REPORT TO CONGRESS

Effects of the Alternative Motor Fuels Act CAFE Incentives Policy

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HIGHLIGHTS

The Alternative Motor Fuels Act of 1988, Pub. L. 100-94, October 14, 1988, (AMFA) provides Corporate Average Fuel Economy (CAFE) incentives for the manufacture of vehicles that use alcohol or natural gas fuels, either exclusively or as an alternative fuel in conjunction with gasoline or diesel fuel. AMFA directs the Secretary of Transportation, in consultation with the Environmental Protection Agency Administrator and the Secretary of Energy, to conduct a study and submit a report to Congress evaluating the success of the policy decision to offer CAFE credit incentives for the production and sale of dual-fuel vehicles.

As required by the statutory language, this study evaluates: (1) the availability to the public of alternative fuel vehicles and alternative fuels; (2) energy conservation and security; (3) environmental considerations; and (4) other relevant factors. It is also required that the Department of Transportation either extend the incentive program for dual-fuel vehicles up to four years beyond model year 2004, with a maximum allowable increase in average fuel economy per manufacturer of 0.9 miles per gallon (the maximum through MY 2004 is 1.2 miles per gallon); or issue a *Federal Register* notice that explains why the incentive program was not extended.

This study indicates that the AMFA CAFE credit incentive program for producing dual-fuel vehicles has had mixed results. Key findings include:

- The AMFA CAFE credit program has been successful in stimulating a significant increase in the availability of alternative fuel vehicles. Nearly all of these have been flexible-fuel vehicles that can operate on gasoline or E85 fuel (a mixture of 15 percent gasoline and 85 percent ethanol). There are currently about 1.2 million of these vehicles on the road. Because manufacturers had to overcome technological challenges, nearly the entire increase in the number of these vehicles has been in the past three years.

- The auto manufacturers stated that the CAFE incentive program has been a major factor in developing and manufacturing alternative fuel vehicles in high volumes. They also stated that extension of the credit provision will be a major factor in their decision to continue offering dual-fuel vehicles in the volumes that are being produced today.

- While the availability and use of alternative fuels has increased since the inception of the CAFE credit incentive provision, it has not nearly kept pace with the increase in the number of alternative fuel vehicles. Although there are 176,000 gasoline stations nationwide, there are only 5,236 alternative fuel refueling sites and just 121 of these offer E85. The Federal government, and specifically DOE, the General Services Administration and the U.S. Department of Agriculture (USDA) are involved with efforts to promote the use and expansion of alternative fuels and the alternative fuel infrastructure. A major focus of these efforts is the development of different feedstocks for ethanol and on partnerships that result in the expansion of the ethanol fueling infrastructure.

- Due to the lagging development of the alternative fuel infrastructure and the fact that E85 fuel is typically more expensive on a gasoline-equivalent basis, the vast majority of dual-fuel vehicles rarely operate on alternative fuel. Even under these circumstances, use of E85 increased from 694,000 gasoline gallon equivalents in1996, to more than 3.3 million gasoline gallon equivalents in 2000. It is also important to note that even if relatively few of these vehicles are actually being operated on E85, it is still valuable to be increasing that capability throughout the fleet because it could potentially contribute to the future transition away from petroleum, could spur an increase in the number of E85 refueling sites, and provide consumers an alternative if there are gas shortages or gas prices increase significantly.

- Conducting an assessment of the energy and environmental impacts of the dual-fuel vehicle credit incentive is complicated by uncertainty regarding automobile manufacturers' behavior. While the use of alternative fuels can reduce petroleum consumption and greenhouse gas emissions, the energy consumption and environmental impacts cannot be assessed with any reasonable amount of certainty because we cannot determine what manufacturers would have done in the absence of the credit incentive.

- If it is assumed that vehicle manufacturers took advantage of the incentive to relax the effect of the CAFE standard on the rest of their fleet, then the credit incentive has resulted in an increase in alternative fuel use (almost all E85), and some slight increase in petroleum consumption (about one percent) and greenhouse gas emissions (well less than one percent). Unless the availability and use of alternative fuels is significantly expanded, the CAFE credit incentive program will not result in any reduced petroleum consumption or greenhouse gas emissions in the future.

- It is also possible that manufacturers might have responded to strong consumer demand for performance and utility and produced the same vehicles without the provision as they did with it. In this case, manufacturers would have chosen to pay civil penalties rather than meet the CAFE standard. Under this scenario, the main effect of the program has been to greatly expand the population of vehicles that have the potential to use alternative fuels.

- In the past year, three significant initiatives have addressed issues related to the dual-fuel vehicle CAFE credit incentive. The National Energy Policy Development Group, in its May 17, 2001, report on the National Energy Policy states that, "ethanol vehicles offer tremendous potential if ethanol production can be expanded." Additionally, the report states that, "a considerable enlargement of ethanol production and distribution capacity would be required to expand beyond their current base in the Midwest in order to increase use of ethanol-blended fuels." In July 2001, the National Academy of Sciences' report on CAFE recommended that credits for dual-fuel vehicles should be eliminated, with the

> provision that enough lead-time be given to limit adverse impacts on the automotive industry." Finally, on August 2, 2001, the U.S. House of Representatives passed H.R. 4, which is entitled the Securing America's Future Energy (SAFE) Act of 2001. This bill, which has been placed on the Senate legislative calendar, includes a provision that would extend the dual-fuel vehicle CAFE credit incentive program through model year 2008.

Based on the results of this study, our preliminary conclusion is that continuation of the program should consider other actions that could improve the program and its chances for success. Specific actions by Congress or others might include any or all of the following:

(1) Examine alternatives to the current dual-fuel vehicle CAFE credit program structure, such as linking the CAFE credit to actual alternative fuel used;

(2) Develop, implement, and evaluate policies, regulations, or programs to promote the actual use of alternative fuels by consumers; and

(3) Develop, implement, and evaluate policies and programs that facilitate more rapid expansion and use of the alternative fuel infrastructure. Such policies and programs should be evaluated, taking into account the availability of alternative fuel and other potential transportation uses for each fuel.

In view of the nation's energy security interests, it is important to increase alternative fuel capability throughout the fleet. Given the mixed results of the program to date, it would be prudent for Federal agencies, Congress, industry, and other interested stakeholders to identify additional programs and authorities that could contribute to achieving greater use of alternative fuels in dual-fuel vehicles that receive the CAFE credit.

EXECUTIVE SUMMARY

I. BACKGROUND

Corporate Average Fuel Economy (CAFE)

In the wake of the Arab oil embargo and petroleum shortages in the 1970's, Congress enacted the Energy Policy and Conservation Act (EPCA) in 1975. This Act created the Corporate Average Fuel Economy (CAFE) program under which mandatory fuel economy standards are set for passenger car and light truck fleets.

Corporate average fuel economy is the average fuel economy, expressed in miles per gallon (mpg) of a manufacturer’s fleet of either 1) passenger cars or 2) light trucks up to 8,500 lbs. gross vehicle weight rating (GVWR) produced in the U.S. over any particular model year. The values are determined by computing the weighted fuel economy average of the various model types of a manufacturer in a model year.

Fuel economy values are based on the results of tests required and conducted by the U.S. Environmental Protection Agency (EPA). Compliance is determined first by considering each manufacturer's actual average fuel economy achievement for the model year. If the manufacturer exceeds the standard for that year, the law permits the surplus to be used as "credits" to be carried forward or backward up to three years to help offset shortfalls in other years. However, if those credits are not sufficient to fully offset the shortfall, the manufacturer is subject to civil penalties.

Alternative Motor Fuels Act of 1988 (AMFA)

AMFA, Pub. L. 100-94, October 14, 1988, provides CAFE credit incentives for the manufacture of vehicles that use alcohol or natural gas fuels, either exclusively or as an alternate fuel in conjunction with gasoline or diesel fuel. The primary purpose of AMFA is to encourage the widespread use of these fuels and to promote the production of alternative fuel vehicles by manufacturers.

In enacting AMFA, Congress sought to provide incentives directly to the auto makers in order to put an end to the "cause and effect" paradigm, in which auto makers had consistently argued that they would manufacture and market alternative fuel vehicles, if only a supply and distribution infrastructure were available to support an alternative fuel vehicle fleet. The fuel industry, for their part, argued that it would develop such an infrastructure, if there were significant demand for alternative fuels in the marketplace that would justify the capital expense.

Congress sought to address this situation by allowing special treatment of CAFE calculations for "dedicated" and "dual-fuel" (also referred to as “flexible-fuel”) vehicles. Through AMFA, Congress amended the automotive fuel efficiency provisions of Title V of the Motor Vehicle Information and Cost Savings Act by the addition of a new section that contains incentives for the manufacture of vehicles designed to operate either exclusively or flexibly on methanol, ethanol or natural gas. A manufacturer producing alternative fuel vehicles that meet specific energy efficiency and minimum driving range requirements is able, if the manufacturer chooses, to raise its overall fleet fuel economy average by manufacturing these vehicles.

The maximum CAFE benefit permitted from the addition of dual-fuel vehicles to a manufacturer's fleet is 1.2 mpg for model years 1993 through 2004. Most vehicles produced in response to AMFA have been flexible-fuel vehicles designed to operate on E85, a mixture of 85 percent ethanol and 15 percent gasoline. Vehicles powered by electricity, liquid petroleum gasoline (LPG), and bio-diesel are not covered by AMFA.

Reporting Requirements

AMFA directs the Secretary of Transportation, in consultation with the EPA Administrator and the Secretary of Energy, to conduct a study and submit a report by September 30, 2000, to the Commerce Committee of the U.S. House of Representatives and the U.S. Senate Committees on Commerce, Science, and Transportation and Governmental Affairs, evaluating the success of the policy decision to offer CAFE credit calculation incentives for dual-fuel and gaseous dual-fuel vehicles. Accordingly, this report focuses primarily on the impact of dual-fuel (flexible-fuel) vehicles, although it also presents some information on the larger group of alternative fuel vehicles, which includes dedicated vehicles.

As required by the statutory language, the evaluation is based on: (1) the availability to the public of alternative fuel automobiles and alternative fuels; (2) energy conservation and security; (3) environmental considerations; and (4) other relevant factors. The statutory language also requires that by December 31, 2001, the Department of Transportation either extend the incentive program for dual-fuel vehicles beyond MY 2004 for up to four more years with a maximum allowable increase in average fuel economy for a manufacturer of 0.9 miles per gallon; or issue a *Federal Register* notice that justifies termination of the incentive program.

II. *METHODOLOGY*

Multiple sources of data and information were used to support the analyses and conclusions in this report. Sources include the DOE Alternative Fuels Data Center (AFDC) and publications from the Energy Information Administration (DOE/EIA), the Center for Transportation Research at Argonne National Laboratory, and the Oak Ridge National Laboratory (ORNL). The AFDC was created to facilitate the directives of AMFA, to gather and analyze information on the fuel consumption, emissions, operation, and durability of alternative fuel vehicles, and to provide information on alternative fuel vehicles to government agencies, private industry, research institutions, and other related organizations. Other contributors and resources used for this study are EPA's National Vehicle and Fuel Emissions Laboratory, the California Energy Commission and the Government Accounting Office. Private sector sources include the American Petroleum Institute (API) and the American Methanol Institute (AMI). NHTSA data and analyses also were used.

In addition to these sources, NHTSA published a *Federal Register* notice soliciting responses to questions and issues related to automobile manufacturing, fuel production, distribution and retailing and topics of general public interest. (See 65 FR 26805; May 9, 2000--Docket No.: NHTSA 2000-7087.) The agency received comments on the published notice from eight organizations: three automotive manufacturers (General Motors Corporation, DaimlerChrysler Corporation, and Ford Motor Corporation), an automotive association (Alliance of Automobile Manufacturers), three alternate fuels coalitions (National Ethanol Vehicle Coalition, Clean Fuels Development Coalition, and Members of the Renewable Fuels Association), and a state government (Missouri Department of Natural Resources' Energy Center). No comments were received from environmental groups or the oil industry.

As well as responding to some of the questions presented in the *Federal Register* notice, all of the organizations that commented expressed support for extending the CAFE credit incentives for dual-fuel vehicles for the additional four years (through 2008). Subsequent to closing of the comment period, letters in support of extending the credit provision were received from several Senators and House Members. Also subsequent to closing of the comment period, a joint letter expressing opposition to extension of the provision was received from the Sierra Club, the American Council for an Energy-Efficient Economy, the Center for Auto Safety, and the U.S. Public Interest Research Group.

III. *FINDINGS*

Availability of Alternative Fuel Vehicles

The number of dual-fuel alternative fuel vehicles has increased to over 1.2 million vehicles. The vast majority of these vehicles are light trucks. Those vehicles using E85 as an alternative fuel include 115,000 passenger cars and 1,077,000 light trucks. Recent increases (MY 1998 through MY 2000) have been dramatic. In 1997, there were no dual-fuel light trucks. By 2000, close to 8 percent of all light trucks produced were dual-fueled vehicles. About 1.4 percent of passenger cars produced in MY 2000 were dual-fueled vehicles (compared to .025 percent in 1993).

Some manufacturers have used the CAFE credits for producing dual-fuel vehicles to help meet their CAFE requirements, notably Ford in its 1999 light truck fleet and DaimlerChrysler in its 1998 and 1999 light truck fleets. None of the automobile manufacturers have achieved the maximum benefit level of 1.2 mpg for their fleet. However, both Ford and DaimlerChrysler are approaching the 0.9 mpg maximum benefit level that would be allowed, if the dual-fuel vehicle CAFE credit provision were extended. In addition, GM has announced plans to significantly increase its production of dual-fuel vehicles.

Based on the automobile manufacturers' responses to the *Federal Register* notice, termination of the CAFE incentive program would significantly reduce the amount and types of alternative fuel vehicles available in the U.S. The manufacturers stated that the CAFE incentive program has been a major factor in developing and manufacturing alternative fuel vehicles in high volumes. They also stated that extension of the credit provision will be a major factor in their decision to continue offering dual-fuel vehicles in the volumes that are being produced today. A reduction in the production of these vehicles would likely result in a sharp decrease in interest in expanding the alternative fuel refueling infrastructure, and possibly result in a decrease in the number of alternative fuel refueling stations being operated.

Availability of Alternative Fuel

While there are an estimated 176,000 conventional fuel refueling stations nationwide, the National Renewable Energy Laboratory (NREL) reports that there are 5,236 alternative fuel refueling sites as of May, 2001, with alternative fuel refueling sites in all 50 states. In comparison, there were 4,676 alternative fuel refueling sites in the U.S. in 1995. Unfortunately, while ethanol is the alternative fuel that most of the dual-fuel vehicles that have been produced can operate on, less than three percent of the alternative fuel refueling sites offer ethanol. The vast majority of alternative refueling sites (3,270) are those that offer liquefied petroleum gas (LPG).

<u>Ethanol:</u> There are 121 ethanol (E85) refueling sites in the U.S., up from 37 in 1995. Ethanol refueling sites can be found predominantly in the Midwest, close to the major supplies of ethanol. Efforts by DOE are underway in Minnesota to help construct a number of ethanol refueling sites. As seen with CNG, fuel suppliers can rise to meet the demand by developing the necessary infrastructure. Although the trend in alternative fuels is in the direction of E85 use, the infrastructure has been slow to develop because these vehicles can use conventional fuel. Further, studies have shown that refueling stations need at least 200 steady customers for any single grade in order to make profitable use of the facilities. Though large numbers of flexible-fuel vehicles are being sold, they are spread out over the entire nation, and achieving a "critical mass" of 200 that use a single refueling station is still difficult to achieve. The small number of outlets available today points out the need to intensify the E85 refueling infrastructure. In addition, it is safe to say that many people who have purchased flexible-fuel vehicles do not know they could use E85. More public education in areas where E85 refueling stations exist is needed to inform people so that they are aware they can use E85.

<u>Methanol</u>: There are only two methanol (M85) refueling sites in the U.S., significantly down from 88 in 1995. Both of these sites can be found in California. The total number of methanol (M85) refueling stations has been dropping in the past few years, due to the lack of M85-capable flexible-fuel vehicles.

Natural Gas: There are currently 1,237 compressed natural gas (CNG) refueling sites and 44 liquified natural gas (LNG) refueling sites in the U.S., up from 1,065 CNG refueling sites in 1995. Natural gas refueling stations are usually located in urban areas near the major concentrations of natural gas vehicles, and are frequently constructed on a company's site to serve its fleet vehicles. Dedicated CNG vehicles, both heavy duty and industrial use, have been in the marketplace for some time, thus the larger number of refueling sites compared to E85 where the influx of vehicles using E85 in large numbers has just materialized in the past three years.

The cost to retrofit an existing refueling station's or retail outlet's gasoline/tank for E85 ranges from $5,000 to $30,000. For a new, underground tank and pump, the price ranges from $50,000 to $70,000. For LPG, the installation cost of a new outlet is $25,000 to $40,000. For CNG, the installation cost for an initial outlet is $250,000 to $500,000.

Since ethanol is the alternative fuel that most dual-fuel vehicles are capable of operating on, it is important to note the current water quality concerns regarding Methyl Tertiary-Butyl Ether (MTBE), an additive used to increase the oxygen content of gasoline. If MTBE is banned as a gasoline additive and fuel producers replace MTBE with ethanol, it is uncertain if there will be enough refinery capacity to both replace MTBE and to fuel flexible-fuel vehicles a substantial portion of the time with E85. Because of this situation, along with the small number of ethanol refueling stations nationwide coupled with the growing number of vehicles capable of using ethanol entering the marketplace, some special incentives to spur the development of an E85 refueling supply and distribution network might be warranted.

The Federal government, and specifically DOE, the General Services Administration and the U.S. Department of Agriculture (USDA) are involved with efforts to promote the use and expansion of alternative fuels and the alternative fuel infrastructure. A major focus of these efforts is the development of different feedstocks for ethanol and on partnerships that result in the expansion of the ethanol fueling infrastructure.

DOE runs the Clean Cities Program, which unites public-private partnerships that deploy AFVs and build supporting infrastructure, with the common goal of building the alternative fuels market. DOE also operates the Office of Fuels Development (OFD), whose primary focus is on working to reduce the cost of replacing imported oil with ethanol made from domestic resources such as corn fiber, bagasse and rice straw. OFD also includes a vital outreach and educational effort under its purview - the Regional Biomass Energy Program (RBEP). The specific goal of the RBEP is to increase the production and use of bioenergy resources, and help to advance the use of biomass feedstocks and technologies.

DOE and the General Services Administration (GSA) are jointly managing a program called the Federal AFV USER Program, whose goal is to support the expansion of an alternative fuel infrastructure by concentrating large quantities of Federal AFVs and substantially increasing the use of alternative fuels in Federal AFVs in six selected areas: Albuquerque, NM; Denver, CO; Melbourne/Titusville/Kennedy Space Center, FL; Minneapolis/St. Paul, MN; Salt Lake City, UT; and the San Francisco Bay area.

USDA agencies will use ethanol fuels in their fleet vehicles where practicable and reasonable in cost. USDA's E85 flex-fuel vehicles will use ethanol fuel where those vehicles operate in geographical areas that offer E85 fueling stations, and USDA agencies will purchase or lease alternative fuel vehicles, including E85 flex-fuel vehicles, for geographic areas that offer alternative fueling.

Use of Alternative Fuels

While alternative fuel use in alternative fuel vehicles in the U.S. has been rising over the past decade, it still represents a very small portion of total highway fuel use. In 1992, the Energy Information Administration estimated that a total of 230 million gasoline gallon equivalents of alternative fuel was used in alternative fuel vehicles. For 2001, that number was projected to rise to 366 million gasoline gallon equivalents, or an increase of roughly 6 percent per year. In comparison, the highway use of gasoline and diesel was about 133 billion gallons in 1992, and that number was projected to rise to about 164 billion gallons in 2001, or an increase of roughly 2 percent per year. Thus, alternative fuel use in alternative fuel vehicles has been rising at a rate three times faster than the total highway use of gasoline and diesel. Nonetheless, alternative fuel use only accounts for 0.22 percent of total highway fuel use.

Analysis of the Effects on Energy Conservation and the Environment

The current trend in alternative fuels seems to be in the direction of ethanol (E85), due to the relative transparency to the operator in using either ethanol or gasoline, and the relative ease and minimal cost associated with converting a gasoline-fueled vehicle to one that can accept either gasoline or ethanol. The CAFE incentives available to automobile manufacturers for selling vehicles capable of operating on alternative fuels have led to sales of more than one million ethanol flexible-fuel vehicles through the 2000 model year. Automobile manufacturers have responded to the incentives Congress provided in the Act. However, for several reasons, these flexible-fuel vehicles are operating almost exclusively on gasoline.

The CAFE credit incentive for dual-fuel vehicles can assist manufacturers in complying with the CAFE standards. Other than producing dual-fuel vehicles, manufacturers must either use other means (weight reductions, advanced technology, pricing, product mix shifting, and/or marketing) to meet the standards or pay civil penalties for not meeting the standard.

Conducting an assessment of the energy and environmental impacts of the CAFE credit incentive is complicated by behavioral uncertainty. While the use of alternative fuels can reduce petroleum consumption and greenhouse gas emissions, the energy consumption and environmental impacts cannot be determined with any reasonable amount of certainty because we cannot predict what manufacturers would have done in the absence of the credit incentive. If vehicle manufacturers took advantage of the incentive to relax the effect of the CAFE standard on the rest of their fleet, then the credit incentive has resulted in some slight increase in alternative fuel use (almost all E85), petroleum consumption (about one percent) and greenhouse gas emissions (well less than one percent).

It is also possible that manufacturers might have responded to strong consumer demand for performance and utility and produced the same vehicles without the provision as they did with it. In this case, manufacturers would have chosen to pay civil penalties rather than meet the CAFE standard. Under this scenario, the main effect of the program has been to greatly expand the population of vehicles that have the potential to use alternative fuels.

This report presents an analysis of the energy conservation and environmental effects to date, as well as projections through 2008, using an assumption that manufacturers used the incentive to relax the effect of the CAFE standard on the rest of their fleet. This assumption yields an "upper bound" estimate of the increase in petroleum consumption and greenhouse gas emissions. The analysis focuses on E85 flexible-fuel vehicles because they represent almost all of the vehicles that have been produced that are eligible for the credit. Note that because dual-fuel vehicles must meet Federal emission standards for criteria pollutants such as NO_x or volatile organic compounds, on both gasoline and the alternative fuel, the most significant environmental impacts are on greenhouse gas emissions. Therefore, the analysis of environmental impacts is focused on greenhouse gas emissions. In the case of petroleum consumption, 85 percent of E85 fuel used by flexible-fuel vehicles offsets the increase in gasoline use that results from the lower fuel economy associated with the credit, since 85 percent of E85 is ethanol and 15 percent is gasoline. In the case of greenhouse gas emissions, the offset is about 25 percent, since flexible-fuel vehicles burning E85 still generate some greenhouse gas emissions. The results of the analysis indicate that the incentive has resulted in an increase in alternative fuel use (almost all E85), and some slight increase (about one percent) in petroleum consumption and greenhouse gas emissions for 1996 through 2000. The effects beyond 2000 will depend almost entirely on the amount of E85 fuel used by FFVs. Unless actions are taken to significantly expand the availability and use of alternative fuels, the CAFE credit incentive program will not result in any reduced petroleum consumption or greenhouse gas emissions in the future.

It is important to note that the analysis assumes that, in the absence of the CAFE credit incentive, manufacturers would have chosen to take other actions to improve their average fleet fuel economy rather than pay CAFE penalties. We do not know with certainty that the manufacturers wouldn't have produced the same vehicles in the absence of the credit incentive. Therefore, the actual energy and environmental impacts are uncertain.

IV. *CONCLUSIONS*

Our evaluation of the AMFA CAFE credit incentive policy for dual-fuel vehicles indicates that the program has had mixed results. Key findings include:

- The AMFA CAFE credit program has been successful in stimulating a significant increase in the availability of alternative fuel vehicles. Nearly all of these have been flexible-fuel vehicles that can operate on gasoline or E85 fuel (a mixture of 15 percent gasoline and 85 percent ethanol). There are currently about 1.2 million of these vehicles on the road. Because manufacturers had to overcome technological challenges, nearly the entire increase in the number of these vehicles has been in the past three years.

- The auto manufacturers stated that the CAFE incentive program has been a major factor in developing and manufacturing alternative fuel vehicles in high volumes. They also stated that extension of the credit provision will be a major factor in their decision to continue offering dual-fuel vehicles in the volumes that are being produced today.

- While the availability and use of alternative fuels has increased since the inception of the CAFE credit incentive provision, it has not nearly kept pace with the increase in the number of alternative fuel vehicles. Although there are 176,000 gasoline stations nationwide, there are only 5,236 alternative fuel refueling sites and just 121 of these offer E85. The Federal government, and specifically DOE, the General Services Administration and the U.S. Department of Agriculture (USDA) are involved with efforts to promote the use and expansion of alternative fuels and the alternative fuel infrastructure. A major focus of these efforts is the development of different feedstocks for ethanol and on partnerships that result in the expansion of the ethanol fueling infrastructure.

- Due to the lagging development of the alternative fuel infrastructure and the fact that E85 fuel is typically more expensive on a gasoline-equivalent basis, the vast majority of dual-fuel vehicles rarely operate on alternative fuel. Even under these circumstances, use of E85 increased from 694,000 gasoline gallon equivalents in1996, to more than 3.3 million gasoline gallon equivalents in 2000. It is also important to note that even if relatively few of these vehicles are actually being operated on E85, it is still valuable to be increasing that capability throughout the fleet because it could potentially contribute to the future transition away from petroleum, could spur an increase in the number of E85 refueling sites, and provide consumers an alternative if there are gas shortages or gas prices increase significantly.

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- If it is assumed that vehicle manufacturers took advantage of the incentive to relax the effect of the CAFE standard on the rest of their fleet, then the credit incentive has resulted in an increase in alternative fuel use (almost all E85), and some slight increase in petroleum consumption (about one percent) and greenhouse gas emissions (well less than one percent). Unless the availability and use of alternative fuels is significantly expanded, the CAFE credit incentive program will not result in any reduced petroleum consumption or greenhouse gas emissions in the future.

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Based on the results of this study, our preliminary conclusion is that continuation of the program should consider other actions that could improve the program and its chances for success. Specific actions by Congress or others might include any or all of the following:

(1) Examine alternatives to the current dual-fuel vehicle CAFE credit program structure, such as linking the CAFE credit to actual alternative fuel used;

(2) Develop, implement, and evaluate policies, regulations, or programs to promote the actual use of alternative fuels by consumers; and

(3) Develop, implement, and evaluate policies and programs that facilitate more rapid expansion and use of the alternative fuel infrastructure. Such policies and programs should be evaluated, taking into account the availability of alternative fuel and other potential transportation uses for each fuel.

In view of the nation's energy security interests, it is important to increase alternative fuel capability throughout the fleet. Given the mixed results of the program to date, it would be prudent for Federal agencies, Congress, industry, and other interested stakeholders to identify additional programs and authorities that could contribute to achieving greater use of alternative fuels in dual-fuel vehicles that receive the CAFE credit.

I. Introduction

Recognizing the substantial portion of energy consumption attributed to the light vehicle transportation sector, the need to conserve the Nation's energy resources, and the need to reduce the dependence upon foreign energy feed stocks and improve air quality, Congress passed the Energy Conservation and Policy Act of 1975 to institute fuel efficiency requirements for passenger cars and light trucks. Corporate average fuel economy, or "CAFE," the weighted sales average of a manufacturer's fleet of new passenger cars and light duty trucks, was mandated for newly manufactured passenger cars produced after 1977 and light trucks after 1978. Congress directed the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) to promulgate these fuel economy standards and to enforce them via civil penalties levied against automakers that do not comply with established CAFE levels.

Along with the improvements in light transportation fleet fuel efficiency, legislators sought to address the conservation of domestic energy resources, or more specifically, the reduction in fossil fuel consumption, through a replacement strategy accomplished by use of alternative fuels. In order to promote this method of conserving fossil fuels, Congress enacted the Alternative Motor Fuels Act of 1988, Pub. L. 100-94, October 14, 1988, (AMFA). To assist in achieving the goals of promoting the use of alternative fuels, AMFA provided incentives for manufacturers of light vehicles to design, develop, manufacture and market passenger cars and light trucks that would operate on the alternative fuels. AMFA's manufacturing incentives were established through amendments to the Motor Vehicle Information and Cost Savings Act by allowing for special considerations in CAFE calculations for vehicles that operate intermittently or exclusively on the alcohol and natural gas fuels. The Energy Policy Act of 1992, Pub. L. 102-486, October, 24, 1992, (EPACT) sought to further reduce transportation fossil fuels consumption through replacement with alternative fuels, and expanded the definition of what constituted an alternative fuel.

Along with these provisions for light vehicle manufacturing incentives, AMFA directs the Department of Transportation, in consultation with DOE and the Environmental Protection Agency, to conduct an evaluation and issue a report on the impact of the CAFE incentives program on the extent of fossil fuel replacement and other associated benefits and to issue its findings to Congress, along with recommendations for continuing to offer these manufacturing incentives. AMFA also directs NHTSA to issue, by December 31, 2001, either a final rule that extends the incentive program for up to an additional four years with a reduced maximum mile per gallon CAFE credit attribution, or a *Federal Register* notice that the program will be discontinued with justification for that decision. The evaluation is to be conducted based on the availability to the public of alternative fueled automobiles and the alternative fuels; energy conservation and security; environmental considerations; and any other factors deemed to be relevant.

Multiple resources were used to collect and to analyze information and data to facilitate this study and report. The majority of information was extracted from U.S. Department of Energy data sources, including the Alternative Fuels Data Center (AFDC), the Energy Information

Administration (EIA), the 19th edition of the Transportation Energy Data Book, publications from the Center for Transportation Research at Argonne National Laboratory, and the Oak Ridge National Laboratory (ORNL). The AFDC was created to facilitate the directives of AMFA. The purpose of the AFDC is to gather and analyze information on the fuel consumption, emissions, operation, and durability of alternative fuel vehicles, and to provide unbiased, accurate information on alternative fuel vehicles to government agencies, private industry, research institutions, and other related organizations. Other significant government and public resources include the EPA, the California Energy Commission, and the General Accounting Office. Private sector sources include the American Petroleum Institute (API) and the American Methanol Institute (AMI). Statistical data and related information were also accessed from NHTSA's in-house data and analyses.

In order to obtain specific information relative to alternative fuels and alternative fuel vehicles from the private sector, NHTSA published a *Federal Register* notice (65 FR 26805; May 9, 2000) requesting both specific information in the form of responses to questions, as well as other relevant factual information, including but not limited to statistical and cost data or marketing studies, and the sources of that information. Questions were grouped into three main categories: 1) Questions/ Issues Primarily Related to Automobile Manufacturers; 2) Questions/Issues Primarily Related to Fuel Producers, Distributors and Retailers; and 3) Questions/Issues of General Interest. Auto makers were requested to provide specific information on whether and to what extent the incentives program was a factor in offering alternative fuel vehicles for sale; what costs were incurred in the design and manufacturing of these vehicles; what costs were passed on to consumers in the form of a price differential to their baseline conventional fuel models; how and to what extent these vehicles were marketed; what specific technologies were developed to accommodate the alternative fuels; and what future plans would be with or without the extension of the incentives program.

The fuel producers, refiners, distributors and marketers were requested to provide relevant information on AMFA's effect on plans to produce alternative fuels; how the program directly affects the decisions to make the fuel accessible to consumers, expressed in terms of capital expenditures to improve and expand the supply and distribution infrastructure, and what efforts have been made to educate the consumers on the merits of alternative fuels as a replacement for conventional fossil fuels. Questions of general interest were targeted at consumers and focused on purchasing decisions, complaints or issues relative to vehicle driveability and dependability; what complimentary programs would aid in the proliferation of purchases of alternative fuels and vehicles; and other questions focusing on consumers' commercial acceptance of alternative fuels and vehicles. Responses to these questions and other comments of relevance are contained in Appendix A.

II. Background

The vitality and economic growth of the U.S. is linked to affordable transportation. Relative to most countries, the U.S. is sparsely populated and development depends on access by highway vehicles. The interstate highway system made possible large scale freight movement by truck and facilitated travel by car. The availability of good roads and inexpensive fuel resulted in the development of large cars without much regard for fuel efficiency. The decade of the 1960s was one of the most productive in U.S. history due in part to a thriving automotive industry and inexpensive petroleum fuel. This fortuitous situation came to a rapid end in 1973 when the Organization of Petroleum Exporting Countries (OPEC) dramatically raised the price of crude oil. The resulting increases in fuel prices caused auto sales to decline and induced a long period of slow growth and inflation in the U.S.

The Corporate Average Fuel Economy Program (CAFE)

As a result of the energy crisis of 1973, and in recognition of the Nation's increasing utilization and subsequent dependency upon foreign sources of fossil fuels, Congress enacted the Energy Conservation and Policy Act of 1975 (PL 94-163; December 22, 1975). The Act amended the Motor Vehicle Information and Cost Savings Act by adding Title V: "Improving Automotive Efficiency," establishing corporate average fuel economy requirements for passenger cars and light trucks. Fuel economy is defined as the average mileage traveled by an automobile per gallon of gasoline (or an equivalent amount of other fuel) consumed as measured in accordance with the testing and evaluation protocol set forth by the Environmental Protection Agency (EPA) Administrator (49 U.S.C. §32904). Corporate average fuel economy is the sales weighted average fuel economy, expressed in miles per gallon, of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs. (3636.4 Kg) or less manufactured for sale in the United States, for any given model year (49 U.S.C. §32901).

The Act authorized the Secretary of Transportation to administer the CAFE program. The Secretary delegated the authority to the NHTSA Administrator. (41 FR 25015; June 22, 1976). NHTSA was authorized to determine the maximum feasible CAFE levels; approve credit "carry back" and "carry forward" plans; determine and either grant or deny exemptions from the requirements for low-volume manufacturers; monitor the program through mandatory pre-model year and mid-model year manufacturer reports; and submit annually to Congress a report on the current status of the CAFE program. CAFE standards are to be promulgated 18 months prior to the beginning of the model year for which they are subscribed, with their determination established upon four basic statutory criteria: 1) technological feasibility; 2) economic practicability; 3) the effect of other Federal standards upon fuel economy; and 4) the need for the Nation to conserve energy.

The first year for which the standards were established for passenger cars was model year (MY) 1978 at a level of 18.0 miles per gallon (mpg); the standards increased to 19.0 mpg for MY 1979 and 20.0 mpg for MY 1980. The Act directed NHTSA to establish and promulgate standards administratively for MYs 1981, 1982, 1983 and 1984, and to specify fuel economy requirements for MYs 1985 and thereafter at 27.5 mpg. The fuel economy standard for light trucks was established for MY 1979 at 17.2 mpg for 2-wheel drive models and 15.6 mpg for models equipped with 4-wheel drive. Several changes in characterizing light truck fleet composition were made over the years, including mandatory and optional calculation of combined 2- and 4-wheel drive configurations in combination with domestically produced vehicles and “captive” imports, which are vehicles produced outside of the U.S. that are marketed under a domestic manufacturer’s nameplate; optionally calculated domestic and import fleets; and finally single fleet calculations. Passenger vehicle calculations also changed over the years, and current calculations are made for manufacturers import fleets and the domestically produced fleet. Table II-1 summarizes the history of fuel economy standards for both passenger cars and light trucks from the program’s inception through MY 2002, the latest year for which targets have been set.

The most recent fuel efficiency requirements for a manufacturer’s passenger car fleets, either those domestically produced or imported, is 27.5 mpg, the same performance level that was established by the Act for 1985**.** Light truck CAFE has been established through MY 2003 at 20.7 mpg. This level has remained unchanged since MY 1996 as a result of a rider incorporated into each year’s Transportation and Related Agencies Appropriations Act that forbids NHTSA from changing the standard.

Table II-1

Fuel Economy Standards for Passenger Cars and Light Trucks Model Years 1978 through 2002 (in MPG)				
Model Year	Passenger Cars	Light Trucks [1]		
		Two-wheel Drive	Four-wheel Drive	Combined [2], [3]
1978	18.0 [4]	...	...	...
1979	19.0 [4]	17.2	15.8	...
1980	20.0 [4]	16.0	14.0	... [5]
1981	22.0	16.7 [6]	15.0	... [5]
1982	24.0	18.0	16.0	17.5
1983	26.0	19.5	17.5	19.0
1984	27.0	20.3	18.5	20.0
1985	27.5 [4]	19.7 [7]	18.9 [7]	19.5 [7]
1986	26.0 [8]	20.5	19.5	20.0
1987	26.0 [9]	21.0	19.5	20.5
1988	26.0 [9]	21.0	19.5	20.5
1989	26.5 [10]	21.5	19.0	20.5
1990	27.5 [4]	20.5	19.0	20.0
1991	27.5 [4]	20.7	19.1	20.2
1992	27.5 [4]	...	...	20.2
1993	27.5 [4]	...	...	20.4
1994	27.5 [4]	...	...	20.5
1995	27.5 [4]	...	...	20.6
1996	27.5 [4]	...	...	20.7
1997	27.5 [4]	...	...	20.7
1998	27.5 [4]	...	...	20.7
1999	27.5 [4]	...	...	20.7
2000	27.5 [4]	...	...	20.7
2001	27.5 [4]	...	...	20.7
2002	27.5 [4]	...	...	20.7

1. Standards for MY 1979 light trucks were established for vehicles with a gross vehicle weight rating (GVWR) of 6,000 pounds or less. Standards for MY 1980 and beyond are for light trucks with a GVWR of 8,500 pounds or less.

2. For MY 1979, light truck manufacturers could comply separately with standards for four-wheel drive, general utility vehicles and all other light trucks, or combine their trucks into a single fleet and comply with the standard of 17.2 mpg.

3. For MYs 1982-1991, manufacturers could comply with the two-wheel and four-wheel drive standards or could combine all light trucks and comply with the combined standard.

4. Established by Congress in Title V of the Motor Vehicle Information and Cost Savings Act.

5. A manufacturer whose light truck fleet was powered exclusively by basic engines which were not also used in passenger cars could meet standards of 14 mpg and 14.5 mpg in MYs 1980 and 1981, respectively.

6. Revised in June 1979 from 18.0 mpg.

7. Revised in October 1984 from 21.6 mpg for two-wheel drive, 19.0 mpg for four-wheel drive, and 21.0 mpg for combined.

8. Revised in October 1985 from 27.5 mpg.

9. Revised in October 1986 from 27.5 mpg.

10. Revised in September 1988 from 27.5 mpg.

A manufacturer whose CAFE level for its passenger car or light truck fleet does not meet the standard for a given model year is subject to a civil penalty of $5.50 for each tenth of a mile below the required fuel efficiency level for each vehicle sold in the model year (49 U.S.C. §32912(b)). Historically, Asian and domestic manufacturers (Chrysler, prior to the merger with Daimler-Benz; Ford; and General Motors) have either met or exceeded both the passenger car and light truck fleet requirements, whereas several of the European luxury vehicle manufacturers have consistently failed to comply with the passenger car fleet requirements and have paid substantial penalties over the years. Appendix B summarizes those manufacturers who have failed to meet the requirements and the associated penalties paid for those non-compliances.

Manufacturers can earn CAFE "credits" to offset their deficiencies in their CAFE performances. Specifically, when the average fuel economy of either the passenger car or light truck fleet for a particular model year exceeds the established standard, the manufacturer earns credits. The number of credits a manufacturer earns is determined by multiplying the tenths of a mile per gallon that the manufacturer exceeded the CAFE standard in that model year by the amount of vehicles they manufactured in that model year. These credits can be applied to any three consecutive model years immediately prior to or subsequent to the model year in which the credits are earned. The credits earned and applied to the model years prior to the model year for which the credits are earned are termed "carry back" credits, while those applied to model years subsequent to the model year in which the credits are earned are known as "carry forward" credits (49 U.S.C. §32903(b)). Failure to exercise carry forward credits within the three years immediately following the year in which they are earned will result in the forfeiture of those credits. As is evident in Appendix B, penalties for failing to meet fuel economy standards can be substantial. The United States has collected close to a half billion dollars in CAFE penalties through 1999. Earned and "banked" credits that can offset shortfalls in fuel efficiency can have significant financial implications for manufacturers.

CAFE has impacted the amount of highway fuel used in the U.S. Figure 1 illustrates highway fuel use in the U.S. since 1970. Figure 2 illustrates the average fuel economy for cars and light trucks since CAFE standards were implemented in the late 1970s. The impact of CAFE is clearly shown on Figure 1. Without CAFE, highway fuel use might be 35 percent higher than it is today.

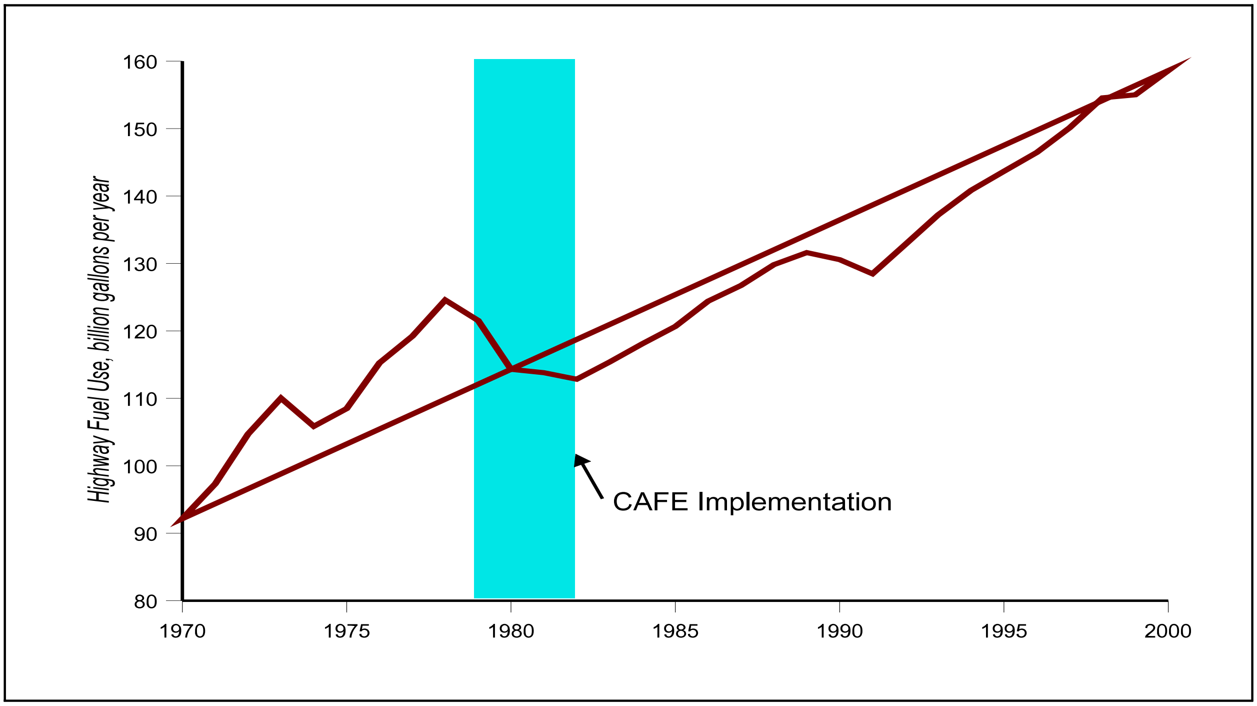

Figure 1. U.S. Highway Fuel Use Since 1970
Source: Energy Information Agency

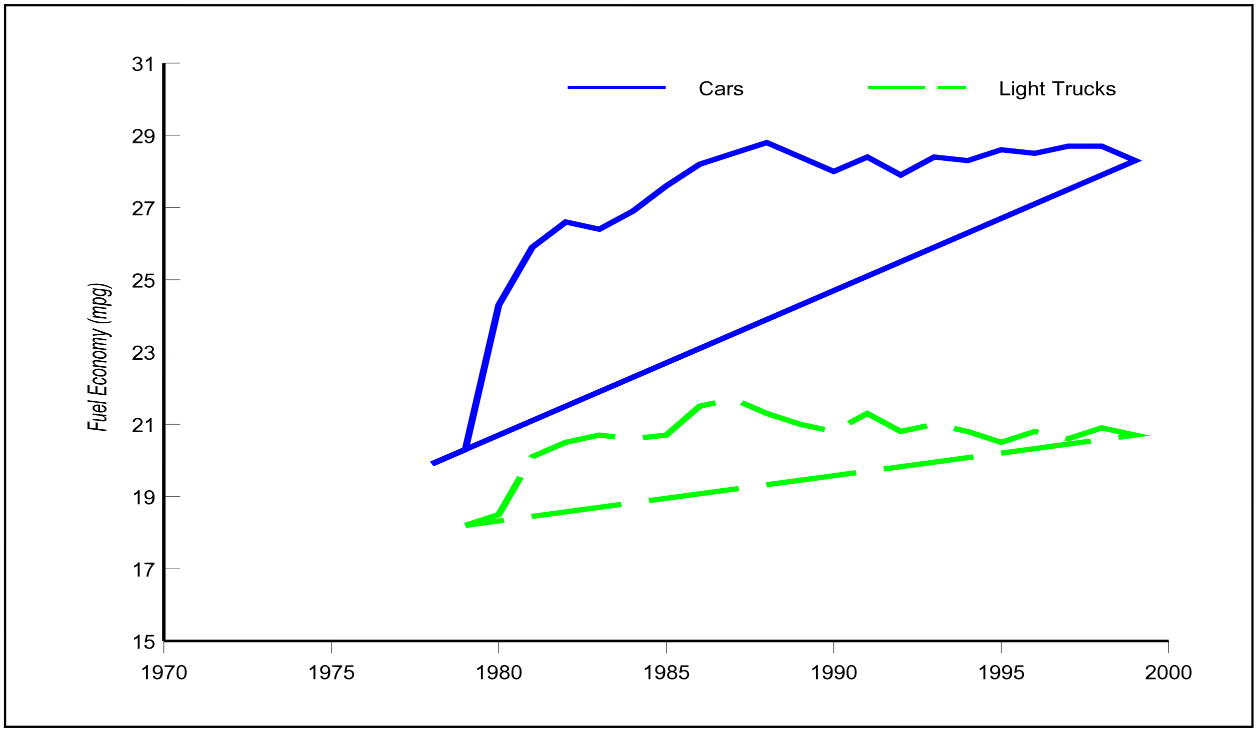

Figure 2. Car and Light Truck CAFE Since Inception
Source: U.S. Department of Transportation

AMFA CAFE Credits

Though CAFE has been effective in improving the average fuel economy of the light vehicle fleet, the transportation sector remains overwhelmingly dependent on petroleum-based fuels (approximately 95 percent of transportation energy comes from petroleum) and on technologies that provide virtually no flexibility. The transportation sector currently accounts for approximately two-thirds of all U.S. petroleum use and roughly one-fourth of total U.S. energy consumption. Highway transportation petroleum consumption has risen from 121 billion gallons per year in 1979, when CAFE was enacted, to 155 billion gallons per year in 1999 (28 percent over 20 years). EIA projects U.S. dependence on imported petroleum will grow to 54 percent in 2000 and 57 percent in 2005. Dependence of U.S. autos and trucks on imported oil was one of the major driving forces behind congressional passage of AMFA and EPACT.

Citing the dependency upon foreign energy sources and the associated compromise to National energy security; the increasing deleterious effect of combustion of petroleum upon the atmosphere; and that replacement fuels such as methanol, ethanol and natural gas would burn cleaner and more efficiently and would reduce the amounts of carbon dioxide released to the atmosphere, Congress enacted AMFA. The primary purpose of AMFA was to encourage the widespread use of methanol, ethanol and natural gas as light vehicle transportation fuels and to promote the production of alternative fuel vehicles by automobile manufacturers. In enacting AMFA, Congress sought to provide incentives directly to the auto makers in order to put an end to the “cause and effect” paradigm, in which auto makers had consistently argued that they would manufacture and market alternative fuel vehicles if only a supply and distribution infrastructure were available to support an alternative fuel vehicle fleet as the fuel industry simultaneously argued that it would develop such an infrastructure if there was significant demand for alternative fuels in the marketplace that would justify the capital expenditures.

AMFA contains provisions that allow for special treatment of vehicle CAFE calculations for “dedicated” and “dual-fuel”(also referred to as “flexible-fuel”) methanol, ethanol and natural gas alternative fuel vehicles. To afford these incentives, AMFA amended the automotive fuel efficiency provisions of Title V of the Motor Vehicle Information and Cost Savings Act by addition of a new section that contains incentives for the manufacture of vehicles designed to operate either exclusively or flexibly on methanol, ethanol or natural gas. Vehicles that operate exclusively on a 70 percent or greater methanol or ethanol concentration, or only on compressed or liquefied natural gas are recognized by AMFA to be “dedicated” alternative fuel vehicles. Those that have the capability to operate on either conventional gasoline or diesel fuel, or a mixture of the fuel and gasoline or diesel fuel, or only on the alternative fuel, without modification to the vehicle, are considered as “dual-fuel” or “flexible-fuel” vehicles. A manufacturer producing alternative fuel vehicles that meet specific energy efficiency and minimum driving range requirements is able, if the manufacturer chooses, to raise its overall fleet fuel economy average by manufacturing these vehicles.

A “dual energy” vehicle is defined by AMFA as:

> i) Which is capable of operating on alcohol and on gasoline or diesel fuel:
> ii) Which provides equal or superior energy efficiency, as calculated for the applicable model year during fuel economy testing for the Federal Government, while operating on alcohol as it does while operating on gasoline and diesel fuel; [and]
> iii) Which, for model years 1993 through 1995 and, if the Administrator of the Environmental Protection Agency determines that an extension of this clause is warranted, for an additional period ending not later that the end of the last model year for which section 513(b) and (d) applies, provides equal or superior energy efficiency, as calculated for the applicable model year during fuel economy testing for the Federal Government, while operating on a mixture of alcohol and gasoline or diesel fuel containing exactly 50 percent gasoline or diesel fuel as it does while operating on gasoline or diesel fuel [.]

Similarly, a “natural gas dual energy” vehicle is one:

> i) Which is capable of operating on natural gas and on gasoline or diesel fuel; [and]
> ii) Which provides equal or superior energy efficiency as calculated for the applicable model year during fuel economy testing for the Federal Government, while operating on natural gas as it does while operating on gasoline or diesel fuel [.].

AMFA directed NHTSA to establish two minimum driving ranges; one specification for the alcohol/gasoline or diesel dual energy vehicles when operating on the alcohol and the other for the natural gas dual energy vehicles while operating on natural gas. In establishing these criteria, AMFA directed the agency to consider consumer acceptability, economic practicability, technology, environmental impact, safety, driveability, performance and other factors considered relevant. Minimum driving ranges for the alcohol vehicles were established at 200 miles, and natural gas vehicle range was required to meet or exceed 100 miles. EPACT amended the natural gas dual energy driving range to 200 miles. NHTSA codified this requirement in April 1996. EPACT also revised the terminology of the AMFA qualified fuels. Section 301.8(A) of EPACT revised the definitions in Section 513(h)(1)(C) of the Motor Vehicle Information and Cost Savings Act by redefining a “dual energy” and “natural gas dual energy” vehicles to “dual-fuel” vehicles. In addition, a broader category of “alternative fuel” vehicles was established that would also include vehicles capable of operating on liquefied petroleum gas, hydrogen, coal derived liquefied petroleum, fuels derived from biological materials, electric vehicles that include those deriving power from battery sources and solar energy, ethers and any other materials that the Secretary of Energy deems to be substantially non-petroleum in origin and that deliver substantial energy security and environmental benefits.

Section 6 of AMFA amended the fuel economy provisions of Title V of the Motor Vehicle Information and Cost Savings Act through the addition of section 513 that provides CAFE incentives for vehicles capable of operating on alternative fuels. Beginning in MY 1993, manufacturers of alternative fuel vehicles could qualify for special treatment in the calculation of their CAFE by computing the weighted average of the fuel economy while operating on gasoline or diesel fuel and when operating on the alcohol after dividing the alcohol fuel economy by a factor of 0.15. As an example, a dedicated alternative fuel vehicle that would achieve 15 mpg fuel economy while operating on alcohol would have a CAFE calculated as follows:

FE = (1/0.15)(15) = 100 miles per gallon.

For alternative dual-fuel vehicles, an assumption is made that the vehicles would operate 50% of the time on the alternative fuel and 50% of the time on conventional fuel, resulting in a fuel economy that is based on a harmonic average of alternative fuel and conventional fuel. The fuel economy for an alternative dual-fuel model is calculated by dividing 1.0 by the sum of 0.5 divided by the fuel economy as measured on the conventional fuel and 0.5 divided by the fuel economy as measured on the alternative fuel, using the 0.15 volumetric conversion factor. For example, for an alternative dual-fuel model that achieves 15 miles per gallon operating on an alcohol fuel and 25 mpg on the conventional fuel, the resulting CAFE would be:

FE = 1/((0.5/25) + (0.5/100) = 40 miles per gallon

Calculation of fuel economy for natural gas vehicles is performed in a similar fashion. For the purposes of this calculation, the fuel economy is equal to the weighted average of the fuel economy while operating on natural gas and while operating on either gasoline or diesel fuel. AMFA specifies the energy equivalency of 100 cubic feet of natural gas to be equal to 0.823 gallons of gasoline, with the gallon equivalency of natural gas to be considered to have a fuel content, similar to that for alcohol fuels, equal to 0.15 gallons of fuel (49 U.S.C. §329059(c)). Calculations to determine the adjusted CAFE values for natural gas alternative fuel vehicles are performed in similar fashion. For example, under this conversion and gallon equivalency, a dedicated natural gas vehicle that achieves 25 miles per 100 cubic feet of natural gas would have a CAFE value as follows:

FE = (25/100) x (100/0.823)(1/0.15) = 203 miles per gallon

These calculation procedures, along with the fuel economy testing procedures for alternative fuel vehicles, were codified by the EPA in 1994 (59 FR 39638; August 3, 1994).

AMFA also limits the extent to which these special considerations can improve a manufacturer’s average fuel economy. For model years 1993 through 2004, the maximum increase that can be attributed to this program is 1.2 mpg for each category of automobiles (domestic and import passenger car fleets; light truck fleets). The incentive program can be extended at the approval of the Secretary of Transportation for up to four years beyond MY 2004, but at a ceiling reduced from 1.2 mpg to 0.9 mpg. In the event that the Secretary of Transportation reduces the current CAFE requirement from 27.5 mpg for any model year, any increase of CAFE resulting from the AMFA calculation amount will be reduced by the CAFE standard, but may not be reduced to yield less than 0.7 mpg (49 U.S.C. §32906(b)).

EPACT re-codified the provisions of Section 513 of the Information and Cost Savings Act as

Title 49 U.S.C. Sections 32901, 32905 and 32906. In addition, the definition of alternative fuel was expanded to include liquefied petroleum gas, hydrogen, liquid fuels derived from coal and biological materials, electricity and any other fuel that the Secretary of Transportation determines to be substantially non-petroleum based and has environmental and energy security benefits. The law also revised terminology by replacing Adual energy@ and Anatural gas dual energy@ with "alternative fueled vehicles@ in order to more appropriately reflect the expanded list of alternative fuels. Beginning in MY 1993, manufacturers of these alternative fuel automobiles that met the minimum driving range and energy efficiency criteria could qualify for special treatment in the calculation of their CAFE.

The decision to either extend the program for dual-fuel or gaseous dual-fuel vehicles beyond MY 2004 or to issue of a *Federal Register* notice that justifies termination of the incentive program must be made by December 31, 2001. No later than September 30, 2000, the Secretary of Transportation, in consultation with the EPA Administrator and the Secretary of Energy, is to submit to the Commerce Committee of the U.S. House of Representatives and the U.S. Senate Committees on Commerce, Science, and Transportation and Government Affairs, a report that assesses the success of the policy decision to offer these CAFE calculation incentives for dual-fuel and gaseous duel fuel vehicles. In performing the study and in the execution of the report, DOT/EPA/DOE is to consider:

1) the availability to the public of alternative fuel automobiles and alternative fuels;
2) energy conservation and security;
3) environmental considerations; and
4) other relevant factors.

Recent Events

In the last year, several events have transpired related to CAFE and the credit incentive provision. These are summarized below:

On May 17, 2001, the Energy Policy Development Group, led by Vice President Cheney, issued its National Energy Policy. This report made recommendation's to President Bush regarding the path that the administration's energy policy should take and included specific recommendations regarding vehicle fuel economy and CAFE. The report recommends that the President direct the Secretary of Transportation to:

- Review and provide recommendations on establishing CAFE standards with due consideration of the National Academy of Sciences study to be released in July 2001. Responsibly crafted CAFE standards should increase efficiency without negatively impacting the U.S. automotive industry. The determination of future fuel economy standards must therefore be addressed analytically and based on sound science.

- Consider passenger safety, economic concerns, and disparate impact on the U.S.

versus foreign fleet of automobiles.

- Look at other market-based approaches to increasing the national average fuel economy of new motor vehicles.

The National Energy Policy Development Group also stated in their report that, “ethanol vehicles offer tremendous potential if ethanol production can be expanded.” Additionally, the report states that, “a considerable enlargement of ethanol production and distribution capacity would be required to expand beyond their current base in the Midwest in order to increase use of ethanol-blended fuels.”

The fiscal year 2001 DOT Appropriations Act still included the rider prohibiting the Department from revising the CAFE standards, however it also included a provision directing the Department to fund a National Academy of Sciences study on the effectiveness and impacts of CAFE standards. On July 30, 2001, the National Academy of Sciences released their report entitled, “Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards.” This report included 15 findings and seven recommendations. Recommendation 5 stated that, “Credits for dual-fuel vehicles should be eliminated, with the provision that NHTSA’s notice of such action provides enough lead-time to limit adverse impacts on the automotive industry.”

On August 2, 2001, the U.S. House of Representatives passed H.R. 4, which is entitled the Securing America’s Future Energy (SAFE) Act of 2001. This bill, which has been placed on the Senate legislative calendar, includes provisions in Section 203, Dual Fueled Automobiles, which alter the AMFA CAFE credit incentive program by extending it for an additional four model years to 2008 and by extending the 1.2 mpg limitation on the maximum allowable CAFE credit that can be earned by a specific manufacturer’s fleet through model year 2008 as well. The deadline for making a decision whether to extend the program beyond 2008 would be December 31, 2005, with the report on the effects of the program due on September 30, 2004.

On July 10, 2001, Secretary Mineta sent a letter to Congress asking that the freeze on CAFE standards be lifted immediately so NHTSA could resume its CAFE rulemaking responsibilities. However, the freeze was not lifted until December 2001, when the FY 2002 Appropriations Act for the Department of Transportation, for the first time in six years, did not include a rider freezing CAFE standards. NHTSA immediately resumed its CAFE rulemaking responsibilities and issued a Notice of Proposed Rulemaking for MY 2004 light truck standards on January 24, 2002.

III. Availability of Alternative Fuel Vehicles

AMFA's provisions allow for special treatment of CAFE calculations for "dedicated" and "dual-fuel" methanol, ethanol and natural gas alternative fuel vehicles. To afford these incentives, AMFA amended the automotive fuel efficiency provisions of Title V of the Motor Vehicle Information and Cost Savings Act by the addition of a new section that contains incentives for the manufacturer of vehicles designed to operate either exclusively or flexibly on methanol, ethanol or natural gas. Vehicles that operate exclusively on an 85 percent or greater methanol or ethanol concentration, or only on compressed or liquefied natural gas are recognized by AMFA to be "dedicated" alternative fuel vehicles. Those that have the capability to operate on either conventional gasoline or diesel fuel, or a mixture of the fuel and gasoline or diesel fuel, or only on the alternative fuel, without modification to the vehicle, are considered to be "dual-fuel" or "flexible-fuel" vehicles. A manufacturer producing alternative fuel vehicles that meet specific energy efficiency and minimum driving range requirements (at least 200 miles) may be able to raise their overall fleet fuel economy performance by manufacturing these vehicles. A description of the vehicles eligible for the credits is presented below.

Description of Alternative Fuels/Vehicles Eligible for CAFE Credit

Ethanol: Ethanol (C_2H_5OH) is a liquid alcohol fuel (sometimes referred to as grain alcohol) currently made from corn. Like methanol, ethanol can be used to make a gasoline additive (ETBE), and is used in an 85 percent blend with gasoline to power flexible-fuel vehicles. Currently, the primary use of ethanol is as a gasoline blending component in gasohol, reformulated gas, and in wintertime oxygenated fuels.

Changes to ethanol flexible-fuel vehicles relative to gasoline vehicles consist mostly of a sensor which will detect the type of fuel being pumped to the engine, and sets of engine maps to ensure that the vehicle operates on ethanol in a manner consistent with its operation on gasoline. Additionally, since higher flow-rate fuel injectors are used to accommodate the lower energy density of ethanol relative to gasoline, software changes relative to injector control (injector duration, etc.) may be necessary to ensure proper operation of the fuel injection system.

Ethanol is corrosive to some metals, although less so than methanol. Metals recommended for use with ethanol include carbon steel, stainless steel, and aluminum (if suitably protected from corrosion). Ethanol is less prone to attack elastomeric materials, so many common elastomers can be used with ethanol without risk of deterioration. No special manufacturing techniques are needed for ethanol fuel systems for flexible-fuel vehicles.

Unlike with methanol, manufacturers are offering a number of vehicle models as ethanol flexible-fuel vehicles at no extra cost. More than 600,000 of these ethanol flexible-fuel vehicles were made available in MY 2000.

Methanol: Methanol (CH_3OH) is a liquid alcohol fuel (sometimes referred to as wood alcohol) produced from natural gas. Methanol is used as a fuel for racing vehicles at the Indianapolis 500, and was first used as a vehicle fuel in the 1930's. It is currently being used to make MTBE, a gasoline additive; however, the use of MTBE is being phased out due to water quality concerns.

Methanol sold for light-duty dual-fuel (also called "flexible-fuel") vehicles is actually M85 (a blend of 85 percent methanol and 15 percent unleaded gasoline). Changes to methanol flexible-fuel vehicles relative to gasoline vehicles consist mostly of a sensor which will detect the type of fuel being pumped to the engine, and sets of engine maps to ensure that the vehicle operates on methanol in a manner consistent with its operation on gasoline. Additionally, since higher flow-rate fuel injectors are used to accommodate the lower energy density of methanol relative to gasoline, software changes relative to injector control (injector duration, etc.) may be necessary to ensure proper operation of the fuel injection system.

Methanol will attack and corrode certain metals, such as magnesium and aluminum. Additionally, the corrosion products of aluminum and methanol will precipitate out of the liquid fuel and clog filters and fuel injectors. For this reason, it is recommended that metals such as stainless steel and carbon steel be used in methanol fuel systems and fuel delivery systems. Methanol will also attack many common elastomeric materials, like rubber, polyurethane, and most plastics. Elastomers with high fluorine content and Teflon have been proven to be compatible with methanol. No special fabrication techniques are necessary to produce methanol fuel systems for flexible-fuel vehicles, although new techniques would probably be necessary to produce methanol reformers for methanol-fueled fuel cell vehicles.

In the past, methanol has been used in a blend with 15 percent gasoline in methanol flexible-fuel vehicles; however, at the present time, no manufacturer is offering a methanol flexible-fuel vehicle. When they were being offered, the cost of methanol flexible-fuel vehicles were about the same as their gasoline-fueled counterparts. Currently, interest in methanol is centered around its use in fuel cell vehicles.

Natural gas: Natural gas is made up mostly of methane (CH_4), and is one of the world's most abundant fossil fuels. In the U.S., natural gas is commonly used for space heating and electricity generation. The United States has a large domestic supply of natural gas and an extensive pipeline system to provide natural gas throughout the country. Natural gas is a popular alternative fuel for transportation use due to its low cost and widespread availability. Usually, natural gas is used in a vehicle as a compressed gas (CNG), but it can also be used as a cryogenic liquid (LNG).

There are two types of light-duty CNG vehicles or fuel systems currently being produced: dedicated vehicles which operate exclusively on natural gas and dual-fuel or bi-fuel vehicles which have fuel systems for both natural gas and gasoline. Vehicle fuel systems for flex-fuel and dedicated natural gas vehicles are very similar. The main difference is that the gasoline fuel system is left intact on the dual-fuel or bi-fuel vehicle. Both dual-fuel or bi-fuel and dedicated CNG vehicles are equipped with high pressure storage cylinders. Electronic software and hardware changes for natural gas vehicles include any additional sensors and controls to operate the natural gas fuel system, and engine control maps may be changed relative to a comparable gasoline vehicle to improve performance on natural gas (especially with dedicated natural gas vehicles).

By itself, natural gas is benign and does not cause many materials compatibility problems. However, natural gas can contain two contaminants, water vapor and hydrogen sulfide gas, which can result in corrosion of natural gas fuel system components. Natural gas dryers have been developed to remove sufficient water vapor from the fuel to prevent corrosion from the water vapor and the hydrogen sulfide, which is corrosive in the presence of water vapor. Compressed natural gas tanks themselves can be made either of steel, aluminum, composite materials or some combination of the materials. Current Federal Motor Vehicle Safety Standard 304 addresses the safety concerns of CNG tanks in motor vehicles.

Vehicle range for CNG and LNG depends on fuel storage capacity, but generally it is less than that of comparable gasoline-fueled vehicles. Power, acceleration, and cruise speed are comparable with those of an equivalent gasoline-fueled engine. Cylinder location and number may displace some of the payload capacity.

In terms of maintenance and reliability, the high-pressure tanks in CNG vehicles require inspection and certification. Some fleets have reported two to three years longer service life and extended time between required maintenance. However, manufacturers recommend conventional maintenance intervals.

A few light-duty CNG vehicles are currently being produced by the auto manufacturers. Production and sales of light-duty CNG vehicles are low because they cost between $1,500 and $6,000 more than their gasoline counterparts.

Description of Other Alternative Fuels/Vehicles - Not Eligible for Credits

Electricity: Electricity is unique among alternative fuels in that mechanical power is derived directly from it, rather than from the release of stored chemical energy through combustion to provide mechanical power. Electricity is produced in power plants powered by coal, natural gas, water (hydroelectric), or nuclear energy, and is available throughout the country. Electricity is being used in vehicles through the use of storage batteries and an electric motor, although fuel cells are also being explored to provide electricity to the electric motor through the conversion of chemical energy to electricity.

Relative to conventional gasoline vehicles, electric vehicles require a very different set of electronic controls and electronic hardware to operate. This includes motor controllers, inverters, and any battery management software.

Electric vehicles do not have materials compatibility issues in the same sense that other alternative fuel vehicles do. Issues that arise related to materials will involve the materials used to make the batteries themselves, such as lithium, lead, and cadmium. Many battery technologies involve the use of materials that can be harmful to humans (such as acid in a lead-acid battery), or can cause environmental harm if disposed of improperly.

Currently, electric vehicles cost more than their gasoline-fueled vehicles. However, there are conflicting estimates on the eventual cost to buy and operate an electric vehicle. Bringing down the cost of battery packs has become a recent focus. Less expensive battery technology is critical to making electric vehicles more affordable to the average consumer.

Although there are hybrid-electric vehicles (HEV) on the market that employ the dual-fuel concept, they have been ruled by NHTSA as gasoline powered vehicles because the electricity used to drive the motors is all generated by burning gasoline or diesel fuel on board. They do not have the ability to draw electric power from an electric grid by plugging into a power source and cannot operate on electric power for the minimum range.

Liquefied Petroleum Gas (LPG): LPG includes several light hydrocarbons which become liquids under modest pressures (up to 300 psi). For vehicle use, LPG consists mostly of propane (C_3H_8) and thus is most often called propane. Propane has been used as a motor fuel for more than 60 years in the U.S. and is the most commonly used alternative fuel. Propane is widely used in barbecue grills and for space heating, and is widely available throughout the U.S.

The majority of LPG vehicles are gasoline engines. There are both dedicated and dual-fuel LPG engines. The majority of LPG-fueled engines are specially manufactured converted gasoline engines. Electronic software and hardware changes for LPG vehicles include additional sensors and controls necessary to operate the LPG fuel system.

LPG is primarily propane, which is fairly benign and does not cause many materials compatibility problems. LPG tanks are usually made from steel or from aluminum, and are made to conform to DOT and ASME regulations. Care should be taken in choosing elastomeric materials, as butyl rubber is not compatible with propane and hoses made from this material will swell and leak. Some materials compatibility problems may arise from water and/or residues left behind when propane is evaporated, including corrosion and deterioration of hoses and pipes.

LPG is currently used to fuel more light-duty vehicles than all other alternative fuels combined. Approximately 300,000 vehicles in the U.S. are fueled with LPG. Most of these vehicles are in fleets.

Biodiesel: Biodiesel refers to a diesel fuel produced by reacting vegetable oils with methanol or ethanol. Biodiesel is commonly used in a blend with 80% standard diesel fuel, a blend known as B20. Biodiesel can be used in compression-ignition engines with little or no modification.

Biodiesel is physically very similar to regular diesel fuel, and there has been no indication that any materials compatibility issues have arisen with metals used in the distribution, storage, dispensing, or onboard use of biodiesel. Some reports have been provided that biodiesel may cause problems with certain types of elastomeric materials. No special manufacturing techniques are needed for fuel systems for biodiesel vehicles, since biodiesel can be used in most diesel vehicles without making any modifications to the vehicle at all.

No electronic software or hardware changes are necessary to operate a vehicle on biodiesel. In colder climates, fuel heaters may be installed to prevent the biodiesel from gelling.

The biggest drawback to biodiesel is cost. The cost of fuel is determined by the feedstock being used, and the fuel price is estimated at $2.50 a gallon or more due to small-scale production and feedstock costs. Research activities are underway in the U.S. to use biodiesel, especially for urban transit.

Commercial/Merchandising Issues

Fleet vs. Public Sales: Data are not readily available to provide a quantitative accounting of how alternative fuel vehicle sales are being distributed between fleets and public users; however, some qualitative statements can be made. CNG, LNG, and propane vehicles are being sold primarily to fleet operators because the economics of these vehicles can be favorable, depending on the annual average fuel use of the fleet. DaimlerChrysler stated in their response to the *Federal Register* notice, that except for their E85 minivan program, almost every alternative fuel vehicle has been sold in the fleet market. Electric vehicles are being sold both to fleet users and to the public, with models such as the Toyota RAV4 EV being offered solely to fleet operators, and models such as the GM EV1 being offered predominantly to the public. The vast majority of ethanol flexible-fuel vehicles are being sold to the general public, because of the manufacturers' strategy of offering ethanol flexible-fuel capability in the entire production run of certain vehicle/powertrain combinations.

Marketing Strategies: Manufacturers are pursuing a variety of strategies to market alternative fuel vehicles to fleet buyers. These include the production of flyers and brochures targeted at specific areas of the fleet market, the production of Internet websites designed to highlight each manufacturer's alternative fuel offerings, and participation in various programs such as the DOE Clean Cities Program. Manufacturers are also participating in the DOE Clean Cities Program's *Advancing the AFV Choice* marketing seminars being held in Clean Cities across the nation. Manufacturers are also placing advertisements for their alternative fueled vehicle offerings in fleet and alternative fuel publications. A new marketing strategy recently employed by Ford Motor Co. is the advertisement of their alternative fueled vehicle offerings on the side of transit buses. Additionally, Ford also ran a series of ads for the Ford TH!NK City electric car, which were broadcast on network and cable television during the Spring of 2000.

Manufacturers are also cooperating in the production of educational material for use in schools such as the GM story, "Daniel and his Electric Car," and the Texas General Land Commission's "Alberta Einstein Music Video," and its companion board game.

To enable a new generation of engineers to become familiar with alternative fuel technologies, major automakers, government agencies and engineering societies are currently sponsoring student design competitions such as FutureTruck, FutureCar, the Ethanol Vehicle Challenge, and the Tour de Sol. University and college students participate in all four design competitions, while high school students participate in the Tour de Sol. In the first three competitions students are provided vehicles by the manufacturers, which they then modify to meet the goals of the challenge. In all competitions the vehicles then are formally judged against a multitude of criteria. The design team scoring the best overall is determined to be the winner. Awards are also given out for individual categories. The automakers benefit by witnessing new, innovative approaches to design and quite frequently end up employing many of the student engineers who were part of the design team, especially if it was a winning team. These competitions are widely publicized by the sponsors. This year, the FutureTruck competition was broadcast live on yahoo.com.

<u>Incentives</u>: A number of incentives are available to reduce incremental costs of alternative fuel vehicles for U.S. purchasers, both from the Federal government and from state governments. The Federal government offers a tax deduction of $2,000 to $50,000 (dependent on vehicle size) for the purchase or conversion of qualified alternative fuel vehicles, and a credit is available for 10% of the purchase price of an electric vehicle, up to $4,000. Thirty-five states offer some sort of alternative fuel vehicle incentive, including Colorado, which offers incentives that include a tax credit for up to 85 percent of the incremental cost of an alternative fuel vehicle, sales tax exemptions, and reduced fuel tax rates on CNG and LPG.

<u>Market Locations and Regional Sales Specifics</u>: Infrastructure considerations are a major influence on alternative fuel vehicle sales. Availability of an infrastructure in a given area for a given fuel will dictate whether or not vehicles using that fuel will be popular (or even available) in that area. Also, the availability of an infrastructure itself can vary from region to region depending on the availability of the alternative fuel. For example, propane vehicles are popular in rural areas, because of propane's availability in rural areas as a home heating fuel. Propane is especially popular as a motor fuel in Texas, because of that state's abundant natural supply of the fuel. Natural gas vehicles can be found throughout the U.S., since the country has an extensive natural gas pipeline system providing the fuel to most areas. While ethanol vehicles are sold throughout the country, ethanol vehicle infrastructure is centered in the corn-producing states in the Midwest.

In some cases, alternative fuel vehicle sales can dictate the construction of infrastructure. Electric vehicles are offered predominantly in California and Arizona due to the favorable climate in those states. It was felt by the auto manufacturers that the warm Southwestern climate offered the most favorable environment for these vehicles, and thus vehicles such as the GM EV1 were offered only in those two states. In this case, the electric vehicle infrastructure was constructed as a result of the increasing numbers of EVs being introduced.

Future AFV Technologies

The CAFE incentives have had a clear impact on the development of new alternative fuel vehicle technologies. For instance, ethanol vehicle technology has been developed significantly, to the point where these vehicles are being produced in large numbers at no incremental cost to the consumer. Also, the Partnership for a New Generation of Vehicles (PNGV) which was a program involving the government and the auto industry to develop a vehicle capable of obtaining 60 to 80 mpg fuel economy and AMFA programs have been mutually beneficial. These programs have produced technologies which are applicable to alternative fuel vehicles, in terms of weight reduction, high-pressure storage tanks, advanced batteries, etc. The PNGV program was instrumental in the development of fuel cells that can use alternative fuels such as hydrogen, methanol, or ethanol. This should result in increased interest in these alternative fuels in the future.

On January 9, 2002, DOE announced the establishment of the FreedomCAR program. FreedomCAR is a new public-private partnership with the nation's automobile manufacturers to promote the development of hydrogen as a primary fuel for cars and trucks. It replaces and builds on the PNGV program. It will focus on the research needed to develop hydrogen from domestic renewable sources, and technologies to enable mass production of affordable hydrogen-powered fuel cell vehicles and the hydrogen-supply infrastructure to support them.

The fuel cell employs a rather interesting technology in that it does not burn the fuel, but rather catalyzes it. The fuel cell uses hydrogen as a fuel and by combining it with oxygen, produces electricity and water as a by- product. Fuel cells are electrochemical energy conversion devices. They are two to three times more efficient than internal combustion engines in converting fuel to power. However, there remain any number of technological hurdles before the fuel cell replaces the internal combustion engine as the prime mover for motor vehicles. Size, weight, and cost are examples of some of the concerns. Although fuel cell prices have dropped from their space age levels, they are still much higher per kilowatt than the price of internal combustion engines.

Many of the technological advances that led to today's state of the art developments were in the areas of materials used in the fuel system to reduce evaporative emissions and corrosion caused by some fuels. Special fuel sensors were developed to aid in maintaining performance and making the transition from gasoline to the alternative fuel seamless in the operation and performance of the vehicle.

Ford has developed a number of new technologies to provide outstanding emissions along with safety and performance features on their dedicated natural gas vehicles. Technologies are being developed to apply these to their dual-fuel vehicles. Ford did not provide figures for the development cost of these technologies individually, but throughout the years, has spent more than one billion dollars on the development of alternative fuel vehicles.

While it is too early to predict what direction alternative fuel vehicles will take in the future, considerable work is underway in the areas of hybrid-electric vehicles, advanced battery development such as Lithium-Hydride, and fuel cells.

Impact of AMFA on Future Plans

Based on the auto manufacturers' response to the *Federal Register* notice, termination of the CAFE credit would result in a significant reduction in the number and types of alternative fuel vehicles available in the U.S. The manufacturers stated that the CAFE incentive program has been a major factor in developing and manufacturing alternative fuel vehicles in high volume. They also stated that extension of the credit provision will be a major factor in their decision to continue offering dual-fuel vehicles in the volumes that are being produced today.

The reduction in the available CAFE credit from 1.2 mpg to 0.9 mpg may result in a reduction of the number and types of alternative fuel vehicles made available in the U.S. Allowing the credit to remain at 1.2 mpg could result in as many as 1.2 million alternative fuel vehicles being made available each year, while reducing the credit to 0.9 mpg could result in only as many as about 900,000 alternative fuel vehicles being made available each year. It is likely that many of these 900,000 alternative fuel vehicles would not be made available if the credit were terminated. Such a reduction in the production of these vehicles would likely result in a sharp decrease in interest in expanding the alternative fuel refueling infrastructure, and possibly result in a decrease in the number of alternative fuel refueling stations being operated.

According to the study, *An Analysis of Alternative Fuel Credit Provisions of US Automotive Fuel Economy Standards* (Rubin, J. and Leiby, P., July, 2000), conducted by ORNL of the alternative fuel CAFE credit provisions, if the CAFE credits were reduced to zero, the number of alternative fuel vehicles purchased, (excluding those attributable to EPACT mandates) would fall to about 0.5% of new vehicle sales depending on the year in question. They then concluded that the value of alternative fuel vehicle-generated CAFE credits is responsible for about one-half of all new alternative fuel vehicles that will likely be produced over the next decade. That same study found that if alternative fuel vehicles are produced in large scale production runs and the retail availability of alternative fuel is equivalent to gasoline, there would be a 32% penetration of alternative fuel vehicles into the marketplace by the year 2010 and a 7% penetration of alternative fuels in the same year.

Number of Alternative Fuel Vehicles Subject to AMFA

The number and percentage of vehicles manufactured (annually & aggregate) since the beginning of MY 1993 with dedicated and dual-fuel capacity is shown in Table III-1.

Table III-1

Year	Total Car Production (Thousands)	Dedicated Fuel Cars (Thousands)	Flexible-fuel Cars (Thousands)	Flexible-fuel Percent of Total
1993	8040.8		2.0	.025
1994	8544.0		2.4	.028
1995	9497.1		2.0	.021
1996	7922.7		5.3	.067
1997	8043.2	2.3	5.1	.063
1998	8267.4	0.3	3.5	.042
1999	8773.9	0.8	4.8	.055
2000	8962.9	0.4	126.2	1.408
TOTAL	68052.0	3.8	151.3	.222

Year	Total Light Trucks Production (Thousands)	Dedicated Fuel Light Trucks (Thousands)	Flexible-fuel Light Trucks (Thousands)	Flexible-fuel Percent of Total
1993	4788.4	0.2		
1994	5470.7	1.5		
1995	5677.7			
1996	5241.7	0.7		
1997	6118.7	0.7		
1998	6499.7	1.9	147.2	2.265
1999	6748.9	1.6	420.1	6.225
2000	7228.1	1.0	546.7	7.564
TOTAL	47773.9	7.6	1114.0	2.332

Dual (Flexible) Fuel Vehicle Lines Available in MY 2000 vs. MY 1993

<u>Passenger Cars</u>

In MY 1993, the only flexible-fuel car was the Ford Taurus FFV with a production of 2,000. Again in MY 1994, MY 1995, and MY 1996, the Ford Taurus FFV was the only flexible-fuel car, with a production of 2,400 in MY 1994, a production of 2,000 in

MY 1995, and a production of 5,300 in MY 1996.

Ford produced 5,100 Taurus FFV's in MY 1997. The Ford Taurus FFV was the only flexible-fuel car produced in MY 1998, with a production of 3,500. In MY 1999, the Ford Taurus FFV repeated as the only flexible-fuel car with a production of 4,800. The Ford Taurus FFV and Ford Taurus wagon FFV, with a combined production of 126,200 were the only MY 2000 flexible-fuel passenger car models.

<u>Light Trucks</u>

From MY 1993 through MY 1997 there were no dual-fuel light trucks produced. In MY 1998 there were two Chrysler flexible-fuel light trucks:

Caravan/Voyager 2WD FFV: production of 142,800 (4-speed automatic)
Town & Country 2WD FFV: production of 4,400 (4-speed automatic)

There were no other flexible-fuel light trucks produced in MY 1998. In MY 1999, DaimlerChrysler (DC) had three dual-fuel trucks in its domestic fleet as follows:

Caravan 2WD FFV: production of 148,600 (4-speed automatic)
Town & Country 2WD FFV: production of 5,900 (4-speed automatic)
Voyager 2WD FFV: production of 77,200 (4-speed automatic)

There were four dual-fuel Ford light truck lines sold in MY 1999:

Ranger 4X2 FFV: production of 97,100 (4-speed automatic)
Ranger 4X2 FFV: production of 24,700 (5-speed manual)
Ranger 4X4 FFV: production of 47,300 (4-speed automatic)
Ranger 4X4 FFV: production of 19,300 (5-speed manual)

In MY 2000, there was an expansion of the availability of flexible-fuel light trucks. This included:

GM produced four light trucks:

Sonoma 2WD-FFV: production of 12,500 (4-speed automatic)
Sonoma 2WD-FFV: production of 6,200 (5-speed manual)
S10 2WD FFV: production of 54,300 (4-speed automatic)
S10 2WD FFV: production of 26,100 (5-speed automatic)

There were two DaimlerChrysler light truck models:

Caravan 2WD FFV: production of 203,200 (4-speed automatic)
Town & Country 2WD FFV: production of 31,600 (4-speed automatic)

Ford/Mazda produced eight flexible-fuel light trucks models:

Mazda 2WD FFV: production of 8,600 (4-speed automatic)
Mazda 2WD FFV: production of 4,700 (4-speed automatic)
Ranger 2WD FFV: production of 113,000 (4-speed automatic)
Ranger 2WD FFV: production of 22,200 (5-speed manual)
Mazda 4WD FFV: production of 2,000 (4-speed automatic)
Mazda 4WD FFV: production of 1,200 (5-speed manual)
Ranger 4WD FFV: production of 48,300 (4-speed automatic)
Ranger 4WD FFV: production of 12,800 (5-speed manual)

Impact of Flexible-fuel Vehicles on MY 1993-1999 CAFE

An analysis was performed to determine the impact of flexible-fuel cars and light trucks on CAFE during MY 1993-1999. The analysis consisted of identifying the flexible-fuel vehicles in each model year and comparing the CAFE computed using the flexible-fuel credits for these vehicles, indicated by CAFE FFV, with the CAFE computed using "normal" fuel economy values.

In MY 1993, the Ford Taurus FFV was the only flexible-fuel car which had credits entitling it to a fuel economy of 42.4 mpg and an estimated mid-model year production of 2,000. This produced a Ford domestic CAFE of 27.95 mpg based on mid-model year data. However, if this particular Taurus had a "normal" fuel economy of 28.0 mpg (for a 3.0 Liter Taurus), then the Ford domestic CAFE would have been 27.94 mpg, or 0.01 mpg less.

From MY 1993 through MY 1999 the Ford Taurus was the only flexible-fuel car with measurable (at least 0.1 thousand) production. As seen in the accompanying table, the inclusion of the Taurus flexible-fuel vehicle fuel economy credits produced a benefit of no more than 0.03 mpg in the Ford domestic CAFE.

There were no dual-fuel light trucks produced from MY 1993 through MY 1997. In MY 1998 and MY 1999 there were over 300,000 Caravan/Voyager and Town and Country flexible-fuel vans produced by Chrysler/DaimlerChrysler. Ford estimated almost 200,000 Ranger flexible-fuel sales in its MY 1999 fuel economy report. The increase in light truck CAFE due to the flexible-fuel vehicle credits, i.e., CAFE FFV-CAFE Normal, ranged from 0.57 mpg to 0.94 mpg as shown in Table III-2.

Table III-2
MY 1993-1999 CORPORATE AVERAGE FUEL ECONOMY USING FLEXIBLE-FUEL ECONOMY CREDITS COMPARED WITH "NORMAL" CAFE

		Ford Domestic Cars	Chrysler/DaimlerChrysler Domestic Trucks	Ford Domestic Trucks

MY	Actual EPA Year End	MMY CAFE with FFV credit	MMY CAFE Normal	MMY CAFE with FFV credit	MMY CAFE Normal	MMY CAFE with FFV credit	MMY CAFE Normal
1993	28.3	27.95	27.94	*	*	*	*
1994	27.7	27.37	27.35	*	*	*	*
1995	27.7	27.45	27.44	*	*	*	*
1996	26.4	26.61	26.59	*	*	*	*
1997	27.2	27.09	27.06	*	*	*	*
1998	27.8	27.34	27.31	20.54	19.93	*	*
1999	27.6	26.94	26.91	20.74	19.80	20.41	19.84

* No flexible-fuel vehicles produced in these years.
Note: Mid-Model Year (MMY) CAFE level differs from EPA final year end totals due to additional adjustments made by EPA. The first column indicates these totals for Ford domestic cars as an example.

While dedicated alternative fuel vehicles played an important role during the process of technological developments for dual-fuel alternative fuel vehicles, their intrusion into the marketplace has been too small to have had any impact on the CAFE of manufacturers.

Economic incentives to produce flexible-fuel vehicles

The previously referenced ORNL study, *An Analysis of Alternative Fuel Credit Provisions of US Automotive Fuel Economy Standards* (Rubin, J. and Leiby, P., July, 2000), examined how CAFE credits for producing alternative fuel vehicles influence the behavior of vehicle manufacturers. In doing so, the study estimated the value to vehicle manufacturers of CAFE credits that are generated from the sale of alternative fuel vehicles. The study concludes that the theoretical marginal value of a CAFE credit from the production of a dedicated alternative fuel vehicle and a flexible/dual-fuel vehicle would be $1100 and $550 respectively. When adjusted by the ratio of actual versus estimated total penalties paid over the ten-year period 1986-1995 ($45 million/$71 million), the range of marginal values becomes $638-$319 per dedicated and flexible/dual-fuel vehicles respectively.

If model volumes are 100,000 units per annum or more, the incremental manufacturing cost associated with alcohol dedicated or alcohol flexible-fuel vehicles will be substantially less than the projected marginal value of the CAFE credit under either of the above scenarios.

	Marginal Value	**Marginal Value (Adj.)**	**Incremental Per Unit (@ 100,000 units/ year)**
Dedicated Alcohol	$1100	$638	$223
Flexible/Dual Alcohol	$ 550	$319	$284

Thus the net effect of the credit could provide a benefit to the manufacturer between $415 per unit for the dedicated alcohol fueled model ($638-$223) and $35 per unit ($319-$284) for the flexible-fueled model when using the more conservative adjusted market value estimates. If the unadjusted market value per credit estimates are used, the gap between per unit credit and incremental manufacturing cost becomes even more favorable to the auto maker. The net per vehicle credit would be $877 for the dedicated model ($1100-$223) and $266 for the flexible-fueled model ($550-$284).

The other alternative fuel technologies for which cost volume estimates were made include CNG, LPG, and electric power. Diesel and electric or gas and electric hybrid technologies were not investigated by ORNL. Of the remaining technologies, only LPG would yield a net credit to the vehicle manufacturer when the unadjusted marginal value per credit assumption is used:

	Marginal Value	Marginal Value (Adj.)	Incremental Per Unit
Dedicated LPG	$1100	$638	$741
Flex/Dual LPG	$550	$319	$887

The dedicated LPG fueled vehicle would yield a net credit per vehicle of $359 ($1100-$741) at an annual production volume of 100,000 vehicles. The study did not quantify incremental manufacturing costs at higher annual volumes and all other technologies did not yield a favorable net credit.

CNG technology proved to be nearly twice as expensive as LPG and even less attractive from the standpoint of net marginal CAFE credits to auto manufacturers:

	Marginal Value	Marginal Value (Adj.)	Incremental Per Unit
Dedicated	$1100	$ 638	$1548
Flexible / Dual	$ 550	$ 319	$1701

Whether the marginal value of the CAFE credit is adjusted or not, the result is a net manufacturing cost increase per vehicle. For the dedicated CNG vehicle, net incremental cost is $448 unadjusted ($1100-$1548). Net incremental cost for the flexible-fuel vehicle is $1151 unadjusted ($550-$1701). The comparison between marginal credit vs. marginal cost is much more unfavorable when the CAFE credit is adjusted. Net incremental costs after adjustment would be $910 for the dedicated fuel vehicle($638-1548) and $1382 for the flexible-fuel vehicle ($319-$1701).

The study concluded that there is strong evidence to believe that the CAFE credit incentives for alternative fuel vehicles have value to U. S. manufacturers since manufacturer-specific data show that current CAFE standards are a binding constraint. The value of these CAFE credits was found to exceed the incremental manufacturing costs of alcohol alternative fuel vehicles at medium-to-large scale production volumes.

Summary

The AMFA CAFE credit program has been successful in stimulating a significant increase in the availability of alternative fuel vehicles (mostly E85 flexible-fuel vehicles). While the number of dedicated alternative fuel vehicles (cars and light trucks) has actually decreased in recent years, the growth in dual-fuel vehicles has been significant, especially in the past three years. Since 1998, the annual production of flexible-fuel light trucks has increased 270 percent, and from 1999 to 2000, the annual production of flexible-fuel passenger cars grew from 4,800 to 126,200 vehicles. Since EPACT was enacted in1992, the population of alternative fuel vehicles has grown to over 1.2 million vehicles, and the number of alternative fuel vehicles in the Federal fleet has increased from a small number of demonstration vehicles under AMFA to over 45,000 alternative fuel vehicles in 2000. In their comments responding to the *Federal Register* notice, automobile manufacturers stated that the CAFE credit provision has strongly influenced their decision to produce dual-fuel vehicles and would continue to do so in the future.

IV. Availability and Use of Alternative Fuels

Transportation's Dependence on Petroleum and Issues Relevant to Energy Supply and Price

Since the petroleum "shocks" of the 1970s, the inflation-adjusted price of crude oil has generally declined until the spring of 2000 when prices increased due to renewed resolve by OPEC and some non-OPEC members to control crude oil supply to raise prices. Since the oil shocks of the 1970s several events combined to keep oil prices low: the end of the Cold War; a diminution in the market power of OPEC due to an increase in petroleum production from non-OPEC nations; and the cementing of U.S. security ties to the most important oil-exporting nations. Unfortunately, these developments have engendered a complacency on the part of the American public not unlike that which preceded previous oil shocks. The growing dependence of the U.S. on imported petroleum offsets the positive developments that have occurred in the global petroleum market over the past 20 years, i.e., the potential impact of a petroleum shock on the U.S. is growing regardless of its origin or whether it is politically motivated. Historically, periods of low prices have been followed by steep price spikes, of which we have just recently been reminded.

Based on information collected by the EIA in 1999, world crude oil reserves amount to about 1,000 billion barrels, and world natural gas reserves amount to about 5,140 trillion cubic feet. Of this total, the Middle East controls about 65 percent of the world's oil reserves and about 35 percent of the world's natural gas reserves (the former U.S.S.R. controls another 38 percent of the world's natural gas reserves). North American reserves of oil amount to just 6-7 percent of world reserves, and North American reserves of natural gas amount to just 5-6% of world reserves. Today, the Persian Gulf region holds about two-thirds of the entire world's known oil reserves. The U.S. imports more than 53 percent of its petroleum–much of it coming from the Persian Gulf region. EIA's Annual Energy Outlook 2000 estimates that this oil importation will increase to 62 percent by the year 2010.

The world's oil resources are as concentrated as ever in the OPEC nations, notably in the Persian Gulf. EIA projects that by 2010, OPEC's market share is likely to reach the levels of the 1970s, as its share of world supply grows from 41 percent in 1992 to 52 percent in 2000 to over 65 percent in 2020. In addition to concern about concentration of oil resources, new concerns have recently been raised that the peak in oil production could occur within ten years.[1] Economic growth in the Pacific rim is giving rise to a growth in world oil demand that could well lead to a short-supply situation within the next five to ten years. Recent analysis by EIA indicates that the world oil production peak may not occur for another 20 to 50 years.[2] Regardless of when the peak is reached, crude oil prices are likely to increase significantly in advance of peak production.

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[1] "The End of Cheap Oil," Colin J. Campbell and Jean H. Leberrère, *Scientific American*, Volume 278, No. 3, March 1998.

[2] "Long Term World Oil Supply," Energy Information Administration presentation, April 2000.

The costs to the U.S. economy from a future oil price shock could be enormous. Based on analyses of previous oil shocks, recent studies have estimated the macroeconomic impacts as reducing U.S. economic activity by an average of over 2 percent per year for three to four years or more, which translates into gross national product (GNP) reductions in the range of six hundred billion dollars over three years, up to possibly $3 trillion over fifteen years if the lost economic growth were not subsequently made up.[3,4]

Unfortunately, unlike other energy using sectors, which have introduced substitute fuels and fuel switching flexibility since the oil shocks of the 1970s and 1980s, the transportation sector remains overwhelmingly dependent on petroleum-based fuels (approximately 95 percent of transportation energy coming from petroleum) and on technologies that provide virtually no flexibility. The transportation sector currently accounts for approximately two-thirds of all U.S. petroleum use and roughly one-fourth of total U.S. energy consumption. Highway transportation petroleum consumption has risen from 121 billion gallons per year in 1979, when CAFE was enacted, to 155 billion gallons per year in 1999 (28 percent over 20 years). EIA's Annual Energy Outlook 2000 projects U.S. dependence on imported petroleum will grow to 54 percent in 2000 and 60 percent in 2005.

In light of this dependence of the transportation sector on petroleum (and recent sharp increases in the price of gasoline), it is clear that substitution of petroleum-based transportation fuels (gasoline and diesel) by non-petroleum-based fuels ("replacement fuels," including alternative fuels such as electricity, ethanol, hydrogen, liquefied petroleum gas, methanol, and natural gas) could be a key means of reducing the vulnerability of the U.S. transportation sector to disruptions of petroleum supply and have significant benefits to the U. S. economy. Even moderate uses of alternative and replacement fuels in place of petroleum can bestow significant economic benefits by reducing the global demand and price for oil. Displacing petroleum with alternative and replacement transportation fuels helps hold down petroleum prices in two ways. First, reducing the demand for petroleum decreases the world price for oil. Although the actual impact will depend on precisely how OPEC responds, a reasonable rule of thumb is that a 1 percent decrease in U.S. petroleum demand will reduce world oil price by about 0.5 percent, in the long-run. Short-run (one year or less) impacts would be even greater, due to the short-run inelasticity of oil supply and demand.

A second benefit of increased alternative and replacement fuel use is its potential to reduce the impact of a supply shortage on prices. As evidenced in the industrial and utility sectors, the existence of alternatives to oil provides potential substitutes for oil in the event of a production cutback. Since it is precisely the non-responsiveness of transportation oil demand to oil production cutbacks that makes oil price shocks possible, increasing competition for oil by using

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[3] Energy Modeling Forum, "International Oil Supplies and Demands," EMF Report 11, Vol. II, April 1992, Stanford University.

[4] Greene, David L., and Leiby, Paul N., "The Social Costs to the U.S. of Monopolization of the World Oil Market, 1972-1991," Oak Ridge National Laboratory, March 1993, ORNL-6744.

alternative fuels reduces the ability of oil suppliers to constrain supply in order to increase the price of oil.

Availability of Alternative Fuels

The National Energy Policy Development Group, in its May 17, 2001, report on the National Energy Policy states that, “The lack of infrastructure for alternative fuels is a major obstacle to consumer acceptance of alternative fuels and the purchase of alternative fuel vehicles.” The report further states that lack of infrastructure, “is also one of the main reasons why most alternative fuel vehicles actually operate on petroleum fuels, such as gasoline and diesel.” The report’s discussion of alternative fuel vehicles includes the statement that, “ethanol vehicles offer tremendous potential if ethanol production can be expanded.” Additionally, the report states that, “a considerable enlargement of ethanol production and distribution capacity would be required to expand beyond their current base in the Midwest in order to increase use of ethanol-blended fuels.”

The National Renewable Energy Laboratory reports that there are 5,236 alternative fuel refueling sites as of May 2001, with alternative fuel refueling sites in all 50 states. In comparison, there were 4,676 alternative fuel refueling sites in the U.S. in 1995. Unfortunately, while ethanol is the alternative fuel that most of the dual-fuel vehicles that have been produced can operate on, less than three percent of the alternative fuel refueling sites offer ethanol.

The Federal government, and specifically DOE, the General Services Administration and the Department of Agriculture are involved with efforts to promote the use and expansion of alternative fuels and the alternative fuel infrastructure. A major focus of these efforts is the development of different feedstocks for ethanol and on partnerships that result in the expansion of the ethanol fueling infrastructure.

DOE runs the Clean Cities Program, which unites public-private partnerships that deploy AFVs and build supporting infrastructure, with the common goal of building the alternative fuels market. Within these partnerships reside fuel suppliers, which are continually committing to providing facilities, fuels and services.

DOE also operates the Office of Fuels Development (OFD), whose primary focus is on working to reduce the cost of replacing imported oil with ethanol made from domestic resources such as corn fiber, bagasse and rice straw. OFD programs look to the longer term, with efforts investigating more advanced ethanol conversion technologies utilizing plants, trees and other feedstocks grown specifically for energy purposes. OFD also includes a vital outreach and educational effort under its purview - the Regional Biomass Energy Program (RBEP). The specific goal of the RBEP is to increase the production and use of bioenergy resources, and help to advance the use of biomass feedstocks and technologies.

DOE and the General Services Administration (GSA) are jointly managing a program called the Federal AFV USER Program, whose goal is to support the expansion of an alternative fuel infrastructure by concentrating large quantities of Federal AFVs and substantially increasing the use of alternative fuels in Federal AFVs in six selected areas: Albuquerque, NM; Denver, CO; Melbourne/Titusville/Kennedy Space Center, FL; Minneapolis/St. Paul, MN; Salt Lake City, UT; and the San Francisco Bay area.

In August 2001, the USDA announced that its agencies will use ethanol fuels in their fleet vehicles where practicable and reasonable in cost. USDA's more than 700 E-85 flex-fuel vehicles will use ethanol fuel where those vehicles operate in geographical areas that offer E-85 fueling stations, and USDA agencies will purchase or lease alternative fuel vehicles, including E-85 flex-fuel vehicles, for geographic areas that offer alternative fueling.

Presented below is information on the number of sites providing each alternative fuel and some additional information on where these sites are located.

Ethanol: There are 121 ethanol (E85) refueling sites in the U.S., up from 37 in 1995. Ethanol refueling sites can be found predominantly in the Midwest, close to the major supplies of ethanol. Efforts by DOE are underway in Minnesota to help construct a number of ethanol refueling sites. As seen with the CNG, fuel suppliers can rise to meet the demand by developing the necessary infrastructure. Although the trend in alternative fuels is in the direction of E85 use, the infrastructure has been slow to develop because these vehicles could use conventional fuel. However, it is important to note that even if relatively few of these vehicles are actually being operated on E85, it is still valuable to be increasing that capability throughout the fleet because it could potentially contribute to the future transition away from petroleum, could spur an increase in the number of E85 refueling sites, and provide consumers an alternative if there are gas shortages or gas prices increase significantly.

Further, studies have shown that refueling stations need at least 200 steady customers for any single grade in order to make profitable use of the facilities. Though large numbers of flexible-fuel vehicles are being sold, they are spread out over the entire nation, and achieving a "critical mass" of 200 that use a single refueling station is still difficult to achieve. The small number of outlets available today points out the need to intensify the E85 refueling infrastructure. In addition, it is safe to say that many people who have purchased flexible-fuel vehicles do not know they could use E85. More public education in areas where E85 refueling stations exist is needed to inform people so that they are aware they can use E85.

Methanol: There are only two methanol (M85) refueling sites in the U.S., significantly down from 88 in 1995. Both of these sites can be found in California. The total number of methanol (M85) refueling sites has been dropping in the past few years, due to the lack of M85-capable flexible-fuel vehicles.

Natural Gas: There are currently 1,237 CNG refueling sites and 44 LNG refueling sites in the

U.S., up from 1,065 CNG refueling sites in 1995. Natural gas refueling stations are usually located in urban areas near the major concentrations of natural gas vehicles, and are frequently constructed on a company's site to serve its fleet vehicles.

Electricity: There are 558 electric recharging sites in the U.S., up from 188 in 1995. The vast majority of electric recharging sites can be found in the Southwest (California and Arizona), where the majority of electric vehicles are being sold. There is also a large concentration of electric recharging sites in Alabama and Georgia, where electric utilities have been proponents of electric vehicles. The availability of public refueling is not as important for electric vehicles as it is for other alternative fuels, since most (if not all) operators of electric vehicles will have a charger located at the vehicle's storage yard or garage to recharge the vehicle when it is not being used.

Liquefied Petroleum Gas (LPG): There are currently 3,270 propane sites in the U.S.. LPG is sold throughout the U.S. as a home heating fuel, and many stations offering refueling of propane tanks also offer vehicle refueling.

Biodiesel: There are currently four biodiesel refueling sites in the U.S. The National Biodiesel Board counts seven major suppliers of biodiesel as members, located mostly in the Midwest. Biodiesel can be pumped through conventional diesel refueling equipment, so widespread availability of biodiesel would not pose a major obstacle with respect to infrastructure.

As of May 2001, there were 121 public E85 refueling outlets in operation. For LPG, the most widely available alternative fuel, although it has availability in all states, there are only 3,270 outlets in the U.S. These outlets require little maintenance. There are 1,237 CNG outlets in the U.S. For M85, there are only two refueling sites remaining. There are 44 LNG outlets, and 558 electricity outlets in the U.S. As illustrated in the following table and in Appendix C, this adds up to a current total of 5,236 alternative fuels refueling stations in the U.S.

Table IV-1
NUMBER OF ALTERNATIVE FUEL REFUELING OUTLETS

ALTERNATIVE FUEL INFRASTRUCTURE	
Fuel	Total Number of Outlets
E85	121
Electricity	558
LPG	3,270
CNG	1,237
LNG	44
M85	2
Biodiesel	4
Total outlets	5,236

The costs to retrofit an existing gasoline tank for E85 range from $5,000 to $30,000. For a new, underground tank and pump, the price ranges from $50,000 to $70,000. For LPG, the installation cost of a new outlet is $25,000 to $40,000. For CNG, the installation cost for an initial outlet is $250,000 to $500,000.

Energy Equivalence of Alternative Fuels to Conventional Fuels

The table below illustrates the amount of each alternative fuel necessary to provide the same energy as a gallon of gasoline or diesel fuel.

Table IV-2
ALTERNATIVE FUEL EQUIVALENCY

	CNG	**LNG**	**Propane**	**Methanol (M85)**	**Ethanol (E85)**	**Biodiesel (B20)**
Gasoline	125 scf	1.5 gal	1.4 gal	1.8 gal	1.4 gal	0.9 gal
Diesel	139 scf	1.7 gal	1.5 gal	2.0 gal	1.6 gal	1.0 gal

It is difficult to calculate a gasoline equivalency for electricity because the conversion of a fuel to energy is not done onboard the vehicle, as with an internal combustion engine, but is merely stored on the vehicle in batteries. For the purposes of the EPA Fuel Economy Guide, energy consumption by electric vehicles is reported in terms of kilowatt-hours per 100 miles. For purposes of corporate average fuel economy, a petroleum-equivalent fuel economy is calculated using a petroleum equivalence factor of 82,049 Watt-hours per gallon. This factor takes into consideration the relative efficiency of the electricity production and distribution infrastructure, the energy content of the electricity, and a fuel content factor. To illustrate the results of this calculation, the electric Ford Ranger has a city rating of 38 kWh/100 miles and a highway rating of 44 kWh/100 miles, or a combined rating of 41 kWh/100 miles. This corresponds to a petroleum-equivalent fuel economy of 202 miles per gallon using the above factor.

Fuel Prices Relative to Gasoline and Diesel

A survey of Clean Cities was conducted in April 2000 to determine average prices for alternative fuels across the nation. Table IV-3 illustrates the average retail prices determined as a result of this survey. As this table shows, compressed natural gas cost less per gasoline-equivalent gallon (GGE) than gasoline, but LPG and ethanol cost more per GGE. No price estimates were available for methanol or for biodiesel, but both would probably be more expensive than gasoline or diesel fuel.

Table IV-3
SELECTED FUEL PRICES AS OF APRIL 10, 2000

Gasoline	$1.52 / gallon	Methanol	n/a
Diesel	$1.42 / gallon	Ethanol	$1.80 / GGE
CNG	$0.89 / GGE	Electricity	$0.07 / kWh
LPG	$1.62 / GGE	Biodiesel	n/a

Use of Alternative Fuels

Alternative fuel use in the U.S. has grown significantly since the passage of AMFA alternative fuel incentives, as illustrated in Table IV-4. In 1992, alternative fuel use in the U.S. amounted to 230 million gasoline gallon equivalents; in 2000, alternative fuel use is estimated to be 368 million gasoline gallon equivalents, an overall increase of 60 percent.[5]

[5] Data on alternative fuel use is only available from 1992 to the present.

As seen in Table IV-4, all of the alternative fuels have seen notable increases in use between 1992 and 2000, with the exception of methanol (neat and in M85) and ethanol in an E95 blend. The rise in CNG and LNG usage is due to an increasing number of CNG and LNG vehicles available from original-equipment manufacturers. A large increase in ethanol (in the form of E85) has also occurred, due to increased interest in E85 spurred by the large numbers of E85 flexible-fuel vehicles being produced by the domestic manufacturers.

Table IV-4
ALTERNATIVE FUEL USE 1992 & 2000, MILLION GASOLINE GALLON EQUIVALENTS

	1992	**2000**	**% Change**
LPG	208.1	250.0	20%
CNG	16.8	104.5	520%
LNG	0.6	7.5	1,150%
Methanol (M85)	1.1	1.1	0%
Methanol, Neat	2.5	0.4	(85%)
Ethanol (E85)	0.02	3.3	16,400%
Ethanol (E95)	0.1	0.1	0%
Electricity	0.4	1.7	325%
Total	229.6	368.1	60%

Electricity has also enjoyed a large increase, due to the OEM offerings of electric vehicles in the Southwest.

Methanol usage and E95 usage have experienced a decline between 1992 and 2000. Methanol usage in a blend of 15 percent gasoline (known as M85) has not seen an increase, and it is likely that this alternative fuel use will decline further in the coming years, due to a lack of methanol flexible-fuel vehicles being offered. The large decrease in neat methanol use can be attributed to neat methanol's popularity as a transit bus fuel in the early 1990's and the phase-out of these vehicles within the last four or five years. The small amount of E95 (ethanol blended with 5 percent gasoline) can be attributed to a small fleet of transit buses; it is not likely at this point that this use will increase in the coming years.

Change in Rate of Alternative Fuels Consumed

Alternative fuel use in alternative fuel vehicles in the U.S. has been rising over the past decade. In 1992, EIA estimated that a total of 230 million gasoline gallon equivalents of alternative fuel were used in alternative fuel vehicles; for 2001, that number is projected to rise to 366 million gasoline gallon equivalents, or an increase of roughly 6 percent per year. In comparison, the highway use of gasoline and diesel was about 133 billion gallons in 1992, and that number is projected to rise to about 164 billion gallons in 2001, or an increase of roughly 2 percent per year. Thus, alternative fuel use in alternative fuel vehicles has been rising at a rate three times faster than the total highway use of gasoline and diesel. Nonetheless, alternative fuel use only accounts for 0.22 percent of total highway fuel use.

Alternative Fuel Use Relative to Total Energy Consumption

In 2000, according to EIA, the U.S. consumed about 99 quadrillion BTU of energy (equivalent to about 859 billion gallons of gasoline) in all of its energy-consuming activities. Transportation activities (road, air, water, and rail) represent about 27 percent of that total, or the equivalent of about 243 billion gallons of gasoline. Highway transportation consumption was about 157 billion gallons, or about 67 percent of total transportation energy usage.

Ethanol: Ethanol is used either as E85 to power flexible-fuel vehicles, or blended into gasoline to make gasohol. In 2000, the U.S. used about 1.0 billion gasoline gallon equivalents of ethanol in these two uses.

Methanol: Methanol is used either as M85 to power flexible-fuel vehicles, or as MTBE blended into gasoline as an oxygenate. In 2000, the U.S. used about 3.1 billion gasoline gallon equivalents of methanol in these two uses.

Natural Gas: In 2000, the U.S. used about 18.8 quadrillion BTU (or about 163 billion gasoline gallon equivalents) of natural gas (excluding natural gas used to make electricity). Natural gas use in transportation is estimated to represent about 0.06 percent of that total, or 98 million gasoline gallon equivalents.

Liquefied Petroleum Gas (LPG): In 2000, the U.S. used about 2.7 quadrillion BTU (or about 24 billion gasoline gallon equivalents) of LPG. LPG use in transportation is estimated to represent about 1.0 percent of that total, or 243 million gasoline gallon equivalents.

Electric: In 2000, the U.S. used about 3.4 trillion kilowatt-hours of electricity. Electric use in transportation is estimated to represent about 0.002 percent of that total, or 57 million kilowatt-hours.

Biodiesel: No estimates have currently been made of the amount of biodiesel being used in the U.S.

Ethanol Supply and Demand

Due to the water quality concerns regarding MTBE and the rapidly increasing number of E85 flexible-fuel vehicles, the supply and demand of ethanol was specifically examined. Information about current ethanol supply capacity, as well as information about ethanol plants being constructed and ethanol plants being planned, was taken from an ethanol supply and demand analysis performed for the Renewable Fuels Association. This report indicated that currently, ethanol production capacity in the U.S. is about 1.72 billion gallons per year. Plants under construction can add another 123 million gallons per year, and plants in the engineering and planning stages can add another 149 million gallons per year. The analysis assumed that the plants being constructed and the plants being planned would all be online in 2003, providing a total ethanol production capacity of about 1.99 billion gallons of ethanol per year. A straight line extrapolation results in estimated 2010 production capacity of about 2.6 billion gallons per year. This represents an increase in production capacity of about 4.3 percent per year.

Ethanol in gasohol was assumed to be a constant percentage of highway gasoline use, based on current gasohol use of 1.1 percent of highway gasoline, taken from EIA alternative fuels information. The increase in ethanol use in gasohol is due to EIA projections that gasoline use will continue to increase in the 2000-2010 time frame. It is projected that the use of ethanol in gasohol will increase from about 1.2 billion gallons in 2000 to about 1.6 billion gallons in 2010.

Based on this analysis, the ethanol supply remaining for ethanol use in flexible-fuel vehicles is the difference between the total ethanol supply and the ethanol use in gasohol. (This analysis did not make any estimates of the replacement of MTBE with ethanol in gasoline.) It is estimated that the amount of ethanol available for use in flexible-fuel vehicles increases from about 400 million gallons in 2000 to about 1 billion gallons in 2010.

MTBE Phase-out

Since ethanol is the alternative fuel that most dual-fuel vehicles are capable of operating on, it is important to note the current water quality concerns regarding MTBE, an additive used to increase the oxygen content of gasoline. If MTBE is banned as a gasoline additive and fuel producers replace MTBE with ethanol, it is uncertain if there will be enough refinery capacity to both replace MTBE and to fuel flexible-fuel vehicles a substantial portion of the time with E85. Because of this situation, along with the small number of ethanol refueling stations nationwide coupled with the growing number of vehicles capable of using ethanol entering the marketplace, some special incentives to spur the development of an E85 refueling supply and distribution network might be warranted.

Summary

EPACT was enacted to encourage the use of alternative fuels and replacement fuels (non-petroleum components of conventional fuels), by setting goals of replacing 10 percent of motor fuel use in 2000 and 30 percent of motor fuel use in 2010 with alternative fuels or replacement fuels. The intent of EPACT was to accomplish the goals through mandates that require certain fleets to purchase and use alternative fuel vehicles. EPACT does not, however, mandate any level of alternative fuel usage in the vehicles acquired. Since EPACT was enacted, alternative fuel use has risen from 230 million gasoline-gallon equivalents to 368 million gasoline gallon equivalents, and replacement fuel usage (MTBE and ethanol in gasohol) has risen from 1.9 billion gallons to 4 billion gallons. Nonetheless, while the availability and use of alternative fuels has increased since the inception of the CAFE credit incentive provision, it has not nearly kept pace with the increase in the number of alternative fuel vehicles. Due to the lagging development of the alternative fuel infrastructure, the vast majority of dual-fuel vehicles rarely operate on alternative fuel.

V. Analysis of the Effects on Energy Conservation and the Environment

The CAFE incentives available to manufacturers for selling vehicles capable of operating on alternative fuels have led to sales of more than one million E85 flexible-fuel vehicles (FFV) through the 2000 model year. Automobile manufacturers have responded to the incentives Congress provided in the Act. However, for several reasons, these FFVs are operating almost exclusively on gasoline.

The CAFE credit incentive for dual-fuel vehicles can assist manufacturers in complying with the CAFE standards. Other than producing dual-fuel vehicles, manufacturers must either use other means (weight reductions, advanced technology, pricing, mix shifting, and/or marketing) to meet the standards or pay civil penalties for not meeting the standard.

Conducting an assessment of the energy and environmental impacts of the dual-fuel vehicle credit incentive is complicated by behavioral uncertainty. While the use of alternative fuels can reduce petroleum consumption and greenhouse gas emissions, the energy consumption and environmental impacts cannot be assessed with any reasonable amount of certainty because we cannot determine what manufacturers would have done in the absence of the credit incentive. If it is assumed that vehicle manufacturers took advantage of the incentive to relax the effect of the CAFE standard on the rest of their fleet, then the credit incentive has resulted in an increase in alternative fuel use (almost all E85), and some slight increase in petroleum consumption (about one percent) and greenhouse gas emissions (well less than one percent).

It is also possible that manufacturers might have responded to strong consumer demand for performance and utility and produced the same vehicles without the provision as they did with it. In this case, manufacturers would have chosen to pay civil penalties rather than meet the CAFE standard. Under this scenario, the main effect of the program has been to greatly expand the population of vehicles that have the potential to use alternative fuels.

This section presents an estimate of the possible energy conservation and environmental effects to date, as well as projections through 2008, using an assumption that manufacturers utilized the incentive to relax the effect of the CAFE standard on the rest of their fleet. This assumption yields an “upper bound” estimate of the increase in petroleum consumption and greenhouse gas emissions. The analysis focuses on E85 flexible-fuel vehicles because they represent almost all of the vehicles that have been produced that are eligible for the credit. Note that because dual-fuel vehicles must meet Federal emission standards for criteria pollutants such as NO_x and volatile organic compounds, on both gasoline and the alternative fuel, the most significant environmental impacts are on greenhouse gas emissions. Therefore, the analysis of environmental impacts is focused on greenhouse gas emissions. In the case of petroleum consumption, 85 percent of E85 fuel used by flexible-fuel vehicles offsets the increase in gasoline use that results from the lower fuel economy associated with the credit, since 85 percent of E85 is ethanol and 15 percent is gasoline. In the case of greenhouse gas emissions, the offset is about 25 percent, since flexible-fuel vehicles burning E85 still generate some greenhouse gas emissions.

It is important to note that the analysis assumes that, in the absence of the CAFE credit incentive, manufacturers would have chosen to take other actions to improve their average fleet fuel economy rather than pay CAFE penalties. We do not know with certainty that the manufacturers wouldn't have produced the same vehicles in the absence of the credit incentive. Therefore, the actual energy and environmental impacts are uncertain.

Analyses and studies performed by DOE have shown a possible approach to achieving greater use of alternative fuels. This approach, which utilizes near-future cellulosic ethanol as the main component of E85, could result in a 70 to 71 percent reduction in petroleum use, a 68 to 102 percent reduction in greenhouse emissions, and a 70 to 79 percent reduction in fossil energy use. Our analysis assumed the production and use of corn-based ethanol as the main component of E85. The above reductions reflect ethanol produced from herbaceous or woody biomass. The possible 102 percent reduction in greenhouse gas emissions is attributable to the reduction of emissions through eased demand on non-ethanol electric power, according to an Argonne National Laboratory study. The CAFE credit incentive may be viewed as an incentive for this infant industry to produce large quantities of cellulosic ethanol, which could result in large reductions in petroleum use and adverse greenhouse gas emissions.

Historical Record

The historical record analyzed for this report covers the period 1996-2000 (see Appendix D).

Tables V-1 and V-2 show both the annual and cumulative sales of FFVs, corresponding non-FFV light vehicle sales, and total light duty sales over this period.

The sharp increase in the number of corresponding vehicles sold is because the number of manufacturers producing FFVs and the number of models each manufacturer produced increased from 1996 to 2000. In 1996 and 1997 only Ford claimed CAFE credits for selling FFVs while in 1998 and 1999 both Chrysler and Ford produced FFVs. In 2000, DaimlerChrysler, Ford, GM and Isuzu[6] all produced FFVs.

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6 GM produced the Isuzu vehicles.

Table V-1
ANNUAL VEHICLE SALES

Year	Flexible-fuel Vehicle Sales	Corresponding Light Vehicle Sales[7]	FFV/ Sub-Total	All Light Vehicle Sales[8]	FFV/ All Sales
1996	5,278	1,438,291	0.37%	13,144,417	0.04%
1997	6,227	1,664,228	0.37%	14,463,546	0.04%
1998	151,339	3,198,215	4.73%	14,309,716	1.06%
1999	442,548	5,372,591	8.24%	15,216,153	2.91%
2000	631,471[9]	7,653,394[10]	8.25%	15,216,153[11]	4.15%
1996-2000	1,236,863	19,326,719		72,397,483	

Conducting an assessment of the energy and environmental impacts of the alternative fuel vehicle credit incentive is complicated by uncertainty regarding automobile manufacturers' behavior. While the use of alternative fuels can reduce petroleum consumption and greenhouse gas emissions, the energy consumption and environmental impacts cannot be determined with any reasonable amount of certainty because we cannot predict what manufacturers would have done in the absence of the credit incentive.

Although we cannot predict what vehicle manufacturers would do in the absence of the credit incentive, we undertook an analysis of what the possible effects would be if manufacturers took advantage of the incentive to relax the effect of the CAFE standard on the rest of their fleet. This assumption yields an "upper bound" estimate of the increase in petroleum consumption and greenhouse gas emissions.

This analysis considered two cases:

Baseline All light vehicles operate exclusively on conventional fuel, including FFVs. There are no CAFE credits claimed from the production and sale of FFVs.

Since the baseline case assumes that all vehicles operate on gasoline, total motor fuel consumption

7 Total OEM sales of passenger cars and light trucks sold by manufacturers making FFVs. This is a pairwise comparison by manufacturer and CAFE category (domestic LDV, import LDV, and LDT). Thus, if a manufacturer made an FFV domestic car but neither an import car nor an FFV truck, only the domestic car sales would be added to the yearly total shown in this column. Note: the CAFE requirements apply separately to each of the three categories: domestic car, import car, and light truck.

8 OEM light duty sales for all manufacturers in that model year, including those that did not produce FFVs.

9 Projected FFV sales consistent with the CAFE credit anticipated by manufacturers in their Pre-Model Year Report to NHTSA.

10 Projected sales.

11 Model year 2000 sales are assumed to equal 1999 sales.

is simply the product of the number of vehicles sold and their expected VMT[12] divided by their city-highway *in-use* fuel economy when operating on gasoline.

However, a complicating factor in this analysis is the need to reflect that, in the *absence* of CAFE credits, the average fuel economy of manufacturer fleets could be higher and the aggregate gasoline consumption could otherwise be lower. Thus, under the AMFA case, there are three components to the calculation:

AMFA 1 percent of the fuel used by FFVs is alternative fuel (E85). Note that for purposes of this analysis, a 1% usage rate for the alternative fuel is assumed. The actual usage rate is somewhat less than 1%.

99 percent of the fuel used by FFVs is conventional fuel

Light vehicles operate with an *average* fuel economy *less than they otherwise would have* in the absence of the AMFA credit. The size of this component is equal to the difference in the amount of fuel used because of the credit.[13]

For each case, estimates were made of both conventional and alternative fuel use, total petroleum[14] consumption, and greenhouse gas emissions using DOE's GREET 1.5a Transportation Fuel-Cycle Model (1999).[15]

Table V-2 shows the fuel consumption and GHG emissions for vehicles sold in the CAFE categories

12 MOBILE6 first year mileage accumulation rates were used. Passenger cars are expected to travel an average of 14,871 miles in their first year, while light trucks are expected to travel an average of 19,445 miles. Although vehicles tend to travel fewer miles the older they become, in analyzing the historical data, all model year vehicles were assumed to travel at their first year rates, since there were very few FFVs produced in the early years of the AMFA program.

13 This difference is calculated as the product of the number of light vehicles sold and their expected VMT divided by the *in-use* fuel economy of those vehicles *with the credit* less the product of the number of light vehicles sold and their expected VMT divided by the *in-use* fuel economy of those vehicles *without the credit*.

14 Since most FFVs are designed to use E85 as their alternative fuel, the change in total petroleum used as a result of AMFA is equal to the fleetwide increase in the amount of conventional fuel used because of the lower fuel economy associated with the CAFE credit plus 15% of the amount of alternative fuel used, since E85 is composed of 15% gasoline and 85% ethanol.

15 GREET is a full fuel life cycle model. It attempts to estimate emissions associated with particular fuels from all sources; from extraction, through production and distribution, to use; including CH_4 and N_2O trace gas effects (using 100-year time horizon weights). According to GREET's computerized model 1.5a, light vehicles produce 498 grams per mile CO_2 equivalent emissions while operating on gasoline and 374 grams per mile CO_2 equivalent emissions while operating on E85. Both estimates are expressed as gasoline equivalents; i.e., in terms of a constant heating unit equal to the energy in a gallon of gasoline. The primary reason that E85 GHG emissions are lower than gasoline GHG emissions is that the corn feedstock used to make the ethanol sequesters CO_2 during the growing process. GREET assumes a gasoline fuel economy of 22.4 miles per gallon and E85 and M85 fuel economies of 23.5 miles per gallon for passenger cars and light trucks. For this report, we converted GREET's CO_2 equivalent emissions rates to carbon equivalent rates expressed in terms of the actual fuel used. Thus, according to GREET 1.5a, E85 has a gasoline equivalent CO_2 equivalent emission factor of 374 grams per mile which is equal to an E85 equivalent CO_2 equivalent emission factor of 6,217 grams per gallon *of E85* (= 374 grams CO_2 equivalent emissions/mile * 23.5 miles/gallon E85 * 81,630 Btu/gallon E85 / 115,400 Btu/gallon gasoline).

Fuel	Fuel Economy	CO_2 Equivalent Emissions	Energy	CO_2 Equivalent Emissions
	(miles/gallon)	(grams/mile)	(Btu/gallon)	(grams/gallon)
Gasoline	22.4	498	115,400	11,155
Neat EtOH			75,670	
E85	23.5	374	81,630	6,217

for which manufacturers claimed AMFA credit through that model year under the baseline case.

Table V-2
FUEL CONSUMPTION AND GHG EMISSIONS FOR VEHICLES SOLD IN THE CAFE CATEGORIES FOR WHICH MANUFACTURERS CLAIMED AMFA CREDIT IN THE BASELINE CASE

Year	Conventional Fuel (million gallons)	Alternative Fuel (million gallons)	Total Petroleum (million gallons)	GHG (MMTCE)[16]
1996	3	0	3	0.010
1997	7	0	7	0.023
1998	151	0	151	0.460
1999	593	0	593	1.805
2000	1,172	0	1,172	3.565

Table V-3 shows the estimated fuel consumption and GHG emissions for vehicles sold in the CAFE categories for which manufacturers claimed credit under the AMFA case, also through the model year indicated.

Table V-3
ESTIMATED FUEL CONSUMPTION AND GHG EMISSIONS FOR VEHICLES SOLD IN THE
CAFE CATEGORIES FOR WHICH MANUFACTURERS CLAIMED CREDIT IN THE AMFA CASE

Year	Conventional Fuel (million gallons)	Alternative Fuel (million gallons)	Total Petroleum (million gallons)	GHG (MMTCE)
1996	5	0	5	0.015
1997	10	0	10	0.032
1998	211	2	211	0.646
1999	825	8	826	2.522
2000	1,644	16	1,647	5.030

16 Million Metric Tons Carbon Equivalent

Table V-4
***ESTIMATED <u>NET</u> EFFECT* OF AMFA PROGRAM (AMFA - BASELINE *DIFFERENCE*)**

Year	Conventional Fuel (million gallons)	Alternative Fuel (million gallons)	Total Petroleum (million gallons)	GHG (MMTCE)
1996	1	0	1	0.004
1997	3	0	3	0.009
1998	60	2	60	0.185
1999	231	8	232	0.717
2000	473	16	475	1.465
1996-2000	768	26	772	2.381

Although we cannot predict what vehicle manufacturers would have done in the absence of the credit incentive, we undertook an analysis of the possible effects of the provision. Thus, as shown in Table V-4, from 1996, when manufacturers first claimed the AMFA CAFE credit, through 2000, the assumption that manufacturers took advantage of the incentive to relax the effect of the CAFE standards on the rest of their fleet would have resulted an increase in alternative fuel use (almost all E85), and some slight increase in petroleum consumption and greenhouse gas emissions. Through 2000, this has resulted in an estimate of:

- an increase in alternative fuel use (a substantial increase in E85 use compared to the pre-1996 period);
- a *total* increase in petroleum consumption of about 772 million gallons (about a one percent increase in highway use petroleum consumption over the five year period); and
- a *total* increase in greenhouse gas emissions of about 2.4 MMTCE (well less than a one percent increase in total passenger car and light truck GHG emissions over the five year period).

These estimates represent an "upper bound" on the possible increase in alternative fuel consumption, petroleum consumption and greenhouse gases attributable to the AMFA CAFE credit incentive from 1996-2000.

<u>Projections</u>

The effects beyond 2000 of the CAFE incentive program will depend almost entirely on the amount of E85 fuel used by FFVs. We have evaluated the effects of extending the CAFE credit to 2008 under four scenarios based on the assumption that manufacturers will continue to be constrained by CAFE and will continue to eschew paying CAFE penalties.

We considered different production rates for FFVs and different amounts of E85 fuel used by the FFVs in an attempt to bound the range of likely outcomes.

FFV Fuel Use	Extent Manufacturers Avail Themselves of the AMFA Credit	
1%	0.9 mpg	1.2 mpg
1% in 2001 - 50% in 2008	0.9 mpg	1.2 mpg

The *CAFE credit* cases assume that manufacturers *currently* producing FFVs (Daimler-Chrysler, Ford, and GM) increase their production of their FFVs to capture either 0.9 mpg or 1.2 mpg credit beginning with the 2001 model year.[17], [18]

The FFV fuel *use* cases shown in Table V-5 assume either that:

4. FFVs continue to use the same low percentage of E85 that they have used in the recent past, or

5. FFVs increase their use of E85 from the current low rate of approximately 1 percent to 50 percent in 2008. This is represented in the model by assuming that *on average* 25 percent of the fuel FFVs use during 2001 - 2008 is alternative fuel.

Table V-5
ANNUAL SALES 2001 - 2008

CAFE Case	Flexible-fuel Sales	Total Light Vehicle Sales
0.9 mpg Credit	944,138	7,653,394
1.2 mpg Credit	1,258,851	7,653,394

Flexible-fuel vehicle *sales* are assumed to increase to the number necessary in order for each manufacturer producing FFVs in 2000 to capture either 0.9 mpg or 1.2 mpg CAFE credit. Total annual light vehicle sales in the 2001 - 2008 period are assumed to equal the total number of light duty vehicles each manufacturer is expected to produce in 2000 in the same CAFE categories the manufacturer is currently producing FFVs.

As before, fuel consumption is the product of the number of vehicles sold and their expected VMT[19] divided by their city-highway *in-use* fuel economy.

17 AMFA currently allows manufacturers to claim up to 1.2 mpg credit towards CAFE through 2004. The proposed extension reduces the amount of credit allowed to 0.9 mpg for 2005 - 2008. Manufacturers could, for internal business reasons, decide not to produce more FFVs in the 2001-2004 time frame than necessary to capture 0.9 mpg credit, even though they are allowed to capture 1.2 mpg credit by producing more of such vehicles. On the other hand, on the premise that Congress will pass H.R. 4270 extending the 1.2 mpg credit to 2008. manufacturers could decide to produce enough FFVs to capture the entire 1.2 mpg credit throughout the 2001-2008 period with the knowledge that they will be able to carry forward these credits for three years.

18 If all manufacturers found themselves constrained by CAFE and elected to produce FFVs as a way of helping them achieve the standard, then the estimates of FFV sales, gasoline consumption, ethanol supply requirements, and greenhouse gas emissions produced as a result of AMFA would double since, currently, only for only about one half of all gasoline light vehicles produced are flexible-fuel vehicles produced in the same CAFE category.

19 VMT for the projection years was estimated by applying the DOE Oakridge National Laboratory's survival rates to EPA's MOBILE6 mileage accumulation rates for the first eight years of the vehicles' life and averaging. Passenger cars are expected to travel 96,109 miles in their first eight years, while light trucks are expected to travel 121,304 miles. Although vehicles tend to travel more miles when new and fewer miles the older they become, in making the projections, all model year vehicles are assumed to travel at the average rate at which they were expected to accrue miles over the period of evaluation. Thus, *for each year*, 2001 - 2008, passenger cars are assumed to travel 12,014 miles, while light trucks are assumed to travel 15,163 miles.

Table V-6

NET EFFECT OF AMFA PROGRAM (AMFA - BASELINE *DIFFERENCE*

FLEXIBLE-FUELED VEHICLES USE ALTERNATIVE FUEL AT A RATE OF 1%

	0.9 mpg CAFE Credit				**1.2 mpg CAFE Credit**			
Year	**Conventional (million gallons)**	**Alternative (million gallons)**	**Total Petroleum (million gallons)**	**GHG MMTCE**	**Conventional (million gallons)**	**Alternative (million gallons)**	**Total Petroleum (million gallons)**	**GHG MMTCE**
2001	731	25	735	2.267	822	28	827	2.550
2002	995	35	1,000	3.085	1,179	41	1,185	3.657
2003	1,263	44	1,270	3.919	1,543	54	1,551	4.786
2004	1,538	54	1,546	4.770	1,915	67	1,925	5.938
2005	1,818	64	1,827	5.638	2,293	80	2,305	7.113
2006	2,103	74	2,114	6.524	2,680	94	2,694	8.311
2007	2,394	85	2,407	7.427	3,074	108	3,090	9.534
2008	2,691	95	2,705	8.348	3,476	122	3,494	10.781
2005-2008	9,005	319	9,053	27.937	11,522	404	11,583	35.739
2001-2008	**13,532**	**478**	**13,603**	**41.978**	**16,982**	**594**	**17,071**	**52.671**
1996-2008	14,300	504	14,375	44.359	17,750	620	17,843	55.052

Low E85 Use

Table V-6 above shows the *net effect* of the AMFA program for vehicles sold in the corresponding model year.

Thus, if manufacturers produce enough FFVs to garner 0.9 mpg CAFE credit and all FFVs continue to use E85 at the current low rate that they have used in the recent past, then from 2001 -2008, we expect that there will be:

- an additional increase in alternative fuel use of about 0.5 *billion* gallons;
- an additional increase in petroleum consumption of about 14 *billion* gallons; and
- an additional increase in greenhouse gas emissions of about 42 MMTCE.[20]

[20] For vehicles produced through the 2008 model year, this corresponds to an additional total *lifetime* GHG emissions of 82 MMTCE.

On the other hand, if manufacturers produce enough FFVs to garner 1.2 mpg CAFE credit and all FFVs continue to use E85 at the current rate, then we expect that there will be:

- an additional increase in alternative fuel use of about 0.6 *billion* gallons;
- an additional increase in petroleum consumption of about 17 *billion* gallons; and
- an additional increase in greenhouse gas emissions of about 53 MMTCE.[21]

Table V-7

***NET EFFECT* OF AMFA PROGRAM (AMFA - BASELINE *DIFFERENCE*)**

FLEXIBLE-FUELED VEHICLES USE ALTERNATIVE FUEL AT AN AVERAGE RATE OF 25%

	0.9 mpg CAFE Credit				1.2 mpg CAFE Credit			
Year	Conventional (million gallons)	Alternative (million gallons)	Total Petroleum (million gallons)	GHG MMTCE	Conventional (million gallons)	Alternative (million gallons)	Total Petroleum (million gallons)	GHG MMTCE
2001	288	633	383	1.949	325	710	432	2.194
2002	386	869	517	2.648	462	1,025	616	3.142
2003	487	1,110	653	3.361	601	1,345	803	4.109
2004	589	1,355	792	4.088	743	1,672	994	5.096
2005	693	1,605	934	4.830	888	2,006	1,189	6.103
2006	800	1,860	1,079	5.587	1,036	2,346	1,388	7.130
2007	908	2,120	1,227	6.359	1,187	2,693	1,591	8.177
2008	1,019	2,386	1,377	7.146	1,341	3,047	1,798	9.245
2005-2008	3,421	7,972	4,617	23.922	4,452	10,092	5,965	30.654
2001-2008	**5,170**	**11,938**	**6,961**	**35.969**	**6,583**	**14,845**	**8,810**	**45.195**
1996-2008	5,476	12,600	7,366	38.019	6,888	15,507	9,214	47.245

High E85 Use

If FFVs increase their use of alternative fuel from the current rate of approximately 1 percent in 2000 to 50 percent in 2008, the *average rate* of alternative fuel will be roughly 25% over the time period analyzed.

Table V-7 shows the *net effect* of the AMFA program for vehicles sold in the corresponding model year.

Thus, if manufacturers produce enough FFVs to garner 0.9 mpg CAFE credit and *on average* 25 percent of the fuel FFVs used during 2001 - 2008 is alternative fuel, then during that period we expect that there will be:

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[21] The corresponding additional total *lifetime* GHG emissions are 111 MMTCE.

- an additional increase in alternative fuel use of about 12 *billion* gallons;
- an additional increase in petroleum consumption of about 7 *billion* gallons; and
- an additional increase in greenhouse gas emissions of about 36 MMTCE.[22]

On the other hand, if manufacturers produce enough FFVs to garner 1.2 mpg CAFE credit and *on average* 25 percent of the fuel FFVs used during 2001 - 2008 is alternative fuel, then we expect that there will be:

- an increase in alternative fuel use of about 15 *billion* gallons;
- an increase in petroleum consumption of about 9 *billion* gallons; and
- an increase in greenhouse gas emissions of about 45 MMTCE.[23]

In all cases, the amount of petroleum used and the amount of greenhouse gases produced increases when the credit is extended to 2008.

Sensitivity Cases

In addition to the four cases discussed above, we considered the case that FFVs would use E85 an average of 50 percent the time, as assumed in the Act, and the case that FFVs would use E85 all the time (100 percent). This analysis is shown on Table V-8 below.

In the 50 percent case, petroleum consumption remains unchanged, if the credit is extended to 2008. However, the amount of greenhouse gases produced still increases if the credit is extended compared to the option of allowing the program to expire in 2004. If FFVs use E85 100 percent of time, petroleum consumption declines, although greenhouse gases still increase.

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[22] The corresponding additional total *lifetime* GHG emissions are 70.1 MMTCE.

[23] The corresponding additional total *lifetime* GHG emissions are 95.2 MMTCE.

Table V-8

NET EFFECT OF AMFA PROGRAM (AMFA - BASELINE *DIFFERENCE*)

MANUFACTURERS PRODUCE FLEXIBLE-FUELED VEHICLES TO GARNER 0.9 MPG CAFE CREDIT

	FFVs Use E85 50% of the Time				FFVs Use E85 100% of the Time			
Year	Conventional (million gallons)	Alternative (million gallons)	Total Petroleum (million gallons)	GHG MMTCE	Conventional (million gallons)	Alternative (million gallons)	Total Petroleum (million gallons)	GHG MMTCE
2001	-174	1,267	16	1.618	-1,097	2,533	-717	0.956
2002	-248	1,738	13	2.193	-1,515	3,476	-994	1.283
2003	-323	2,219	10	2.780	-1,941	4,438	-1,276	1.617
2004	-399	2,710	7	3.378	-2,376	5,419	-1,563	1.958
2005	-478	3,210	4	3.989	-2,820	6,420	-1,857	2.305
2006	-557	3,720	1	4.611	-3,272	7,441	-2,156	2.660
2007	-639	4,241	-3	5.246	-3,734	8,482	-2,461	3.021
2008	**-722**	**4,772**	**-6**	**5.894**	**-4,204**	**9,544**	**-2,773**	**3.390**
2005-2008	-2,396	15,943	-5	19.740	-14,030	31,886	-9,247	11.376
2001-2008	-3,540	23,877	42	29.709	-20,960	47,753	-13,797	17.190
1996-2008	-3,716	25,201	64	31.414	-22,100	50,402	-14,539	18.206

This apparent paradox is explained by the fact that, in the case of petroleum consumption, 85 percent of E85 fuel used by FFVs offsets the increase in gasoline use that results from the lower fuel economy associated with the credit. However, in the case of greenhouse gas emissions, the offset is only about 25 percent, since FFVs burning E85 still generate some greenhouse gas emissions.

Summary

Conducting an assessment of the energy and environmental impacts of the dual-fuel vehicle credit incentive is complicated by behavioral uncertainty. While the use of alternative fuels can reduce petroleum consumption and greenhouse gas emissions, the energy consumption and environmental impacts cannot be assessed with any reasonable amount of certainty because we cannot determine what manufacturers would have done in the absence of the credit incentive. If vehicle manufacturers took advantage of the incentive to relax the effect of the CAFE standard on the rest of their fleet, then the credit incentive has resulted in an increase in alternative fuel use (almost all E85), and some slight increase in petroleum consumption (about one percent) and greenhouse gas emissions (well less than one percent). The effects beyond 2000 will depend almost entirely on the amount of E85 fuel used by FFVs. Unless actions are taken to significantly expand the availability and use of alternative fuels, the CAFE credit incentive program will not result in any reduced petroleum consumption or greenhouse gas emissions in the future.

It is also possible that manufacturers might have responded to strong consumer demand for performance and utility and produced the same vehicles without the provision as they did with it. In this case, manufacturers would have chosen to pay civil penalties rather than meet the CAFE standard. Under this scenario, the main effect of the program has been to greatly expand the population of vehicles that have the potential to use alternative fuels.

In light of recent events, both in the U.S. and abroad, it is important to be increasing alternative fuel capability throughout the fleet for several reasons. Introducing mass quantities of alternative fuel vehicles - specifically ethanol flexible-fuel vehicles - could potentially contribute to the future transition away from petroleum consumption, could facilitate an expansion of the alternative fuels infrastructure, and provide consumers with an alternative if there are gas shortages, if gas prices increase significantly, or if a future energy crisis occurs. Ethanol is not only an alternative fuel, but it is a domestic fuel. Thus, its increased use would decrease our petroleum use and our reliance on foreign oil. The existence of large number of E85 flex-fuel vehicles should make a possible "emergency" switch to alternative fuels much easier in the future. Because these vehicles are manufactured with the capability to operate on E85, there would be no need to convert these vehicles to allow them to utilize ethanol.

In view of the nation's energy security interests, it is important to be increasing alternative fuel capability throughout the fleet. The need to ensure the nation's long-term energy security is of such vital concern that it takes precedent over possible short-term petroleum consumption and environmental impacts.

VI. Summary of Findings and Recommendations

The term "alternative fuel" has been used to describe any fuel other than gasoline or diesel fuel suggested for transportation use. Today's situation resembles in many ways the beginning of the twentieth century, when buyers of early automobiles could choose among internal combustion vehicles, steam vehicles, or electric vehicles. Similar to today, the early 1900's saw great debates about which fuels were best suited for transportation uses, and the availability of fuels and the advantages and drawbacks of the vehicles dictated the choices that consumers made. As history tells us, the internal combustion engine operating on gasoline (and later diesel) was the final winner in that debate.

Alternative fuels have been used extensively in the past in transportation. As mentioned before, electric vehicles enjoyed some measure of popularity in the early 1900's, and both liquefied petroleum gas vehicles and natural gas light- and medium-duty trucks have been in use since the 1950's. The current interest in alternative fuels stems from the ability of these fuels to provide the U.S. with energy security benefits (less dependence on foreign oil for transportation energy needs) and environmental benefits. Additionally, the U.S. could see economic benefits related to reduction of the trade deficit and the production and use of domestically-produced fuels. Therefore, programs that facilitate the development of alternative fuels and alternative fuel vehicles are vital to our national interests.

Our evaluation of the AMFA CAFE credit incentive policy for dual-fuel vehicles indicates that the program has had mixed results. Key findings include:

- The AMFA CAFE credit program has been successful in stimulating a significant increase in the availability of alternative fuel vehicles. Nearly all of these have been flexible-fuel vehicles that can operate on gasoline or E85 fuel (a mixture of 15 percent gasoline and 85 percent ethanol). There are currently about 1.2 million of these vehicles on the road. Because manufacturers had to overcome technological challenges, nearly the entire increase in the number of these vehicles has been in the past three years.

- The auto manufacturers stated that the CAFE incentive program has been a major factor in developing and manufacturing alternative fuel vehicles in high volumes. They also stated that extension of the credit provision will be a major factor in their decision to continue offering dual-fuel vehicles in the volumes that are being produced today.

- While the availability and use of alternative fuels has increased since the inception of the CAFE credit incentive provision, it has not nearly kept pace with the increase in the number of alternative fuel vehicles. Although there are 176,000 gasoline stations nationwide, there are only 5,236 alternative fuel refueling sites and just 121 of these offer E85. The Federal government, and specifically DOE, the General Services Administration and the U.S. Department of Agriculture (USDA) are involved with efforts to promote the use and expansion of alternative fuels and the alternative fuel infrastructure. A major focus of these efforts is the development of different feedstocks for ethanol and on partnerships that result in the expansion of the ethanol fueling infrastructure.

- Due to the lagging development of the alternative fuel infrastructure and the fact that E85 fuel is typically more expensive on a gasoline-equivalent basis, the vast majority of dual-fuel vehicles rarely operate on alternative fuel. Even under these circumstances, use of E85 increased from 694,000 gasoline gallon equivalents in1996, to more than 3.3 million gasoline gallon equivalents in 2000. It is also important to note that even if relatively few of these vehicles are actually being operated on E85, it is still valuable to be increasing that capability throughout the fleet because it could potentially contribute to the future transition away from petroleum, could spur an increase in the number of E85 refueling sites, and provide consumers an alternative if there are gas shortages or gas prices increase significantly.

- Conducting an assessment of the energy and environmental impacts of the dual-fuel vehicle credit incentive is complicated by uncertainty regarding automobile manufacturers' behavior. While the use of alternative fuels can reduce petroleum consumption and greenhouse gas emissions, the energy consumption and environmental impacts cannot be assessed with any reasonable amount of certainty because we cannot determine what manufacturers would have done in the absence of the credit incentive.

- If it is assumed that vehicle manufacturers took advantage of the incentive to relax the effect of the CAFE standard on the rest of their fleet, then the credit incentive has resulted in an increase in alternative fuel use (almost all E85), and some slight increase in petroleum consumption (about one percent) and greenhouse gas emissions (well less than one percent). Unless the availability and use of alternative fuels is significantly expanded, the CAFE credit incentive program will not result in any reduced petroleum consumption or greenhouse gas emissions in the future.

- It is also possible that manufacturers might have responded to strong consumer demand for performance and utility and produced the same vehicles without the provision as they did with it. In this case, manufacturers would have chosen to pay civil penalties rather than meet the CAFE standard. Under this scenario, the main effect of the program has been to greatly expand the population of vehicles that have the potential to use alternative fuels.

- In the past year, three significant initiatives have addressed issues related to the dual-fuel vehicle CAFE credit incentive. The National Energy Policy Development Group, in its May 17, 2001, report on the National Energy Policy states that, "ethanol vehicles offer tremendous potential if ethanol production can be expanded." Additionally, the report states that, "a considerable enlargement of ethanol production and distribution capacity would be required to expand beyond their current base in the Midwest in order to increase use of ethanol-blended fuels." In July 2001, the National Academy of Sciences' report on CAFE recommended that credits for dual-fuel vehicles should be eliminated, with the provision that enough lead-time be given to limit adverse impacts on the automotive industry." Finally, on August 2, 2001, the U.S. House of Representatives passed H.R. 4, which is entitled the Securing America's Future Energy (SAFE) Act of 2001. This bill, which has been placed on the Senate legislative calendar, includes a provision that would extend the dual-fuel vehicle CAFE credit incentive program through model year 2008.

Based on the results of this study, our preliminary conclusion is that continuation of the program should consider other actions that could improve the program and its chances for success. Specific actions by Congress or others might include any or all of the following:

(1) Examine alternatives to the current dual-fuel vehicle CAFE credit program structure, such as linking the CAFE credit to actual alternative fuel used;

(2) Develop, implement, and evaluate policies, regulations, or programs to promote the actual use of alternative fuels by consumers; and

(3) Develop, implement, and evaluate policies and programs that facilitate more rapid expansion and use of the alternative fuel infrastructure. Such policies and programs should be evaluated, taking into account the availability of alternative fuel and other potential transportation uses for each fuel.

In view of the nation's energy security interests, it is important to increase alternative fuel capability throughout the fleet. Given the mixed results of the program to date, it would be prudent for Federal agencies, Congress, industry, and other interested stakeholders to identify additional programs and authorities that could contribute to achieving greater use of alternative fuels in dual-fuel vehicles that receive the CAFE credit.