuel consumption is forecast to increase over the reauthorization period. Gasoline use is projected to increase by 23 billion gallons per year, just short of a 19 percent increase between 2000 and 2010. Projections for all other fuel type show increases over 2000 consumption. These increases in fuel consumption will translate directly into higher amounts of revenue going into the highway and mass transit accounts of the Federal Highway Trust Fund through the reauthorization period and 2020. Table 2 shows the nominal impacts on the Highway Trust Fund motor fuel tax revenues for the forecasts shown in Table 1. More specifically:

- Diesel fuel is projected to increase by 15 billion gallons per year by 2010, a 52 percent increase over 2000.

- Liquefied petroleum gas (LPG) is projected to double, but still to constitute only 1.0 billion gallons per year or less than one percent of gasoline consumption.

- Ethanol, used in gasohol, is projected to more than double by 2010, and methanol to quadruple. The adjusted case shown in Table 1 is the case if ethanol increases to 5.0 billion gallons per year because of legislation.

- Hydrogen use is projected to go from near zero to a very small quantity by 2010.

- Other factors, such as inflation and the backlog of needs for highway and public transportation investment, are relatively major finance concerns that are not addressed in these forecasts of fuel consumption.

## Table 2 Gross Revenues from Motor Fuel Types – Base Case 2000 and Forecasts 2010, 2020

| Fuel Type | Gross Revenues 2000 ($ Billions) | Gross Revenues 2010 ($ Billions) | Gross Revenues 2020 ($ Billions) | Change 2000-2010 ($ Billions) | Change 2000-2020 ($ Billions) |
|---|---|---|---|---|---|
| Gasoline | $22.0 | $26.2 | $30.0 | $4.2 | $8.0 |
| Diesel | 7.0 | 10.7 | 13.1 | 3.7 | 6.1 |
| LPG | 0.06 | 0.12 | 0.13 | 0.06 | 0.07 |
| Ethanol (using adjusted estimates) | -1.1 | -3.9 | -3.9 | -2.8 | -2.8 |
| Methanol | 0.01 | 0.04 | 0.04 | 0.03 | 0.03 |
| Hydrogen | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Totals** | **$28.0** | **$33.2** | **$39.4** | **$5.2** | **$11.4** |

The base-case projections indicate that Highway Trust Fund accounts can support continued increases in Federal outlays over the periods through 2010 and 2020. The gasoline tax, at 18.3 cents per gallon (plus 0.1 cents for leaking underground storage tanks) will yield more than $4.2 billion more per year by 2010 than 2000. The diesel tax, at 24.3 cents per gallon, will yield more than $3.6 billion more per year by 2010 than in 2000. Thus, the base case as forecast by the U.S. DOE is that the Federal Highway Trust Fund accounts will continue to increase with modest but healthy growth because of increased consumption of gasoline and diesel fuels. This translates to an increase of $8.0 billion per year by 2010 in outlays for highways and transit from the impacts of the forecasted increases in diesel and gasoline use.

In Table 2, the adjusted (pessimistic) case is used to predict ethanol-related revenues. Increases in ethanol consumption will temper the beneficial impacts on revenues of the increases in gasoline and diesel use. Due to current ethanol subsidies, a doubling of ethanol consumption by 2010 will involve a doubling of current losses due to ethanol subsidies. Thus, if the current loss is $1.0 billion annually, by 2010, the loss because of ethanol subsidies will double to $2.0 billion annually under current conditions. The revenue available will thus be only $7.0 billion greater annually by 2010 instead of $8.0 billion greater if ethanol consumption did not also increase, unless changes are implemented to eliminate the subsidy for ethanol from trust fund revenues. Currently, there is a multitude of proposals to move the Federal ethanol subsidy from the Highway Trust Fund accounts to the general accounts. Should these come to fruition, the trust fund accounts would have about $9.0 billion more per year of income by 2010 (a gain of $2.0 billion per year for these base-case projections).

The nominal impacts on revenues are not necessarily equivalent to revenues that are deposited into the Highway Trust Fund accounts by treasury each year because there is a lag. In terms of the losses of revenues because of alternative fuels, these are eventually distributed among the states in relation to their relative apportionments of motor fuel taxes and of overall Federal aid. Under current procedures including RABA and the adjustments to funding levels and apportionments that can occur when Congress takes additional actions (such as in FY 2003), there can be some time lag and also some partial disconnect between the impacts of alternative fuels on consumption and revenue collections and the impacts on the states' annual funding streams. However, in overall terms, any loss of revenue because of alternative fuels or other factors will eventually translate into virtually an equivalent loss in expenditures. For the current fiscal years, the primary loss of revenues is because of the different treatment of gasohol and ethanol, which are significant portions of motor fuel consumption. The impacts of natural gas, pure electric vehicles, hydrogen vehicles, and other alternative fueled vehicles are at present negligible.

## Fuel Taxes by Fuel Type

Table 3 shows the current fuel tax rates applied at the Federal level, and the distribution of funds that accrue from Federal fuel taxes. Subsequent revenues accrue to the highway and mass transit accounts. In general, the rates are set to establish equivalency with gasoline taxes, except in the case of ethanol and gasohol. The concern with some fuels, such as liquefied petroleum gas (LPG) and compressed natural gas (CNG), is their widespread use for other purposes and the consequent ease of obtaining and using product for highway use on which Highway Trust Fund taxes have not been paid. These issues of tax evasion also exist for gasoline and diesel fuel, but substantial efforts have been devoted by the Federal government and state governments to minimize fuel tax evasion.

**Table 3 Motor Fuel Excise Tax Rates and Their Disposition**

| Types of Fuel | Tax Rate (Cents Per Gallon) | Disposition of Motor Fuel Tax (Cents Per Gallon) | | | |
|---|---|---|---|---|---|
| | | Highway Trust Fund | | Leaking Underground Storage Tank Trust Fund | General Fund |
| | | Highway Account | Transit Account | | |
| **Gasoline and Diesel** | | | | | |
| Gasoline | 18.4 | 15.44 | 2.86 | 0.1 | |
| Diesel | 24.4 | 21.44 | 2.86 | 0.1 | |
| **Alternative Fuels Taxes** | | | | | |
| Gasohol | 13.1 | 7.64 | 2.86 | 0.1 | 2.5 |
| Liquefied Petroleum Gas | 13.6 | 11.47 | 2.13 | | |
| Liquefied Natural Gas | 11.9 | 10.04 | 1.86 | | |
| M85 (from natural gas) | 9.25 | 7.72 | 1.43 | 0.1 | |
| Compressed Natural Gas (cents per 1000 cu. ft.) | 48.54 | 38.83 | 9.7 | | |

# ISSUES EXAMINED AND THEIR IMPLICATIONS FOR REVENUES

In 2001, the Office of Management and Budget's mid-session review lowered the estimates of projected revenues to the Highway Trust Fund based on lower than expected gasoline tax receipts and truck taxes (especially truck sales), and higher than expected use of gasohol. These revised estimates resulted in an $8.6 billion proposed reduction in payments from the Federal Highway Trust Fund highway account to the states. Although a significant portion of this $8.6 billion has been restored, the revised estimates for FY 2003 have focused attention on the long-term viability of a Federal Highway Trust Fund that is based largely on taxes on petroleum-based motor fuels. The fund's future revenues from petroleum-based taxes will be a function of the total amount of petroleum-based fuel that is used on the highways.

The projection of most importance to the Highway Trust Fund is the continued dominance of gasoline and diesel. Gasoline consumption is projected to rise 37 percent between 2000 and 2020, with diesel consumption projected to rise 86 percent in the same time period (Table 1). In the baseline projections, alternative fuels are not projected to make significant inroads into petroleum's dominance of the transportation sector within the next 20 years. The primary factors of greatest concern include subsidy structures and consumption of ethanol and gasohol, fuel efficiency and vehicle fuel economy, alternative fuels, as well as increased use of diesel and supply-side disruptions.

## Ethanol and Gasohol

Ethanol is a fuel derived from biomass (usually corn), and has been promoted for highway usage in the United States for several reasons. It is seen as a "green" fuel as it is renewable, it subsidizes agricultural interests, and it can be produced in the United States, which is the world's largest producer of corn. These rationales have resulted in ethanol receiving very generous government assistance. Ethanol (the alcohol or non-gasoline portion of gasohol) currently receives a Federal excise tax exemption of 53 cents per gallon, which is scheduled to decline to 52 cents in 2003 and 51 cents in 2005. Legal authority for the Federal tax exemption expires in 2007, but because the exemption has been renewed several times since, it was initiated in 1978. Blending gasoline with ethanol is also encouraged by tax incentives in 17 states to help bolster agricultural markets. Without these tax incentives, ethanol (under many circumstances) could not compete with gasoline, with a wholesale plant gate cost of about $1.25 per gallon, in comparison to gasoline's 80 cents in late 2002. These comparisons are subject to variations as production and market prices for each fuel type change.

The most common ethanol blend is gasohol – a 10 percent ethanol to 90 percent gasoline. This blend is given a 5.3-cent per gallon tax exemption (based on the percentage of ethanol). An additional impact of ethanol on the Highway Trust Fund is that 2.5 cents of the tax received per gallon currently goes to the General Fund for deficit reduction purposes, rather than the Highway Trust Fund. For every billion gallons of gasohol sold in place of gasoline, Highway Account receipts are approximately $78 million lower.

Ethanol can be also be used by some vehicles as a blend called E85 (85 percent ethanol, 15 percent gasoline). There are, at present, more than two million light-duty vehicles (LDVs) on the road in the United States (more than 90 percent trucks) that are "flex-fuel" vehicles (i.e., they can run on gasoline or E85). These are sold largely because of Corporate Average Fuel Economy (CAFÉ) credits that are available for selling alternative fuel vehicles, and their E85 capabilities are currently unused. This occurs because at present E85 is rarely available, but this could obviously change if ethanol usage increases for any reason.

There are current proposals that the 2.5 cents of the tax collected on gasohol that currently goes to the general fund for debt reduction will instead be redirected to the Highway Trust Fund. Other provisions could also act to increase the price competitiveness of ethanol and will increase its usage. One bill (the National Energy Policy Act) further increases the tax credits that are now available for E85 while retail facilities that install a system to sell E85 receive a tax credit of up to $30,000.

The Senate Energy Bill Fuels Agreement, a provision within the National Energy Policy Act, mandates the elimination of methyl tertiary butyl (MTBE) within four years. MTBE has been used in U.S. gasoline at low levels since 1979 to replace lead as an octane enhancer. Since 1992, MTBE has been used at higher concentrations in some gasoline to fulfill the oxygenate requirements set by Congress in the 1990 Clean Air Act Amendments. Because of concerns regarding the health effects of MTBE, it is being eliminated, and ethanol is the most likely substitute oxygenate.

In addition to the fuels agreement, the Renewable Fuels Standard (RFS) provision requires a gradual and increasing percentage of renewable fuels, including ethanol, growing to five billion gallons per year by 2012 – current consumption is approximately 1.7 billion gallons per year. Although most of this increased production will go towards substituting MTBE, once the ethanol is blended with the gasoline the gasohol tax exemption kicks in, reducing the flow of funds to the Highway Trust Fund.

The AEO base case assumes that the oxygenate requirements will be maintained and incorporates an MTBE ban or reduction legislation that has already been passed in 13 states. As a result, the amount of MTBE used by domestic refiners is projected to be cut in half by 2004, from 3.8 billion gallons per year in 2000 to 1.9 billion. Nearly three-quarters of the projected decline in MTBE consumption results from a ban on MTBE in California, which was scheduled to begin at the end of 2002 (but has since been delayed until the end of 2003). The need to maintain oxygen and octane levels and to offset some of the volume loss associated with MTBE removal results in a projected national increase in ethanol blending of 2.5 billion gallons per year in 2004 from the 2000 level of 1.6 billion gallons per year.

AEO projects ethanol flex-fuel vehicles to continue selling at a rate of approximately 26,000 per year to 2020, while pure ethanol-powered vehicles only have projected sales of about 100 for the same period. These numbers appear to be in error as flex-fuel vehicles are currently sold at volumes of more than 200,000 per year.

The Energy Information Administration (EIA) also has a "Federal MTBE ban case" that assumes that MTBE and other ethers cannot be blended into gasoline after 2005. In the Federal ban case, it is projected that the remaining 1.9 billion gallons per year of MTBE blended in gasoline between 2006 and 2010 would be eliminated, with an associated increase of 1.1 billion gallons per year in ethanol consumption. Given the provisions within the Energy bill, about 3.6 billion gallons of ethanol per year would be used to substitute for MTBE once the bans take effect. A recent study by the California Energy Commission estimated future potential ethanol production in the United States and found that existing industry could produce only 2.8 billion gallons per year. New entrants would add an additional 1.5 billion gallons capacity by 2005, bringing total U.S. ethanol production capacity to 4.4 billion gallons per year.

At present, all ethanol is produced using corn as the feedstock. An alternative production method for cellulosic ethanol uses agricultural waste and other biomass as feedstock, which raises the possibility of greatly reduced costs for ethanol production. The National Renewable Energy Laboratory (NREL) estimates that sufficient biomass is produced in the United States to produce 20 billion gallons of cellulosic ethanol per year. In the event that cellulosic ethanol was to come to market, the impact on the Highway Trust Fund would presumably vary over time. Initially, the product would likely receive similar tax credits as conventional ethanol having a detrimental impact on the Highway Trust Fund.

In the event of greatly increased ethanol production, particularly if cellulosic ethanol matures into a viable industry, then an increase in E85-powered vehicles is a possibility. This is more likely to occur earlier in states that are large ethanol producers, as these states will benefit from avoiding the costs of transporting the ethanol.

## Fuel Efficiency and Vehicle Fuel Economy

The FHWA estimates that for every one mile-per-gallon increase in fuel efficiency, the Highway Trust Fund loses about $3.5 billion in revenue. After a sharp increase in LDV fuel economy between 1975 and 1985, there has been a gradual decrease between 1985 and 2001, while heavy-duty trucks (HDTs) have seen almost continuous increases in fuel economy since 1984. This section examines the likelihood of a significant deviation from these trends in the pre-2010 timeframe.

The United States is the world's largest importer of oil, and domestic supplies and production have been declining. This economic reason alone has made fuel economy resurface regularly as a balance of payments and political issue. Two related prominent issues have served to increase present attention on fuel economy. First, energy security issues have come into focus as events in the Middle East serve to raise a question mark over the supply of crude oil. Second, increasing concern over global warming has led almost all other national governments to make commitments to reduce the emissions of greenhouse gases.

Although the United States has not signed the most significant of these commitments, the Kyoto Protocol, there is continuing domestic pressure to address the issue of greenhouse gas emissions. This is manifest in the recently enacted legislation by the California Assembly that would require the Air Resources Board (CARB) to regulate the "maximum feasible" reductions in greenhouse gas emissions by passenger cars and light-duty trucks (LDTs). In the United States, the current debate is over whether and by how much emission should be reduced and whether voluntary or mandatory measures should be utilized.

A significant increase in fuel economy may occur through one or more of the following ways:

- Congress could mandate an increase in CAFÉ standards.
- Auto manufacturers could take voluntary steps to increase the fuel economy of their cars, trucks, and SUVs; this could be a result of competitive pressures or an attempt to head off mandated increases.
- Hybrid vehicle technology could become more wisely utilized, which could occur under either the mandatory or the voluntary scenarios above. Hybrid technology is achieving limited market penetration at present. This technology offers fuel economy gains of 40 to 50 percent and, if sales of these vehicles was to take off more rapidly than expected, this could significantly raise fuel economy for LDVs and some freight trucks.
- If the greenhouse gas legislation passes, it could have an impact similar to that of raising CAFÉ standards significantly. Under the Clean Air Act, California has the ability to set its own automobile emission standards, and other states tend to follow California's lead. The prospects for this legislation and its likely implications are very hard to determine at present.

Any of these four possibilities would have the effect of raising fuel economy thereby reducing the flow of revenue to the Highway Trust Fund. The discussion below highlights the current prospects with regard to fuel economy for LDVs and heavy-duty vehicles, because these are somewhat separate markets with regard to existing and prospective fuels and technologies.

### *Light-Duty Vehicles (Automobiles, Light Trucks, and Sport Utility Vehicles)*

The past few years have seen a number of bills intending to raise CAFÉ standards proposed in both the House and the Senate. These bills have ranged from proposing removing the light-truck and car distinction and increasing fuel economy by 33 percent by 2007 (the Automobile Fuel Economy Act: S.804), to another bill proposing raising all CAFÉ standards to 36 mpg by 2016. All of the bills aimed at raising CAFÉ have, for the moment, been defeated. A small increase in fuel economy standards for light trucks and SUVs has been mandated.

In 2001, with funding from the U.S. DOT, the National Academies published a study on CAFÉ standards and their findings, which included estimates of cost-effective fuel economy gains under a variety of assumptions. These gains ranged from a 21 percent gain for subcompact cars in the low technology cost scenario, to 49 percent for large SUVs under the same assumptions. The average cost scenario cost-effective fuel economy gains are shown in Table 4. In the event that Congress does raise CAFÉ standards, it is reasonable to assume that the new standards would increase by 25 to 30 percent, consistent with the fleet weighted averages from the National Academies study.

## Table 4 Cost-Effective Fuel Economy Levels for 2013 (14-Year Payback Period, 12 Percent Discount Rate)

| | Base MPG | Cost-Effective MPG | Percentage Gains (%) | Cost ($) |
|---|---|---|---|---|
| **Automobiles** | | | | |
| Subcompact | 31.3 | 35.1 | 12% | $502 |
| Compact | 30.1 | 34.3 | 14 | 561 |
| Midsize | 27.1 | 32.6 | 20 | 791 |
| Large | 24.8 | 31.4 | 27 | 985 |
| **Light Trucks** | | | | |
| Small SUVs | 24.1 | 30.0 | 24% | $959 |
| Mid SUVs | 21.0 | 28.0 | 33 | 1,254 |
| Large SUVs | 17.2 | 24.5 | 42 | 1,629 |
| Minivans | 23.0 | 29.7 | 29 | 1,079 |
| Small Pickups | 23.2 | 29.9 | 29 | 1,067 |
| Large Pickups | 18.5 | 25.5 | 38 | 1,450 |

Source: Effectiveness and Impact of CAFÉ Standards, National Academy of Sciences report, 2001, Table 4-2, p. 67.

Although CAFÉ standards have not been raised at present, it appears likely that they will be altered if not actually raised in the future. When the CAFÉ standards were established, separate standards were set for cars and trucks as, at the time, trucks were believed to be used predominantly in industry or farming. SUVs are classified as trucks and so are subject to this lower fuel economy standard. One option for altering CAFÉ that has been advocated by environmentalists is to close this "SUV Loophole." This would involve either integrated standards for an overall fleet or common standards for different vehicle types.

In July 2000, the Ford Motor Company announced that it would increase the fuel economy of its SUVs by 25 percent by 2005. General Motors (GM) and DaimlerChrysler announced plans to either match or beat Ford in this regard. GM plans to match Ford through an equivalent gain in GM's light-truck fleet, while DaimlerChrysler intends to improve the fuel economy of its entire fleet. Given these commitments, a scenario in which Congress mandates fuel economy improvements that were going to occur regardless is quite plausible.

In addition to these voluntary commitments, the industry is responding by bringing higher fuel economy vehicles to the market. Among the various technologies on offer are hybrid vehicles, which combine an electric motor and an internal-combustion engine. Although hybrids are a new technology, with only the Honda Insight and Civic and the Toyota Prius currently available, auto manufacturers appear to be sufficiently confident in the potential of hybrids that they are releasing a variety of models. Ford is scheduled to release its hybrid SUV, the Escape, in 2003. Nissan has announced that it will incorporate Toyota's hybrid technology into a new car and DaimlerChrysler is joining in with its RAM hybrid. This technology has significant impacts on fuel economy. Currently, the Honda Insight is rated by the Environmental Protection Agency (EPA) at 75 mpg, while the Prius is listed at 57 mpg.

The market penetration potential for hybrids is unclear. At present and on average, hybrid technology raises retail prices by about $4,000, while offering a 40 to 50 percent improvement in fuel economy. The market penetration model used within NEMS indicates that this will result in about a 15 percent market penetration in 12 to 15 years if the technology is successful and widely available in each vehicle class. Given the currently small number of hybrid models that are available, a figure of between four and six percent is reasonable for 2010, with 10 percent being the upper boundary. AEO's projections are slightly lower than this range, with LDV gasoline-hybrid sales accounting for slightly more than three percent of all new LDVs in 2010 in the AEO projections.

Given the recent advent of hybrids, the possibility of technological breakthroughs that would significantly cut the costs of production cannot be ruled out. In the event that this occurred and the costs were halved, it would be reasonable to double the upper bound figure to 30 percent, with an eight percent to 12 percent range of hybrid penetration into the market more likely for 2010.

A 2001 report by the Union of Concerned Scientists (UCS), "Drilling in Detroit," provides an indication of the potential magnitude of the impact of these potential events on oil consumption. UCS examined several scenarios and estimated the resulting fuel savings. UCS determined that the voluntary commitments made by auto manufacturers would save 4.2 billion gallons of oil, per year, by 2010. Closing the "light-truck" loophole (i.e., holding all

LDVs to the 27.5 mpg standard) would save 10 billion gallons per year (in total, not in addition to the 4.2).

UCS also models a strengthening of CAFÉ standards. This scenario has a mandated fleet fuel economy standard of 40 mpg being achieved by 2012. The model assumes that by 2010, hybrid cars and light trucks make up 10 percent of the total fleet. By 2020, more than 90 percent of the new car sales are assumed to be hybrids and fuel cell vehicles make up 0.6 percent of the fleet, or nearly 100,000 cars and light trucks nationwide. EEA considers these projections for hybrid and fuel cell vehicles to be well beyond any probable figure, while the fuel economy standards being used are substantially higher than any that have actually been considered in Congress. Table 5 contains the model estimates for motor fuel saved, both annually and cumulatively, by 2010. Assuming that the displaced fuel would be gasoline taxed at 18.3 cents per gallon, projected losses in revenues (in comparison to the base-case forecasts) are also shown in Table 5. (Base-case forecasts are that revenues and motor fuel consumption will grow by 2010.)

## Table 5 UCS Model Results

| | Voluntary Agreements | 27.5 MPG LDT Standard | 40 MPG CAFÉ Standards |
|---|---|---|---|
| Annual Motor Fuel Reduction (billion gallons) | 4.2 | 10 | 22.7 |
| Annual Loss of Revenues ($ billions) | $0.8 | $1.8 | $4.2 |
| Annual Motor Fuel Saving or Revenue Reduction as a Percentage | 3% | 7% | 15% |
| Cumulative Motor Fuel Savings (billion gallons) | 19.7 | 40.7 | 90.7 |
| Cumulative Revenue Reduction ($ billions) | $3.6 | $7.4 | $16.6 |

These figures would require adjustment to account for additives (such as ethanol) but they give a rough indication of the potential impacts that these measures could have on petroleum-based fuel consumption. Obviously, the specific figures are highly dependent on the actual percentages of changes in fuel efficiency in comparison to these calculated examples.

### *Heavy Vehicles (Freight Trucks)*

Freight trucks can be segregated into three populations based on weight – referred to as light-heavies, medium-heavies, and heavy-heavies. These three populations have exhibited differing trends over the past decade. Light-heavies (between 10,000 and 19,000 pounds gross vehicle weight [GVW]) have switched from gasoline to diesel such that now more than 70 percent of these vehicles are diesel powered and fuel economy has improved by about 0.7 percent a year within the diesel sector. Medium-heavies (between 19,000 and 33,000 pounds) are generally diesel-powered in-city pickup and delivery vehicles and have exhibited

similar improvements in their fuel economies. Heavy-heavies (more than 33,000 pounds) are more than 99 percent diesel powered and have shown fuel economy improvements of about 0.8 percent per year.

These fuel economy trends are unlikely to extend to 2010 because of new emission standards taking effect in 2002 and 2007. Detroit Diesel Corporation states that their 2002 compliant engines exhibit a two to four percent fuel economy penalty, while the impacts of meeting the significantly tighter 2007 standards are undetermined. AEO finds freight truck fuel economy constant, remaining at six mpg from 2001 to 2013, with the negative impacts of the tightened emission regulations negating fuel economy improvements. EEA believes that this is a conservative estimate, and would expect to see some fuel economy gains over those 12 years, particularly as parts of the medium-heavy trucking sector stand to garner fuel-economy gains in the 40 to 50 percent range as hybrid technologies are applied. In addition, new technologies such as electric turbo compounding suitable for heavy-heavy trucks show fuel-economy boosting potential in the five to eight percent range.

## Other Alternative Fuel Vehicles

Some alternative fuels such as compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), and methanol are subject to taxes that do flow to the highway account. Other alternative fuels such as pure electric or hydrogen are untaxed. A significant increase in the use of the untaxed fuels at the expense of the taxed, without a change to the tax system, would obviously hurt revenues. This section examines these untaxed alternative fuels and the probability of their capturing market share from the taxed group of fuels.

### *Purely Electric Vehicles*

Purely electric vehicles can avoid paying any taxes to the Highway Trust Fund entirely; however, electric vehicles have never achieved any significant market penetration to date, despite receiving significant support in California in the form of the 1990 Zero Emission Vehicle (ZEV) mandate. This legislation originally mandated that by 2003, 10 percent of all new cars sold in the state would be ZEV – criteria that only electric vehicles meet. The requirement was delayed to 2010 when it became apparent that the technology was not ready for the market at acceptable cost.

The last two years have seen strong legal challenges to the ZEV mandate from auto manufacturers. A stay order on the ZEV mandate has been issued in Federal court and there is a good deal of uncertainty regarding the likely outcome. The California Energy Commission concluded that the mandate would be very costly, while manufacturers have reported great difficulties in selling electric vehicles. Given these facts, the probability of ZEVs succeeding in the market place even with government intervention looks very low. It appears that the manufacturers could succeed in changing the ZEV mandate to a low emission mandate, which can be met with hybrid and other low emission vehicles. For these reasons, the probability assigned to ZEVs achieving significant market penetration prior to 2010 is low. This low probability is justified as the only electric vehicle being sold at present is the Toyota RAV E4 and, in the first half of 2002, a total of 218 units were sold. Honda has abandoned its Honda EV+ vehicle, and Ford

has recently abandoned its electric vehicle the Th!nk. GM's EV1 has never been released for commercial sale.

### *Fuel Cell Vehicles*

Fuel cell vehicles have been the focus of a great deal of press in the last few years, and were highlighted in the 2003 state of the union address. These vehicles run on either hydrogen or gasoline, with an on-board reformer. High potential fuel efficiency combined with zero emissions has made these a focus of attention for both environmentalists and car companies. Toyota and Honda have stated that they will have fuel cell vehicles on the roads in limited numbers in 2003, with DaimlerChrysler following in 2004. However, the prices that have been mentioned for these cars in the Japanese media have been in the $80,000 region and, with no hydrogen infrastructure available at present, they are only being seriously considered for fleets. The general consensus within the automobile industry is that fuel cells will not make any significant impact prior to 2010. Large cost reductions in fuel cells are required to reduce the high current cost premium, and there is significant uncertainty if such large cost reductions are possible. Many observers believe that such large reductions will never be attained.

These facts, combined with the lack of a hydrogen distribution infrastructure, indicate that hydrogen-powered fuel cells are very unlikely to be of any real concern prior to 2010, and will most likely still be of little consequence even in 2020. Fuel cell vehicles, described as a "bridge" to a hydrogen-powered fuel cell vehicle, that use gasoline as a fuel stand more chance of achieving some market penetration. However, these are unlikely to be a significant factor prior to 2010, and are only likely to achieve low levels of market penetration in the 2010-2020 timeframe.

AEO projections agree with these observations. Hydrogen-powered fuel cell LDV sales are estimated at 200 in 2010 and 700 in 2020, while gasoline-powered fuel cell LDV sales are estimated at zero in 2010 and 56,400 in 2020.

### *Hydrogen as a Fuel for Internal Combustion Engines*

Hydrogen received a mention in the 2003 state of the union address. Hydrogen, usually derived by electrolysis of water or by steam reforming of methane, can be used as a fuel for internal combustion engines. Although a wide variety of methods is available for hydrogen derivation, steam reforming of methane is by far the lowest cost source of hydrogen. Other methods can result in hydrogen costs that are 100 to 200 percent higher than methane reforming, according to a comprehensive study by the NREL.

These processes are not very energy efficient, and hydrogen has the added disadvantage of requiring significant energy for storage, either as a liquid or at high pressures. The high-energy consumption in distribution, dispensing, and vehicle storage is a unique feature of hydrogen as a vehicle fuel. At present, storing sufficient hydrogen on board a car results in a loss of utility in the form of cargo space, as the tanks take up a lot room. While long-term predictions of hydrogen production cost are less than $1.00/kg., delivered cost can be in the order of $3.00 to $4.00 per kg., which translates to a retail price of $3.00 to $4.00 per GGE as one kg. of hydrogen has almost the same energy as one gallon of gasoline. When used in a fuel cell vehicle,

the high efficiency rates can make this retail price economically viable, but at these prices, it is implausible to see hydrogen being used in an internal combustion engine even in the 2010-2020 timeframe.

### *Other Alternative Fuels*

Liquefied Petroleum Gas (LPG) is a mixture of propane and butane. As well as being widely used as a heating and industrial fuel, it is currently the most widely used alternative fuel with sales equal to approximately 0.5 percent of total gasoline sales. There is only a limited supply of LPG and so a significant increase in demand would result in much higher prices. As such, there is no plausible scenario in which LPG will become a significant fuel alternative for LDVs. Furthermore, a barrel of gasoline has an energy content approximately 37 percent higher than that of LPG and the tax rate on gasoline is slightly more than 35 percent higher. Therefore, the vehicular use of gasoline or propane contributes a very similar amount to the Highway Trust Fund.

Natural gas has been widely touted as a clean, widely available fuel to replace gasoline. The fuel is cost competitive with gasoline on an energy content basis. However, both CNG and LNG suffer from on-board storage issues. Tank costs are high, and the tank volume required to achieve an adequate range results in a significant loss of cargo space. Currently, new vehicles capable of running on CNG have a cost premium of $6,000 to 8,000. While some of this high cost is attributable to low sales volume, it appears unlikely that the premium will be less than $2,000 even at high sales volume. In addition, recent spot shortages of natural gas indicate fuel supply constraints, and prices could increase rapidly if demand from transportation grows significantly.

Methanol for use in internal combustion engines can be used neat (pure) or in a blend with gasoline. However, it suffers from several disadvantages that make it unlikely to be a significant factor. The main disadvantages are its toxicity, lower energy content, and corrosivity. Its lower energy content results in either lower driving ranges or loss of cargo space while its corrosive nature means that engine components and fuel system components exposed to methanol must be made of corrosion-resistant materials. At present, there is an inadequate supply of methanol for it to become a significant factor but it is possible to make methanol cheaply from natural gas. However, investments in Gas-to-Liquid (GTL) fuels are more likely to be directed at Fischer-Tropsch diesel (FTD) that does not suffer from methanol's disadvantages. FTD is a synthetic fuel produced from the conversion of natural gas into a diesel fuel. There has been talk of using methanol as a potential fuel cell fuel, which could become an issue in the event that fuel cells vehicles achieved any significant sales prior to 2020, but is almost certainly not an issue in the pre-2010 timeframe.

## Increased Use of Diesel

Most freight trucks are already diesel powered, but at present, the light-duty vehicle (LDV) market is overwhelmingly gasoline powered. This section examines whether the low diesel penetration in cars and light trucks is likely to change and, if it were, how it would impact ton revenues.

Although diesel is taxed at a higher rate per gallon than gasoline, the higher fuel efficiency of diesel cars makes diesel conversion almost revenue neutral in comparison to gasoline vehicles. For every gallon of diesel, 21.44 cents goes to the Highway Account of the Highway Trust Fund, as opposed to 15.44 cents for gasoline, a 38 percent increase. The same amount per gallon goes to the Mass Transit Account. However, diesel fuel has an 11 percent higher Btu content than gasoline (5.8 versus 5.3 million Btu per barrel) and diesel engines are inherently more efficient than gasoline engines, with a typical net fuel economy improvement of about 40 percent, effectively canceling out the higher taxes. From the Highway Trust Fund's standpoint, a mile driven in a diesel-powered car directs as much tax revenue to the fund as a mile driven in a gasoline-powered car.

Europe has seen a large-scale shift in the LDV market, with about 40 percent of LDVs now being powered by diesel. Although a shift of this kind is unlikely to occur to even half the extent prior to 2010 in the United States, a 10 percent diesel market penetration is potentially a low to medium probability event. This shift to diesels would only become a concern for the Highway Trust Fund if two other additional events occurred. First, a considerable proportion of the diesel used was Fischer-Tropsch diesel (FTD), a form of diesel fuel produced from natural gas. Second, a "Clean Diesel" tax exemption, which has been considered in the past, would have to be enacted.

It appears that F-T diesel will become a significant fuel in the coming decades. It is a very clean diesel fuel and can be made from remote sources of natural gas. Shell claims that F-T diesel is price competitive with gasoline when gasoline is at $20 per barrel, although this may be overly optimistic. Regardless, if F-T and regular diesel make the same contribution to the Highway Trust Fund, it is not a concern. However, any tax reduction for clean diesel fuel could impact the Highway Trust Fund.

AEO projects an increase in LDV vehicle diesel consumption from slightly more than one billion gallons in 2000 to more than 2.9 billion in 2010. The diesel-powered car stock is projected to fall from 580,000 to 280,000 from 2000 to 2010, while the stock of diesel-powered LDTs rises from 1.3 million to just more than five million in the same time period. This rise in the stock of diesel-powered trucks is the driving force behind this increase in diesel consumption.

## Potential Supply-Side Disruptions

The current situation in the Middle East and war with Iraq has highlighted the potential for another disruption in oil supplies. The Iraqi invasion of Kuwait in August 1990 effectively removed about nine percent of world oil production from the market and caused considerable uncertainty in the oil market. Saudi Arabia and several other OPEC producers increased production and nearly offset the losses of Iraqi and Kuwaiti supplies. Before the political situation stabilized and the effectiveness of the alternative supply increase proved itself, oil prices rose temporarily from around $21/barrel to around $40/barrel. Within six months, the price had fallen back to pre-disruption levels.

The war would presumably halt oil shipments from Iraq for some period, but sanctions have already restricted Iraq to an average last year of about 2.4 million barrels per day. Saudi Arabia, which maintains spare capacity of some three million barrels per day, could make up

that shortfall single-handedly. Even in the extraordinary event that three-quarters of the Middle East's output was unavailable, industrialized countries have enough oil in their strategic reserves to make good that size shortfall for 30 days, and to replace a smaller shortfall for months – buying time to repair war-damaged infrastructure.

A short-term disruption in oil supplies could however be of long-term significance to the Highway Trust Fund. The short-term price shock in 1973 led to the implementation of the original CAFÉ standards, and another price shock would greatly increase pressure to raise the fuel economy of vehicles and thereby reduce the U.S. dependence on foreign sources of oil. In addition, high gasoline prices and supply uncertainty could alter consumer behavior and manufacturer response so that the market could shift to fuel-efficient vehicles. For example, a very large market shift followed the Iranian oil crisis in 1979 and consumer sentiment towards fuel economy declined only after several years of lower oil prices. A substantial price shock in 2003 could have strong effects on vehicle choice to 2007-2008 and depress gasoline demand to 2010 and beyond.

**CHAPTER 3**

# INTERPRETATION, APPRAISAL, AND APPLICATIONS

## ALTERNATIVE SCENARIOS CONSIDERED

The previous chapter describes the quantitative analysis of five specific issues that could affect future fuel use and subsequent revenues:

- The substitution of ethanol for gasoline;
- Improved fuel economy;
- The possibility of a significant shift to other alternative fuels such as hydrogen or electricity;
- The potential for shifts to diesel an/or clean diesel fuel;
- A "supply shock" in the event of a war in the Middle East.

The analysis showed that the probability of some of these scenarios occurring relative to the base-case assumptions was quite high, and there were several possible routes (both regulatory and voluntary actions) that could impact revenues. Several scenarios of different probabilities were constructed and presented. The scenarios are listed in Table 6.

Only those with medium to high probability were analyzed in detail in this report, with one exception. The exception relates to the potential high penetration of hybrid gasoline-electric vehicles by 2020. Recent pronouncements by GM and Toyota suggest that the probability of such an event is "medium," a revision from early reports. In this context, the term low probability designates a less than 10 percent chance of occurrence, a medium probability designates a 20 to 40 percent chance of occurrence, and a high probability event indicates a 60 to 75 percent of occurrence. Note that events with more than 90 percent probability of occurrence are included in the baseline.

In addition, it is important to note that the fuel consumption reductions from those scenarios are certainly not additive and are (in most instances) mutually exclusive. Specifically, all scenarios within an issue category are mutually exclusive, but some scenarios across issue categories are potentially additive or partially additive in terms of their impact on the Highway Trust Fund. Cases of partial or complete additivity of effects are identified in the report. The effects of a "supply shock" were found to be only temporary (one to three years) but such an event can make the probabilities of all other oil conservation methods increase. Hence, the

"supply shock" scenario is not explicitly modeled, but can be considered as making some of the other scenarios more likely.

## Table 6 Scenarios Screened

| Issue | Scenarios for 2015 | Probability |
|---|---|---|
| **Fuel Economy (Regulation)** | Increased light truck F/E standards to 27.5 mpg | Medium |
| | Increasing all F/E standards to levels recommended by NAS | Medium |
| | Increasing all F/E standard by 50% | Low |
| **Fuel Economy (Voluntary)** | Increasing SUV fuel economy by 25% in 2006 | High |
| | Hybrid penetration of 15% | High |
| | Hybrid penetration of 30% | Medium (revised from low) |
| | Hybrid penetration of 15% in MDTs | Medium |
| **Alternative Fuels (Ethanol)** | Phase out of MTBE and replacement by ethanol | High |
| | Renewable fuel standard of 5 billion gallons/year | Medium |
| | Cellulosic ethanol is cost competitive with gasoline | Low |
| **Diesel Fuel** | Large-scale shift to diesels in light-duty market | Low to Medium |
| | Fischer-Tropsch diesel achieves high penetration and receives tax rebate | Low |
| **Other AFVs** | Battery electric vehicles have significant market penetration | Very Low |
| | Fuel cell vehicles have significant market penetration | Low |
| | Hydrogen is used as a fuel for internal combustion engines | Very Low |
| | CNG or LPG achieve significant market penetration | Low |

In the initial phase of this project, team member EEA evaluated the models used by the FHWA and one model used by the EIA. The former uses a model called FHRM4, while the latter uses a very comprehensive model called NEMS of all energy use in the United States. The review found that FHRM4 had not been updated since the mid-1990s and was currently very out of date. In contrast, the NEMS is updated annually, and its forecasts are considerably more detailed and more widely used. The NEMS forecast was recommended as a benchmark for this analysis effort.

However, the NEMS model cannot be easily modified to account for all the various scenarios of interest to this project. This is because the model contains a number of econometric relationships between variables that determine fuel consumption, and any required changes to one variable can affect other variables in ways that will be inconsistent with the specific intent of the scenario analysis. As a result, for the scenario analysis EEA utilized a simpler non-econometric model of vehicle fuel consumption that was developed for the DOE's Office of Policy, called the Motor Fuel Consumption Model (MFCM).

The MFCM utilizes three major vehicle classes (i.e., cars, LDTs, and HDTs). Cars and LDTs are further disaggregated by fuel type (gasoline, diesel, or alternative fuel) and domestic/import manufacturer. HDTs are also disaggregated by fuel type but are further disaggregated into three weight classes: 1) light-heavy trucks, covering trucks between 8,500 and 14,000 pounds GVW; 2) medium-heavy trucks, covering trucks between 14,001 and 50,000 pounds GVW; and 3) heavy-heavy trucks, covering trucks more than 50,000 pounds GVW. Each vehicle sub-class has associated curves of scrappage by age (vintage) and vehicle miles traveled (VMT) by age. The scrappage curves (as a percent of new vehicle sales) are fixed as are the VMT decline curves, although absolute VMT/vehicle can be changed for all forecast years. The MFCM permits a reasonable approximation of the NEMS output in a substantially simpler model structure.

Because the MFCM is an accounting model, registrations, mpg, and VMT by vehicle sub-class are inputs to the model. Our first step in this analysis was to obtain the detailed forecast of these variables as utilized in the NEMS 2002 forecast. The MFCM inputs were matched to the NEMS forecast and VMT growth rates were adjusted to match the NEMS forecast over time to 2020. Table 7 shows the NEMS forecast for fuel use and VMT, and the matched MFCM forecast; the two forecasts are in close agreement. These forecasts are in barrels per day, which is the common measure used in energy analyses. A barrel is 42 gallons. Results have not been converted to gallons per year because the point of the comparison in Table 7 is to demonstrate that each model provides similar base-case results. The only area of difference was found to be in the light commercial truck area (8,500 to 14,000 pounds GVW) where the EIA/AEO 2002 forecast appears incorrect in its vehicle sales data. Because of the relatively small magnitude of the difference, the MFCM was utilized for further analysis of alternative scenarios. In addition, the estimate of motor fuel gasoline use of 130 billion gallons in 2001 closely matches the actual sales totals reported by the EIA (because most gasoline is used for on-highway vehicles).

## Table 7 Comparison Between AEO 2002 and Matched MFCM Forecast

| | VMT (Billions/Year) | | Consumption (MMB/Day) | |
|---|---|---|---|---|
| **Vehicle Class** | **AEO** | **MFCM** | **AEO** | **MFCM** |
| **Cars and Light Trucks** | | | | |
| 2000 | 2,340 | 2,367 | 7.82 | 7.83 |
| 2010 | 2,981 | 2,990 | 9.76 | 9.73 |
| 2020 | 3,631 | 3,632 | 11.26 | 11.25 |
| **Commercial and Freight Trucks** | | | | |
| 2000 | 284 | 311 | 2.48 | 2.61 |
| 2010 | 374 | 417 | 3.32 | 3.46 |
| 2020 | 472 | 495 | 3.83 | 3.86 |

# INCREASED USE OF ETHANOL AND GASOHOL

EEA's analysis revealed three possible routes to increased use of ethanol, either as neat fuel or as a blend with gasoline (called gasohol). The three are:

- Increased use of ethanol as a result of a ban on MTBE;
- A renewable fuel standard incorporated into the new energy bill; and
- Neat ethanol competing with gasoline as a result of significant cost reduction in production from cellulose.

The potential for the first two events occurring were rated high. The third, however, is rated as having a low probability of occurrence in the context of the timeframe being examined, and is not considered in this report.

The use of ethanol as a substitute for MTBE, which is used as an oxygenate additive to reformulated gasoline, is the primary driver for increased ethanol use in the short term. Currently, 18 states have banned MTBE (the most important one being California), and a Federal ban is being considered. The analysis of these bans is complicated by the need to analyze the effects of other regulations such as the Mobile Source Air Toxics rule, and regulations on the vapor pressure of gasoline. These factors and their implications have been analyzed by the EIA and their findings are utilized in this report.

In brief, currently about 260,000 Mb/day of MTBE are used in a gasoline blend stock, and is typically blended at 11.2 percent by volume to meet reformulated gasoline's oxygenate requirement. Under a Federal MTBE ban by 2007, a 5.8 percent by volume ethanol blend can meet the RFG requirements. This implies a 5.2 percent product volume loss that must be made up, either by increasing the blend to 10 percent ethanol by volume or by using other crude oil-derived additives.

The net effect of a Federal MTBE ban in 2007 is estimated at only about 120 Mb/day increase in demand for ethanol. (Texas is expected to continue use of MTBE.) This will result in a gasohol sales increase of about 2.07 MMb/day if ethanol is used as a 5.8 percent blend, but only 1.2 MMb/day as a 10 percent blend. EEA anticipates that the 10 percent blend is more likely to be used outside of California, where stricter air pollution rules many prevent use of the 10 percent blend. This increase in demand for ethanol, equal to about 2.3 billion gallons/year, when added to current (2001) consumption of slightly more than 1.7 billion gallons/year should provide total ethanol demand for blending in the range of 3.6 billion gallons/year in 2007. If future growth (assuming that RFG oxygenate requirements continue) is at the same rate as that for total gasoline, then ethanol demand will increase to 3.6 billion gallons in 2010, 3.9 billion gallons in 2015, and 4.2 billion gallons in 2020. These values, however, are likely the maximum values for ethanol consumption under this scenario. Gasohol sales will likely be represented by about half the total being a 5.8 percent ethanol blend and the other half being a 10 percent blend under this scenario.

The second scenario is the RFS that requires five billion gallons of renewable fuel to be sold in 2012. Ethanol is the only realistic option to meet these volumes. Note that the scenario for ethanol demand to meet the RFG requirement will be more than 80 percent of the RFS requirement for 2012. Hence, the five billion gallon standard for 2012 would involve only a moderate stretch from the oxygenate use scenario. Beyond 2012, the standard requires that the percentage of ethanol sales to total gasoline sales be held to at least the 2012 levels.

At this point, EEA regards the RFS as the more plausible driver to determine long-term ethanol requirements, because the oxygenate requirement for RFG has limited emissions benefit in more recent low-emission vehicles, which will become the overwhelming part of the fleet by 2015. Hence, EPA could cancel the oxygenate requirement, and ethanol sales will be primarily determined by the RFS.

Table 8 provides the ethanol and gasohol sales volume estimates under the two scenarios. Neat ethanol sales volume is expected to be minimal in either scenario, on the order of 0.1 to 0.2 MMb/day at most. The ethanol sales scenario is largely independent of the fuel economy scenarios in the years to 2010 but, beyond 2012, ethanol sales will decrease by the same percentage as total fuel consumption decreases.

### Table 8 Ethanol and Gasoline Alternative Sales Estimates in the Future (Billion Gallons/Years)

| | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| **MTBE Ban** | | | | | |
| Ethanol | 1.12 | 2.60 | 3.67 | 3.91 | 4.22 |
| Gasohol | 10.50 | 31.50 | 45.90 | 48.90 | 52.70 |
| **Renewable Fuels Standard** | | | | | |
| Ethanol | 1.12 | 2.60 | 4.50 | 5.11 | 5.36 |
| Gasohol | 10.50 | 32.50 | 56.25 | 63.87 | 67.00 |

# FUEL ECONOMY SCENARIOS

It appears very likely that, because of global warming and oil dependence concerns, some form of fuel economy increase could occur because of regulatory pressure. In fact, the DOT has proposed a modest increase in LDT fuel economy to 22.3 mpg in 2007, from its current value of 20.7 mpg. However, it should also be noted that no significant changes from the baseline are even possible through 2006 because of the industry requirement for a three-year lead time to implement even modest changes from its current product plan. A by-product of this fact is that any fuel consumption changes to 2010 are relatively limited (because only new vehicles between 2006 and 2010 would be affected). Larger changes occur only by 2020 as the entire fleet turns over.

The most likely change is similar to the current proposal by DOT, which is a modest 10 percent boost in LDT fuel economy over baseline values to 2020. The baseline estimate is 22.8 mpg in 2010 and 24.2 mpg in 2020. Under this scenario, LDT fuel economy rises to 26.4 mpg in 2020, about 10 percent higher in all years considered after 2010. (A linear ramp up from 2006 to 2010 is also assumed.) Other scenarios modeled are shown in Table 9.

The four scenarios span the range of possible fuel economy scenarios that can be realistically expected in the near future, but obviously have limited impact to 2010. In all cases, the ultimate standards were assumed to be applicable to 2015, because the auto industry requires a 12-year timeframe to change over its entire model line up.

The Department of Energy's Motor Fuel Consumption (MFCM) was utilized to evaluate the effects on fuel consumption, and all scenarios were modeled using a linear ramp up from the baseline mpg in 2006 to the 2015 target mpg value. The results of the analysis are shown in Table 9.

## Table 9 Light-Duty Vehicle Fuel Consumption Under Possible Future Fuel Economy Regulations (MMBbl/Day) (Billions of Gallons/Year) (Percent Change/Year) ($ Billions Change/Year)

| Case | 2010 | 2015 | 2020 |
|---|---|---|---|
| **Base Case (AEO forecast, 2002)** | | | |
| Millions of Barrels per Day | 9.73 | 10.49 | 11.25 |
| Billions of Gallons per Year | (149.2) | (160.8) | (172.5) |
| **Improve LDT fuel efficiency by 10% relative to base case** | | | |
| Millions of Barrels per Day | 9.62 | 10.23 | 10.80 |
| Billions of Gallons per Year | (147.5) | (156.8) | (165.6) |
| Percentage Change from Base Case | (-1.1%) | (-2.5%) | (-4.0%) |
| Dollars per Year Loss from Base Case | ($-0.3) | ($-0.7) | ($-1.3) |
| **Meet NAS study findings for maximum cost-effective fuel efficiency** | | | |
| Millions of Barrels per Day | 9.52 | 9.83 | 10.20 |
| Billions of Gallons per Year | (145.9) | (150.7) | (156.4) |
| Percentage Change from Base Case | (-2.2%) | (-6.3%) | (-9.3%) |
| Dollars per Year Loss from Base Case | ($-0.6) | ($-1.9) | ($-3.0) |
| **Increase fuel efficiency standards by 50% from current value** | | | |
| Millions of Barrels per Day | 9.33 | 9.22 | 9.18 |
| Billions of Gallons per Year | (143.0) | (141.3) | (140.7) |
| Percentage Change from Base Case | (-4.1%) | (-12.1%) | (-18.6%) |
| Dollars per Year Loss from Base Case | ($-1.1) | ($-3.6) | ($-5.9) |

Increasing LDT fuel economy by 10 percent reduces fuel consumption by 0.11 MMBbl/day or about 1.7 billion gallons/year in 2010 and almost 6.9 billion gallons/year in 2020. At the other extreme, the highest proposed fuel economy standard reduces consumption by 6.1 billion gallons/year in 2010 and by 31.7 billion gallons/year in 2020. This scenario reduces fuel consumption by almost 20 percent in 2020.

The fuel savings from alternative voluntary programs fall within this range of fuel consumption reductions. For example, Ford has committed to raise the fuel economy of its SUVs by 25 percent in 2006 (relative to 2000) and GM and DaimlerChrysler have offered to match Ford's commitment. Because SUVs have a 40 percent share of the LDT market, the resulting impact is close to that of the first scenario modeled, which is a 10 percent increase in LDT fuel economy (i.e., 0.25 *x* 0.40).

Hybrid scenarios also fall within this range. While a 20 to 30 percent increase in mpg can be accomplished without hybrid technology, larger increases in fuel economy are likely to be driven by hybrid sales. Hybrid technology itself covers a range of alternative designs; some low-cost "mild" hybrids provide only a seven to 10 percent fuel economy benefit, while some high-cost designs provide 40 to 50 percent benefit. Even if one assumes that future hybrids were all of the high fuel-economy type and penetration reaches 30 percent in 2015, the net fuel economy increase is only on the order of 12 to 15 percent in 2015 (0.4 *x* 0.3 to 0.5 *x* 0.3). EEA believes that hybrid technology can be an important contributor to meeting the goal of 50 percent improvement suggested by the McCain bill, but its separate effect will again fall within the range of fuel economy scenarios considered, as an enabling technology.

One scenario envisages the possibly of MDT adopting hybrid technology, with a penetration of 15 percent in 2015. Hybrid technology can provide a 40 to 50 percent increase in mpg in urban applications, so that MDT mpg can increase by up to 7.5 percent (0.15 *x* 0.5) in 2015. However, total MDT fuel consumption in 2015 is only 0.47 MMBbl/day, and net impact on fuel consumption is very small, on the order of 0.02 MMBbl/day in 2015. Hence, the effects on total fuel consumption are too small to merit any significant concern.

# SHIFT TO DIESEL

A significant shift to diesel engines could be possible if these engines gain widespread consumer acceptance, as in Europe. However, Europe has higher overall fuel prices as well as a favorable gasoline-to-diesel price differential making the diesel option much more attractive to the consumer. Diesel engines are unlikely to capture 50 percent of the market as they do in France.

Indeed, the most likely market is the large class of light trucks, where the diesel engine's torque and durability are valued. The base-case projection calls for a 6.4 percent diesel penetration in light trucks, but only a 0.4 percent penetration in cars for 2010. Penetration is forecast to grow to 7.6 percent in light trucks and 1.2 percent in cars by 2020.

No reliable methodology exists to estimate a high diesel penetration scenario, and long-term "forecasts" are simply subjective estimates based on consumer stated-preference surveys. Optimistic opinions suggest that by 2020, the U.S. market could see diesel perpetration levels similar to that in European countries where diesel and gasoline fuel prices are equalized, or about 30 percent in both cars and light trucks. Because more manufacturers have announced near-term diesel introductions in light trucks, it is estimated that 14 percent of all light trucks can be diesel powered by 2010, and a maximum of 10 percent of cars in that year. This alternative scenario was utilized to estimate a "high" diesel penetration case, which also assumes a 30 percent penetration in 2020 for both cars and light trucks.

A 30 percent diesel penetration is equivalent to about 10 to 12 percent fuel economy increase, so that the net fuel consumption decrease is on the same order as that of some of the fuel economy scenarios considered. It should be noted that, like the hybrid technology, diesel technology is a means of achieving the higher fuel economy standards, and the fuel consumption reductions are not additive with estimates from higher fuel economy scenarios. However, there is a significant shift from gasoline to diesel, as shown in Table 10.

## Table 10 Increased Diesel Scenario (Billion Gallons/Year)

| | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Base Case** | | | | |
| Gasoline | 129.66 | 136.62 | 142.33 | 149.16 |
| Diesel | 46.53 | 54.17 | 59.52 | 61.77 |
| **High Diesel** | | | | |
| Gasoline | 129.66 | 132.83 | 129.26 | 123.10 |
| Diesel | 46.53 | 57.10 | 69.86 | 83.02 |

Even in 2010, gasoline consumption is reduced by 3.8 billion gallons, while diesel consumption increases by 2.95 billion gallons. By 2020, diesel consumption increases by 21.25 billion gallons while gasoline consumption declines by 26.1 billion gallons relative to the base case. Because of the higher taxes on diesel, the net effect on revenue is quite small. However, the declining gasoline consumption between 2010 and 2020 will affect the RFS requirement, which is specified as a percentage of gasoline sales.

Light-duty diesels may require ultra-clean diesel fuel to meet future emission standards, and it is possible that taxes on ultra-clean diesel fuel would be reduced to offset its higher production cost. However, the probability of such a tax reduction and a simultaneous high growth in market penetration is estimated to have a low probability of occurrence.

# SUMMARY OF RESULTS

Under the baseline scenario of "business-as-usual" gasoline consumption will grow by slightly more than 28 percent between 2000 and 2020, while diesel consumption will increase by almost 62 percent. In general, the effects of any alternative scenarios that have a high probability of occurrence (more than 50 percent) on gasoline consumption in 2010 are not large, but can be quite large by 2020.

Two high probability scenarios that have nearly additive effects on highway tax revenue are higher fuel economy standards and the increased use of ethanol as an oxygenate blending agent with gasoline. In this scenario, gasoline demand is reduced by two billion gallons in 2010 relative to the base case, while gasohol blends increase to 46 billion gallons. Demand drops by 10.5 billion gallons in 2020 (relative to the base case) and gasohol sales increase to 52.5 billion gallons.

Likewise, the increase in potential gasohol consumption that is considered a potential high probability event causes about a $2.5 billion impact by 2010 and a $3.1 billion impact by 2020 (in addition to the current negative impact of gasohol on revenues). The reason this scenario does not change much between 2010 and 2020 is that it assumes no further legislative mandate on gasohol consumption.

Based on the base line forecasts and scenario analysis, there are not any substantial short-term threats to motor fuel tax revenues because of alternative fuels or because of rapid advances in fuel efficiency, with the exception of the treatment of gasohol and ethanol.

**CHAPTER 4**

# CONCLUSIONS AND SUGGESTED RESEARCH

This research has shown that while there are serious threats to the continued usefulness and stability of motor fuel taxes, those threats are not unlimited, nor are they likely to have major impacts over the reauthorization period. There are, however, several potential factors of concern to transportation agencies. Agencies need to be prepared to respond to all factors, and will need to refine and manage revenue sources and revenue collection programs to avoid adverse impacts on highway and transit revenues.

## ETHANOL AND GASOHOL

The U.S. GAO has projected that ethanol's exemptions will lower Highway Account Revenue by a total of $13.72 billion between FY 2002 and FY 2012. This projection does not include the energy bill provisions, which look set to pass and further reduce revenues flowing to the Highway Trust Fund. Cellulosic ethanol looks unlikely to play a major role prior to 2010, but it may come of age in the 2010-2020 timeframe, in which case its impact on the Highway Trust Fund would be detrimental were the tax system to remain unchanged.

## FUEL EFFICIENCY AND VEHICLE FUEL ECONOMY

Fuel efficiency improvements, whether voluntary or mandatory, may begin to have a significant impact in the short term, with much greater impacts in the long term. The probability that there will be a short-term improvement in fuel economy as the automobile original equipment manufacturers (OEMs) act on their voluntary commitments to achieve fuel economy gains of about 25 percent is very high. The probability of an increase in the CAFÉ standards as they apply to sports utility vehicles (SUVs) is also high. The probability of an increase of 20 to 30 percent in the CAFÉ standards between now and 2010 for cars and trucks is medium to high, while the probability of a 40 to 50 percent increase is low. Even without any change to CAFÉ, hybrids could likely achieve a 10 percent market penetration by 2020, with a low to medium probability of achieving 30 percent penetration in the event of a technological breakthrough that results in reduced costs.

While there is no potential for a large increase in fuel economy of the heavy-heavy truck fleet, the medium-heavy trucks could have hybrid technologies achieve market penetration rates of 10 to 15 percent in the 2015 timeframe. The fuel economy gains of this technology are

in the 40 to 50 percent range, so the net effect on fuel consumption could be substantial. The light-heavy trucks also could benefit from hybrid technology, but to a lesser extent than the medium-heavies.

## ALTERNATIVE FUELS

Alternative fuels (not including gasohol) are currently a small part – about 0.2 percent – of the overall motor fuel supply. This percentage is unlikely to change prior to 2010 or even by 2020. A number of the alternative fuels, such as LPG (propane), liquefied natural gas (LNG), and methanol fuels are taxed at rates that are comparable to gasoline when the energy content of the fuel is considered, so increased use of these fuels has little impact on Highway Trust Fund receipts. Neither hydrogen nor electricity used as motor fuel is taxed, but the Highway Trust Fund is largely unaffected by these fuels as electric vehicles are unlikely to succeed in the marketplace while hydrogen is very unlikely to be a significant energy source to 2010 or even 2020.

## INCREASED USE OF DIESEL

A large-scale shift in the LDV market from gasoline to diesel power is unlikely in the 2010 timeframe. Even if it were to occur, it is an issue only if clean diesel is widely used and clean diesel fuel is provided some tax exemption. The odds of both conditions being met so as to make it of importance for the Highway Trust Fund are very low.

## POTENTIAL SUPPLY-SIDE DISRUPTIONS

An oil crisis would have the primary effect of a short-term supply shortage, but the resulting price increase could change the preferences of consumers and auto manufacturers towards more fuel-efficient vehicles.

Alternative fuels would receive increased focus in these circumstances. F-T diesel is seen as a significant potential source of future transportation energy but, as it is taxed as normal diesel, this should not affect the Highway Trust Fund. A clean diesel exemption would change this. In the event that cellulosic ethanol was seen as a solution for energy security reasons, then it would probably receive more tax incentives than conventional ethanol receives, with the corresponding decline to the Highway Trust Fund revenue stream.

The overall affect of a supply shock would be to raise the probability of all of these events occurring. There would be greater pressure to raise fuel economy and more attention paid to alternative energy supplies.

# CONCLUSIONS AND RECOMMENDATIONS

Conclusion and recommendations from this study fall into three major categories: 1.) Subsidy structures and consumption of ethanol and gasohol; 2.) Fuel efficiency; and 3.) Alternative fueled vehicles and related impacts.

1.) Increases in ethanol consumption could degrade the Highway Trust Fund by as much as $4.0 billion per year. Changing the existing treatment of ethanol/gasohol to eliminate subsidies out of transportation revenues could add a significant amount of $1.0 billion to $2.0 billion per year. Adjustments should be made to motor fuel taxes (perhaps including gasohol policies that do not adversely impact transportation revenues) to keep pace with needs, and these adjustments should be justified to legislatures based on needs rather than on arguments that fuel efficiency is a problem.

2.) Because the impacts on revenues due fuel efficiency changes will require changes in the vehicle fleet, which has average useful lifetimes of more than 10 years, fuel efficiency impacts on revenues will be low in early years and cumulative over time. However, because there is no reasonable way for transportation agencies themselves to be against improved fuel efficiency, the long-term goal for revenue programs should be to move away from reliance on fuel consumption, if that can be done without negatively impacting revenues.

3.) Alternative fueled vehicles that are powered by fuels, such as hydrogen, pure electric (battery only), natural gas, and other uncommon fuels, have very low or extremely low probabilities of entering the vehicle fleets during the reauthorization period or by 2020. As a consequence, there is no current pressing need to develop procedures and methods to assure that fees are collected from such vehicles. An eventual change to a different tax source from motor fuels would render this issue moot. Fees collected (based on roadway system usage) have several advantages over motor fuel taxes, and should be considered as a long-term approach to financing transportation.

# SUGGESTED RESEARCH

Research is suggested in several areas in order to assure that revenues remain adequate under various contingencies. Although there are no significant threats in the short term because of alternative fuels, there is a significant shortfall between the yields of current motor fuel taxes and the needs of agencies for preservation of assets and service levels. The research needs to be broad rather than specific. The issues of revenue in relation to needs cannot be resolved solely through modifications to existing approaches that remedy the negative impacts of factors such as new fuel types. Research and is recommended in these broad categories:

- Research is needed to identify and recommend long-term approaches to raising sufficient revenues to address the needs of the transportation system and the economy.

- Research is needed on the relationships of investment levels to the economic performance of the nation, states, and localities, and to other measures of public benefit.

- Research is needed on how to implement new revenue sources most effectively.