United States Government Accountability Office

GAO

Report to Congressional Requesters

June 2007

# BIOFUELS

# DOE Lacks a Strategic Approach to Coordinate Increasing Production with Infrastructure Development and Vehicle Needs


GAO-07-713

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## Highlights

Highlights of GAO-07-713, a report to congressional requesters

## Why GAO Did This Study

The U.S. transportation sector is almost entirely dependent on oil, a condition that poses significant economic and environmental risks. Biofuels, such as ethanol and biodiesel, have the potential to displace oil use in transportation fuel. GAO was asked to describe the status of and impediments to expanding biofuel production, distribution infrastructure, and compatible vehicles as well as federal policy options to overcome the impediments. GAO was also asked to assess the extent to which the Department of Energy (DOE) has developed a strategic approach to coordinate the expansion of biofuel production, infrastructure, and vehicles and has evaluated the effectiveness of biofuel tax credits. GAO interviewed representatives and reviewed studies and data from DOE, states, industry, and other sources.

## What GAO Recommends

GAO recommends that the Secretary of Energy (1) collaborate with public and private sector stakeholders to develop a strategic approach that coordinates expected biofuel production with distribution infrastructure and vehicle production, and (2) collaborate with the Secretary of the Treasury to evaluate and report on the extent to which biofuel-related tax expenditures are achieving their goals.

DOE reviewed a draft of this report and generally agreed with the findings and recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-07-713.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Mark Gaffigan at (202) 512-3841 or gaffiganm@gao.gov.

## What GAO Found

Combined ethanol and biodiesel production increased rapidly from about 3.4 billion gallons in 2004 to about 4.9 billion gallons in 2006, but these biofuels—primarily ethanol—composed only about 3 percent of 2006 U.S. gasoline and diesel transportation fuel use. Due to limitations on the production and use of corn—the primary feedstock used to produce ethanol in the United States—15 billion to 16 billion gallons is the generally agreed maximum amount of U.S. corn ethanol production. Using cellulosic feedstocks, such as corn stalks or other plant material, could expand the amount of ethanol produced, but the production costs are currently twice those of corn ethanol. Policies that support cellulosic ethanol research have the potential to increase the future availability of cost-competitive ethanol.

Existing biofuel distribution infrastructure has limited capacity to transport the fuels and deliver them to consumers. Biofuels are transported largely by rail, and the ability of that industry to meet growing demand is uncertain. In addition, in early 2007, about 1 percent of fueling stations in the United States offered E85—a blend of about 85 percent ethanol and 15 percent gasoline—or high blends of biodiesel, such as B20 or higher. Increasing the availability of E85 at fueling stations is impeded largely by the limited availability of ethanol for use in high blends. Several policy options, such as mandating their installation, could increase the number of biofuel dispensers in stations. However, until more biofuel is available at a lower cost, it is unlikely that more fueling stations would lead to significantly greater biofuels use.

In 2006, an estimated 4.5 million flexible fuel vehicles (FFV) capable of operating on ethanol blends up to E85 were in use—an estimated 1.8 percent of the nearly 244 million U.S. vehicles. The number of FFVs may increase substantially because of a recent commitment by DaimlerChrysler, Ford, and General Motors to increase FFV production to compose about 50 percent of their annual production by 2012. Several policy options, such as a tax credit for FFV production, could increase the number of FFVs, but would likely have little impact on biofuel use until E85 is less expensive and more widely available. It is also a concern that because many FFVs are less fuel efficient than other vehicles and rarely use E85, they actually increase petroleum use.

DOE has not yet developed a comprehensive approach to coordinate its strategy for expanding biofuels production with the development of biofuel infrastructure and production of vehicles. Such an approach could assist in determining which blend of ethanol—E10, E85, or something in between—would most effectively and efficiently increase the use of the fuel and what infrastructure development or vehicle production is needed to support that blend level. In addition, DOE has not evaluated the performance of biofuel-related tax credits, the largest of which cost the Treasury $2.7 billion in 2006. As a result, it is not known if these expenditures produced the desired outcomes or if similar benefits might have been achieved at a lower cost.

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**Abbreviations**

| | |
|---|---|
| CAFE | Corporate Average Fuel Economy |
| DOE | Department of Energy |
| EIA | Energy Information Administration |
| EPA | Environmental Protection Agency |
| FFV | flexible fuel vehicle |
| GPRA | Government Performance and Results Act |
| MTBE | methyl tertiary butyl ether |
| NREL | National Renewable Energy Laboratory |
| RFS | Renewable Fuels Standard |
| UL | Underwriters Laboratories |
| USDA | U.S. Department of Agriculture |
| VEETC | Volumetric Ethanol Excise Tax Credit |

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**United States Government Accountability Office**
**Washington, DC 20548**

June 8, 2007

The Honorable Charles E. Grassley
Ranking Member
Committee on Finance
United States Senate

The Honorable Norm Coleman
Ranking Member
Permanent Subcommittee on Investigations
Committee on Homeland Security
and Governmental Affairs
United States Senate

The Honorable Barack Obama
United States Senate

In 2006, the United States accounted for slightly less than 25 percent of the world's oil consumption, making it the world's largest consumer. In particular, the nation's transportation sector is almost entirely dependent on oil and accounts for nearly two-thirds of total U.S. oil consumption. To meet growing demand for oil in the face of limited and declining domestic production, the nation imported about two-thirds of its oil and petroleum products in 2006. Absent dramatic reductions in consumption and significantly increased use of alternative fuels, the nation will become increasingly dependent on imported oil. Because oil is a global commodity and because there is currently relatively little spare oil production capacity, even a minor disruption in the global oil supply could cause large increases in price and economic difficulties for tens of millions of Americans. In addition, there are growing concerns about the negative environmental impacts of oil use, including its role in greenhouse gas emissions that are contributing to potentially significant and damaging changes to the global climate system.

According to the Department of Energy (DOE), if certain technological and other barriers are overcome, domestically produced biofuels made from renewable biomass have the potential to displace as much as 30 percent of current U.S. transportation fuel consumption by 2030, as well as help reduce emissions of greenhouse gases and support farm economies in many states. The development of alternative forms of energy, such as biofuels, has been a national goal since the oil crises of the 1970s, but to

date progress has been limited. Currently, the most commonly produced biofuels are ethanol and biodiesel, made primarily from corn and soybean oil feedstocks, respectively. Ethanol is primarily blended with gasoline in mixtures of 10 percent or less that can be used in any vehicle, but a relatively small volume is also blended at a higher level called E85—a blend of approximately 85 percent ethanol—which can only be used in specially designed flexible fuel vehicles (FFV).[1] Similarly, biodiesel is mostly blended with petroleum diesel at low levels, such as B2 (2 percent biodiesel), but is also commonly blended with diesel as B20 (20 percent biodiesel). Biodiesel in any blend level, as well as 100 percent biodiesel (B100), can generally be used in any diesel engine vehicle.

Using biofuels, particularly in high-level blends as a substitute for oil in transportation fuels, is subject to a number of limitations. For example, corn and soybeans are primarily used in livestock feed and human food products, and therefore using these crops to produce biofuels will likely cause livestock feed and human food prices to rise. Moreover, ethanol is not a gallon-for-gallon replacement for gasoline because it contains only about two-thirds of the energy of a gallon of gasoline. While ethanol combusts more efficiently than gasoline, drivers nonetheless experience about a 25 percent reduction in miles per gallon in vehicles using high blends such as E85. In addition, although DOE, the U.S. Department of Agriculture (USDA), and most other researchers maintain that a gallon of corn ethanol contains more energy than it takes to produce a gallon of the fuel, a small number of researchers believe that corn ethanol has a negative energy balance, meaning that it takes more energy to produce than it contains. Furthermore, because vehicle manufacturers have generally designed vehicles to operate primarily on gasoline or diesel, the use of fuels containing more than 10 percent ethanol or 5 percent biodiesel is not covered under the warranty of most vehicles.

The federal government has implemented a variety of measures to support and promote the greater availability and use of biofuels in place of petroleum. For example, the Environmental Protection Agency (EPA) is responsible for administering the Renewable Fuels Standard (RFS), which mandates that transportation fuel blenders increase their use of renewable fuels such as ethanol and biodiesel from 4 billion gallons in 2006 to 7.5

[1]DOE's Energy Information Administration estimates that the actual annual average ethanol content of E85 is 74 percent due to the need to reduce the ethanol content in fall, winter and spring to avoid vehicle starting problems in cooler weather.

billion in 2012.[2] Other federal agencies, such as DOE and USDA, conduct and fund efforts to further the development of the next generation of biofuels, principally ethanol from cellulosic biomass, which could be produced from farmed crops such as switchgrass and low-value residues from sources like wheat straw and corn stalks that are in abundant supply.[3] DOE is also responsible for monitoring compliance with the requirement that 75 percent of federal fleet vehicle acquisitions be capable of using alternative fuels and that the use of the fuels be increased. In addition, the Department of Transportation administers the Corporate Average Fuel Economy (CAFE) program, which regulates fuel economy for passenger vehicles sold in the United States and provides incentives to automobile manufacturers for producing alternative fuel vehicles, such as FFVs that can use regular gasoline or ethanol blends up to E85.

Federal policy further encourages biofuel availability and use through incentives such as the Volumetric Ethanol Excise Tax Credit (VEETC), which provides a 51 cent per gallon tax credit to fuel blenders for ethanol they blend with gasoline, and a tax credit for the installation of fueling stations to expand public access to biofuels. Tax credits are a type of tax expenditure that result in revenue loss for the federal government. Through tax expenditures, the government forgoes a certain amount of tax revenue to encourage specific behaviors by a particular group of taxpayers. The biofuel-related tax credits are in effect spending programs channeled through the tax system. We recently reported that according to Office of Management and Budget officials, individual agencies should take responsibility for identifying tax expenditures that affect their missions.[4] We also reported that an evaluation of the various energy supply tax credits might involve both DOE and the Department of the Treasury (Treasury). The Government Performance and Results Act (GPRA) of 1993 established a statutory framework for evaluating the performance of federal programs, including tax expenditures. The act requires federal agencies to, among other things, establish program performance goals, gather data on performance, and report the results.

[2]The President recently announced a goal of producing 35 billion gallons of alternative fuels, such as biofuels, coal-to-liquids, and natural gas, by 2017.

[3]Switchgrass is a native grass that thrives on marginal lands, needs little water, and no fertilizer.

[4]See GAO, *Government and Performance Accountability: Tax Expenditures Represent a Substantial Federal Commitment and Need to Be Reexamined*, GAO-05-690 (Washington, DC: Sept. 23, 2005).

In this context, you asked us to describe the status of the nation's (1) biofuel production, (2) biofuel distribution infrastructure, and (3) biofuel compatible vehicles. For each of these components of biofuel development, we also examined impediments to expansion and federal policy options that have been proposed to overcome the impediments. Finally, you asked us to assess the extent to which DOE has developed a strategic approach to coordinate the expansion of biofuel production with distribution infrastructure (transport systems and fueling stations) and vehicle needs and assess the extent to which DOE has evaluated the effectiveness of biofuel tax credits.

In conducting our work, we reviewed data and analyses from DOE's Energy Information Administration (EIA) and other federal, state, and industry sources to determine the current status and trends for ethanol and biodiesel production.[5] We reviewed key scientific and economic studies and spoke with federal and state agency officials, biofuel producers, and academics to identify impediments to increasing biofuel production and the potential policy options that could be pursued to overcome the impediments. To determine the current status and trends for the biofuel distribution infrastructure, including fueling stations that provide E85 or biodiesel blends, we reviewed data from DOE's Alternative Fuels Data Center. We spoke with representatives of major oil companies regarding their biofuel policies for branded fueling stations, and spoke with federal and state agency officials, biofuel producers and distributors, and fueling equipment manufacturers and certifiers regarding challenges to transporting biofuels and increasing the number of biofuel fueling stations and policy options to address those challenges. To determine the current status and trends for biofuel compatible vehicles, including federal fleet vehicles, we reviewed data and analysis from DOE and other federal and automobile industry sources. We spoke with major domestic and foreign automobile manufacturers regarding their plans for producing biofuel compatible vehicles as well as federal and state agency officials and consumer and environmental group representatives regarding the key barriers to increasing the number of biofuel compatible vehicles and policy options to mitigate those barriers. To assess the extent to which DOE has developed a strategic approach to coordinate the expansion of biofuel production with distribution infrastructure and vehicle needs and

[5]EIA is a statistical agency of DOE that provides energy data, forecasts, and analysis to promote sound policymaking, efficient markets, and public understanding regarding energy and its interaction with the economy and environment.

evaluated the effectiveness of biofuel tax credits, we met with key officials at DOE and gathered documentation of how they plan, implement, monitor, and evaluate the performance of biofuel-related programs.

We did not evaluate the costs and benefits of producing and using greater amounts of biofuels, expanding the biofuel distribution infrastructure, or increasing the number of biofuel compatible vehicles. Rather, we assessed the current status of production, distribution infrastructure, and vehicles; identified impediments to their further expansion; and noted steps that could be taken to expand the production and use of biofuels should Congress deem it to be in the national interest. We assessed the reliability of the industry and agency data that we used and found the data to be sufficiently reliable for the purposes of this report. We performed our work between June 2006 and June 2007 in accordance with generally accepted government auditing standards.

## Results in Brief

Ethanol and biodiesel production is rapidly increasing, but the challenge of producing biofuels at a lower cost than that of petroleum fuels makes it unlikely that they will displace a considerable amount of petroleum in transportation fuels until less expensive production processes are developed. From 2004 to 2006, annual U.S. ethanol production increased from 3.4 billion gallons to about 4.9 billion gallons, and annual biodiesel production expanded from 28 million gallons to approximately 287 million gallons. Despite these rapid increases, ethanol and biodiesel together composed only about 3 percent of gasoline and diesel motor fuel used in 2006. About 99 percent of the ethanol produced in 2006 was blended with gasoline at levels of 10 percent or less, and most biodiesel was blended with diesel fuel at levels of 20 percent or less. The key challenge to increasing biofuel production is making biofuels cost competitive with petroleum-based transportation fuels. Currently, the cost of biofuel is largely determined by the cost of feedstocks—primarily corn and soybeans—that are in limited supply and have increased in price due to high demand for biofuel production. For this and other reasons, such as high demand for ethanol as a fuel additive, the average wholesale price of ethanol per gallon in 2006 was about 33 percent more than the average wholesale price of gasoline. Since ethanol contains one-third less energy than gasoline, the price differential is even more significant than this comparison indicates. According to DOE, producing ethanol using cellulosic biomass as the feedstock could greatly expand the amount of ethanol available, but current production costs are roughly double those of corn ethanol. DOE has set a target of 2012 to achieve technological advances, such as reducing the cost of the enzymes used in the production

process, which would make cellulosic ethanol cost competitive with corn ethanol. Energy experts with whom we spoke and our own analysis indicate that because of limitations on the amount of corn and soybeans that are available for biofuel production, given competition for the use of land to grow crops for livestock and human consumption, significant expansion of biofuels production will be unlikely without policies that put a priority on support for cellulosic ethanol research and development and that offer enhanced incentives for its production.

The biofuel distribution infrastructure has limited capacity to transport the fuels and deliver them to consumers, and significant growth in the distribution system faces a variety of impediments. Biofuels are primarily transported by rail, but also by truck and barge, and limited capacity in this distribution system has led to supply disruptions and concerns about the system's ability to effectively transport greater amounts of biofuels if production significantly increases. The key challenges to meeting biofuel transport needs are potential capacity limitations in the freight rail system and the cost of developing a dedicated ethanol pipeline system if one is needed. In addition, less than 1 percent of fueling stations offer E85 or high blends of biodiesel. In early 2007, approximately 1,100 fueling stations, primarily in the Midwest, offered E85, and approximately 400 fueling stations throughout the country offered B20 through B100. Efforts to increase the number of stations offering high-level biofuel blends face challenges. Most significantly, absent a breakthrough in cellulosic technology, it is likely that little ethanol would be blended as E85. Most of the ethanol that is currently projected by EIA to be produced through 2030 could be used—and would likely bring a higher price to the sellers—in low blends as a gasoline extender or oxygenate to reduce vehicle emissions, as this is the way that about 99 percent of ethanol is currently being used. Biofuels also require specialized storage and dispensing equipment. For example, because ethanol is corrosive, E85 requires separate storage tanks, pumps, and dispensers at fueling stations. It can cost a fueling station operator around $3,300 to minimally modify existing equipment or about $60,000 to install new equipment—which may be a significant impediment for many potential retailers. Several potential options have been proposed to increase the number of stations offering biofuels, such as providing enhanced tax credits for station owners to install biofuel compatible dispensers or mandating that station owners install them. While these policy options would likely result in more stations that offer biofuels, given the higher costs and limited availability of biofuels, it is unlikely that the greater number of biofuel fueling stations would lead to significantly greater use of biofuels at this time.

The relatively few biofuel compatible vehicles in use in the United States could increase substantially in the near future because of planned production increases by manufacturers, but impediments to further production increases remain. In 2006, there were an estimated 4.5 million FFVs in the United States—about 1.8 percent of the nearly 244 million U.S. vehicles. Recently, DaimlerChrysler, Ford, and General Motors committed to increasing FFV production to compose about 50 percent of their annual production by 2012 despite limited consumer demand for FFVs and the additional engineering research and material costs to produce FFVs on a significantly larger scale. Several policy options have been proposed to increase the number of biofuel compatible vehicles, such as providing automobile manufacturers with, in addition to the CAFE credits they already receive, tax incentives to offset the additional costs of manufacturing more FFVs or requiring automobile manufacturers to make an increasing percentage of their fleet biofuel compatible until the U.S. automotive fleet is 100 percent FFVs. However, according to the Department of Transportation, DOE, and EPA, some automobile manufacturers have already used CAFE incentives to produce many FFVs that are less fuel efficient and that consumers generally do not operate with biofuels, resulting in increased petroleum use. While various policy options could increase the number of biofuel compatible vehicles, they would likely have little impact on biofuel use unless these fuels become cost competitive and more widely available in higher blends. For example, in early 2007, there were an estimated 257,000 privately owned FFVs throughout California but only one publicly accessible fueling station—located in the San Diego area—that offered E85.

DOE has not yet developed a comprehensive strategic approach to coordinate the expansion of biofuel production with biofuel distribution infrastructure development and vehicle production, and has not evaluated the effectiveness of biofuel tax credits. It is currently not known what blend of ethanol—E10, E85, or something in between—would most effectively and efficiently increase the use of the fuel; what level of distribution infrastructure development or vehicle production is needed to support that blend level; and when the infrastructure and vehicles will be needed. While DOE's Biomass Program has a strategic approach for increasing ethanol production, DOE has not yet developed a comprehensive strategic approach for determining the distribution infrastructure and vehicles needed to transport and use the increased production that could result from the program. Such an approach could assist in resolving these questions and help DOE and other agencies determine what level and types of federal involvement in research and development or subsidies for infrastructure development or vehicle

production are needed to help meet national goals for increasing biofuels use. In addition, the tax credits provided under the VEETC cost the federal government about $2.7 billion in forgone revenue in 2006, according to the Treasury Department. However, DOE and Treasury have not worked together to define their roles and responsibilities for establishing outcome-oriented goals or evaluating and reporting on the results of these and other tax expenditures. Consequently, the extent to which these large tax expenditures have resulted in the production of more ethanol than would have occurred without them, or produced specific outcomes, such as reducing petroleum imports, is unknown. Furthermore, it is not known if similar benefits or outcomes might be achieved by less costly means.

To improve biofuel-related planning and to provide Congress better information on the costs and benefits of biofuel tax expenditures, we are recommending that the Secretary of Energy (1) collaborate with public and private sector stakeholders to develop a comprehensive strategic approach to increasing the availability and use of biofuels that coordinates expected biofuel production levels with the necessary distribution infrastructure development and vehicle production, and (2) collaborate with the Secretary of the Treasury to evaluate and report on the extent to which biofuel-related tax credits are effectively and efficiently achieving their goals, as well as the extent to which they support the department's comprehensive strategic approach for biofuels. In commenting on a draft of this report, DOE agreed with our recommendations. DOE's comments appear in appendix I.

## Background

Over the last 30 years, the United States has benefited from relatively inexpensive and abundant oil supplies, but has also experienced periodic disruptions resulting in price shocks and related energy crises. In 1973, oil cost about $15 per barrel (adjusted for inflation) and accounted for 96 percent of the energy used by the transportation sector. The disruption of oil imports caused by the 1973 oil embargo by the Organization of Arab Petroleum Exporting Countries led to the doubling of oil prices in the United States between 1973 and 1974. Prices doubled again between 1978 and 1981 during the Iranian Revolution and the Iran-Iraq war. Oil prices fell in the mid-1980s, and as the U.S. economy expanded and domestic sources of oil declined, U.S. reliance on imported crude oil grew from 40.5 percent of the U.S. supply in 1980 to 66.1 percent in 2006. Oil now accounts for 98 percent of the energy consumed for transportation, according to EIA. Furthermore, EIA expects oil consumption in the transportation sector to grow by more than 40 percent, increasing from 4.8 billion barrels annually in 2004 to 6.8 billion barrels in 2030.

Biofuels, such as ethanol and biodiesel, are alternative transportation fuels produced from renewable sources. Increasing ethanol and biodiesel production and use have been touted by proponents as a means to address energy security concerns and lower greenhouse gas emissions while raising domestic demand for U.S. farm products. Currently, the most commonly produced biofuels are ethanol and biodiesel, made primarily from corn and soybean oil feedstocks, respectively. The United States is the world's largest corn producer—in the 2005-to-2006 marketing year, farmers produced over 11 billion bushels of corn and exported about 19 percent of the harvest.[6] The United States is also the world's largest soybean producer—in the 2005-to-2006 marketing year, farmers produced over 3 billion bushels of soybeans and exported about 31 percent of the harvest.

In general, large-scale ethanol production is either corn-based or sugar-based, using feedstocks such as sugarcane. Corn, which contains starch that can relatively easily be converted into sugar, is the feedstock for about 98 percent of the ethanol produced in the United States. While Brazil produces large amounts of ethanol from sugarcane, according to USDA, in the United States, the cost of domestic sugarcane feedstock would make ethanol production twice as costly as using corn. Biodiesel is produced by chemically combining a feedstock—such as recycled cooking grease, animal fat, or most commonly soybean oil—with alcohol. Biorefineries not only produce biofuels, but the conversion processes also create valuable coproducts—for example, ethanol production also results in distillers grains that are used as livestock feed.

Since the late 1970s, energy, environmental, and agricultural legislation and policies have encouraged the production and use of ethanol and biodiesel. The Energy Tax Act of 1978 first authorized a motor fuel excise tax exemption for ethanol blends, which was extended in several subsequent statutes. A 54 cent per gallon duty on imported ethanol to offset the U.S. tax incentives was recently extended through the end of 2008.[7] The American Jobs Creation Act of 2004 established a tax credit of up to $1 per gallon of biodiesel produced, and the Energy Policy Act of 2005 (EPAct 2005) extended this credit through 2008. Laws are also in

[6]The marketing year for corn is from September 1 each year to August 31 of the following year, and the marketing year for soybeans is from October 1 each year to September 30 of the following year.

[7]Tax Relief and Health Care Act of 2006 (Pub. L. No. 109-432).

place giving income tax credits and loan guarantees to small ethanol producers. Provisions of the Clean Air Act Amendments of 1990 established programs to control carbon monoxide and ozone problems created by motor fuel emissions, and ethanol and methyl tertiary butyl ether (MTBE) were the primary oxygenates blended into gasoline to meet the programs' standards. Because MTBE was subsequently found to contaminate water, its use is currently being phased out—25 states have banned the additive as of 2006—increasing demand for ethanol. EPA's recently adopted low-sulfur diesel standards designed to help reduce harmful emissions could increase demand for biodiesel, which provides lubricity benefits when blended with regular diesel. The Farm Security and Rural Investment Act of 2002 contained the first energy title in farm bill history, authorizing a range of programs through 2007 to promote bioenergy production and consumption.

In addition, some states have established laws and policies to increase renewable fuel availability and use through biofuel mandates, production incentives, and tax credits. According to the American Coalition for Ethanol, in 2006, 4 states had mandates for the use of renewable fuels, and 12 states had such a mandate under consideration. In addition, 17 states provided ethanol production incentives, and 12 states offered incentives to encourage retailers to provide biofuels at their stations. One of the first states to actively promote biofuels was Minnesota, which currently mandates that 2 percent of the diesel transportation fuel consumed in the state be biodiesel and that 20 percent of gasoline transportation fuel be ethanol by 2013.[8] Minnesota state officials view their support for biofuels as a means to boost their farm economy by increasing demand for feedstock crops while also contributing to a cleaner environment.

Despite the federal and state efforts to support and promote ethanol and biodiesel, the public has been slow to accept them because they have not been cost competitive or readily available compared to relatively cheap

[8]EPA has determined that the sale of blends of E10 or less for most vehicles and up to E85 for FFVs is allowed under the Clean Air Act Amendments of 1990. The state of Minnesota and the Renewable Fuels Association are currently sponsoring research to determine the effects of ethanol blends up to E20 on vehicle fuel systems and emissions. The sponsors plan to submit the results to EPA for an evaluation of E20's compliance with the Clean Air Act. If EPA rules in favor of allowing the use of blends up to E20, the ruling would apply nationwide. In the interim, Minnesota is attempting to meet its 20 percent goal by a combination of E10 and E85 use. In addition, DOE plans to work with EPA to develop a national test program to gather the data required to facilitate the legal certification of fuel blends up to E15 or E20.

and abundant petroleum-based fuels.[9] Furthermore, because biofuels contain less energy per gallon than their petroleum-based counterparts, consumers must purchase more of the fuels to travel the same distance. A gasoline blend containing 10 percent ethanol results in a 2 to 3 percent decrease in miles-per-gallon fuel economy, while in a higher blend such as E85, the decrease is proportionally larger. The energy content of a gallon of biodiesel is about 8 percent lower than that of petroleum diesel, causing vehicles running on B20, for example, to experience about a 2 percent decrease in miles per gallon, while for vehicles running on B100, the decrease is proportionally larger.

Furthermore, the net energy value of biofuels has been the subject of debate. Numerous studies conducted since the late 1970s have estimated the net energy value of corn ethanol, but variations in data and assumptions have resulted in a wide range of estimates, a few indicating that it takes more nonrenewable energy to produce ethanol than is delivered when the fuel is consumed. In 2002, USDA conducted a study to estimate the net energy value of ethanol and to identify the cause of variance among studies.[10] USDA's analysis determined that corn ethanol yields 34 percent more energy than it takes to produce it—considering the entire fuel cycle of growing the corn, harvesting it, transporting it, and distilling it into ethanol—when using the assumption that the fertilizers used in growing the corn were produced by modern processing plants, the corn is converted in modern ethanol plants, and farmers achieve average corn yields. Furthermore, only about 17 percent of the energy used to produce ethanol comes from gasoline or diesel fuel. Therefore, for every gallon of petroleum fuel used to produce ethanol, about six energy equivalent units of ethanol can be produced. Biodiesel, according to a 1998

[9]Some people believe that the prices U.S. consumers pay for petroleum fuels do not reflect their true costs. For example, some researchers have concluded that petroleum fuels would sell at a much higher price—making biofuels more competitive—if the full environmental costs of producing and using petroleum fuels and the full costs of ensuring oil supply security worldwide were accounted for in the price. A comparison of the costs of biofuels and petroleum fuels would also have to take into account the full environmental and other costs of producing biofuels, such as the impacts of potentially devoting greater land area to commercial agriculture and using greater amounts of fresh water for irrigation.

[10]USDA, *The Energy Balance of Corn Ethanol: An Update*, (AER-813), Office of Energy Policy and New Uses, July 2002. Subsequently, in a January 2006 study published in *Science* magazine, University of California, Berkeley, researchers reviewed six representative analyses of fuel ethanol and found that those that reported negative net energy incorrectly accounted for input energy and used some obsolete data.

joint USDA-DOE study, yields 220 percent more energy than is used in its production.

Research on the environmental effects of biofuels on air quality has shown a variety of impacts depending on how the fuels are blended and where they are used. Through 2005 ethanol was primarily used in blends under 10 percent to meet a minimum oxygenate requirement for reformulated gasoline—in accordance with the Clean Air Act Amendments of 1990—to reduce vehicle emissions in certain metropolitan areas with high levels of ground-level ozone. Although oxygenates lead to lower emissions of carbon monoxide, in some cases they may lead to higher emissions of nitrogen oxides and volatile organic compounds, which can in some areas lead to increased ground-level ozone formation due to atmospheric conditions.[11] Regarding greenhouse gas emissions, an Argonne National Laboratory study found that for the entire fuel cycle—from growing the corn to producing the ethanol—corn-based E10 generates about 1 percent lower greenhouse gas emissions than gasoline, while emissions are about 20 percent lower for E85.[12] Biodiesel reduces nearly all forms of air pollution compared to petroleum diesel, although ozone-forming nitrogen oxide emissions are created. According to a joint DOE and USDA study, biodiesel also reduces greenhouse gasses, for example, producing 78 percent less carbon dioxide than diesel fuel for the entire fuel cycle.

In an effort to obtain greater net energy and environmental benefits than with corn ethanol, DOE's Biomass Program is leading research efforts toward developing a process to produce cellulosic ethanol that is cost competitive with gasoline. Cellulosic ethanol is chemically the same as corn- or sugar-based ethanol, but is produced from feedstocks that are of lower economic value. These feedstocks include switchgrass as well as fast-growing woody crops such as hybrid poplar trees, and other biomass materials, such as logging and crop residues. Because cellulosic feedstocks require far less natural gas-derived fertilizer for their production, the overall energy balance and other benefits of cellulosic ethanol could be significantly greater than those of corn ethanol. For

[11]Section 1504(a) of the Energy Policy Act of 2005 (Pub.L. No. 109-58) eliminated the reformulated gasoline oxygenate standard as of May 2006 and required EPA to revise its regulations for the program to allow the sale of nonoxygenated reformulated gasoline.

[12]DOE, *Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas Emissions*, Argonne National Laboratory, January 1999. The study analyzed emissions of three major greenhouse gasses—carbon dioxide, methane, and nitrous oxide.

example, the Argonne National Laboratory study concluded that cellulose-based E85 could reduce fossil energy consumption, such as that of natural gas, coal, and oil, by roughly 70 percent and could reduce greenhouse gas emissions by roughly 70 to 90 percent per vehicle mile traveled in a midsize car. However, while cellulosic feedstocks are abundant and inexpensive, currently, cellulosic feedstock conversion technology is rudimentary and expensive. Consequently, while pilot facilities are operating in the United States and Canada, there are currently no commercial cellulose-to-ethanol facilities operating in the United States, although plans to build such plants are under way. Biodiesel research is not a top priority for DOE, but private companies are developing technology, for example, to produce biodiesel from feedstocks such as algae.

## Biofuel Production Has Increased, and Federal Support Targeting Technology Development Could Address Some of the Impediments to Greater Production

U.S. annual ethanol and biodiesel production increased rapidly from 2004 to 2006, but together these fuels composed only about 3 percent of gasoline and diesel motor fuel used in 2006. The challenge of producing biofuels at a lower cost than petroleum fuels makes it unlikely that they will displace a considerable amount of the petroleum used in transportation fuels until new production processes are developed. The higher relative cost of producing biofuels is largely due to the cost of the primary feedstocks—corn and soybean oil. Producing ethanol from alternative feedstocks such as switchgrass or other biomass materials could expand the geographic range of biofuel plants, but the challenge of producing cost competitive cellulosic ethanol is even greater than for conventional corn ethanol. Nevertheless, policy options exist that could help overcome some of these challenges, allowing biofuels to compose an even greater proportion of the nation's total transportation fuel supply.

### U.S. Ethanol and Biodiesel Production Is Increasing, but These Fuels Provide Only a Very Small Proportion of the Nation's Total Motor Transportation Fuel

From 2004 to 2006, annual U.S. ethanol production increased about 43 percent from 3.4 billion gallons to about 4.9 billion gallons. About 99 percent of the ethanol produced in 2006 was used in gasoline blends of 10 percent or less, and the remaining 1 percent was blended to produce E85. U.S. ethanol production capacity is projected to rise rapidly. According to the Renewable Fuels Association, in early 2007, 114 ethanol plants were operating, 7 of these plants were expanding, and 78 new plants were under construction. According to EIA, on the basis of estimates of the number of plants under construction, domestic ethanol production could rise to at

least 7.5 billion gallons by 2008. Looking out further, EIA projects ethanol use of 11.2 billion gallons in 2012 and, absent significant cellulosic ethanol production, 14.6 billion gallons in 2030.[13] However, some other projections are higher, such as a May 2007 Iowa State University study sponsored in part by USDA, which estimates 14.8 billion gallons of corn ethanol production by 2011.[14] Nevertheless, U.S. ethanol production composed only 3.4 percent of the total amount of gasoline used in 2006. Moreover, on an energy equivalent basis, ethanol made up only 2.3 percent of gasoline used in 2006, because ethanol contains about two-thirds the energy of gasoline. EIA estimates that ethanol will likely account for only 7.6 percent of the volume of gasoline projected to be consumed in 2030.

From 2004 to 2006, annual U.S. biodiesel production increased more than 10-fold from 28 million gallons to approximately 287 million gallons. Biodiesel is mostly used in B20 or lesser concentrations, such as B2, in part due to state mandates, such as in Minnesota, that all diesel fuels contain 2 percent biodiesel. At the beginning of 2007, 105 biodiesel plants were operating, 8 plants were expanding, and 77 companies have plants under construction. Even with this expansion, EIA projects that domestic biodiesel production will likely increase to only 308 million gallons in 2012, and only 395 million gallons in 2030, in part because some plant production capacity is used for other products such as cosmetics.[15] Despite rapid increases in production, biodiesel composed only an estimated 0.6 percent of total diesel motor fuel used in 2006, and a somewhat smaller proportion on an energy equivalent basis due to the fact that biodiesel contains about 8 percent less energy than diesel does.

The recent large increase in biofuel production has occurred for a number of reasons. Greater ethanol production occurred largely as a result of the phaseout of the fuel additive MTBE. Fuel blenders needed a replacement for MTBE to achieve desired performance and emissions characteristics, and ethanol was the best available choice. In addition, the 51 cent per

[13]DOE, EIA, *Annual Energy Outlook 2007*, DOE/EIA-0383(2007). EIA's projection assumes that the support for ethanol provided in recently enacted federal legislation will be extended indefinitely.

[14]Iowa State University, *Emerging Biofuels: Outlook of Effects on U.S. Grain, Oilseed, and Livestock Markets*, Center for Agricultural and Rural Development, May 2007.

[15]EIA's projection in the *Annual Energy Outlook 2007* assumes that the support for biodiesel provided in recently enacted federal legislation will not be extended beyond 2008. However, according to EIA, should the tax credit for biodiesel be reauthorized after 2008, it would significantly increase biodiesel production.

gallon VEETC has helped to make ethanol more cost competitive with gasoline. While the RFS mandate has guaranteed a base level of demand for the fuel, according to economists with whom we spoke, it has had a limited role in increasing ethanol production. In 2006, the production of ethanol exceeded the amount of renewable fuel needed to meet the RFS by 21 percent and, according to our analysis of EIA data, is projected to exceed the amount required in 2012, 3 years before then, in 2009. Current levels of biodiesel production are largely due to the federal excise tax incentives provided by the American Jobs Creation Act of 2004, which was extended through 2008 under EPAct 2005.[16] These incentives include the $1 per gallon tax credit for biodiesel produced from virgin oils or fats and a 50 cent per gallon tax credit for biodiesel produced from recycled grease. Additionally, biodiesel production has increased, in part because of the RFS, which includes biodiesel as a fuel that counts toward meeting the program's overall requirements for the amount of renewable content in motor fuel. Furthermore, state-level biodiesel incentives such as Minnesota's B2 mandate have encouraged biodiesel production by guaranteeing use of the fuel.

## Efforts to Significantly Increase Biofuel Production May Be Impeded by Various Factors That Contribute to High Production Costs Relative to Those of Petroleum Fuels

A key challenge to increasing biofuel production is making biofuels cost competitive with gasoline and diesel fuel. The higher costs of producing biofuels contributes to higher biofuel wholesale prices compared to those for gasoline or diesel, making biofuels less desirable as a substitute. For example, based on a March 2007 estimate provided by USDA, the cost to produce a gallon of ethanol, including the cost of corn and processing, is about $2.51 per gallon of gasoline equivalent,[17] while based on our analysis of EIA estimates, in January 2007, the crude oil and refining components of the retail price of gasoline were about $1.46 per gallon.[18] In 2006, the average wholesale price of ethanol was 33 percent more on a per volume basis than the wholesale price of a gallon of regular unleaded gasoline and

[16]Biodiesel production was also supported by grants from the Commodity Credit Commission Bio-energy Program, which was not funded beyond 2006.

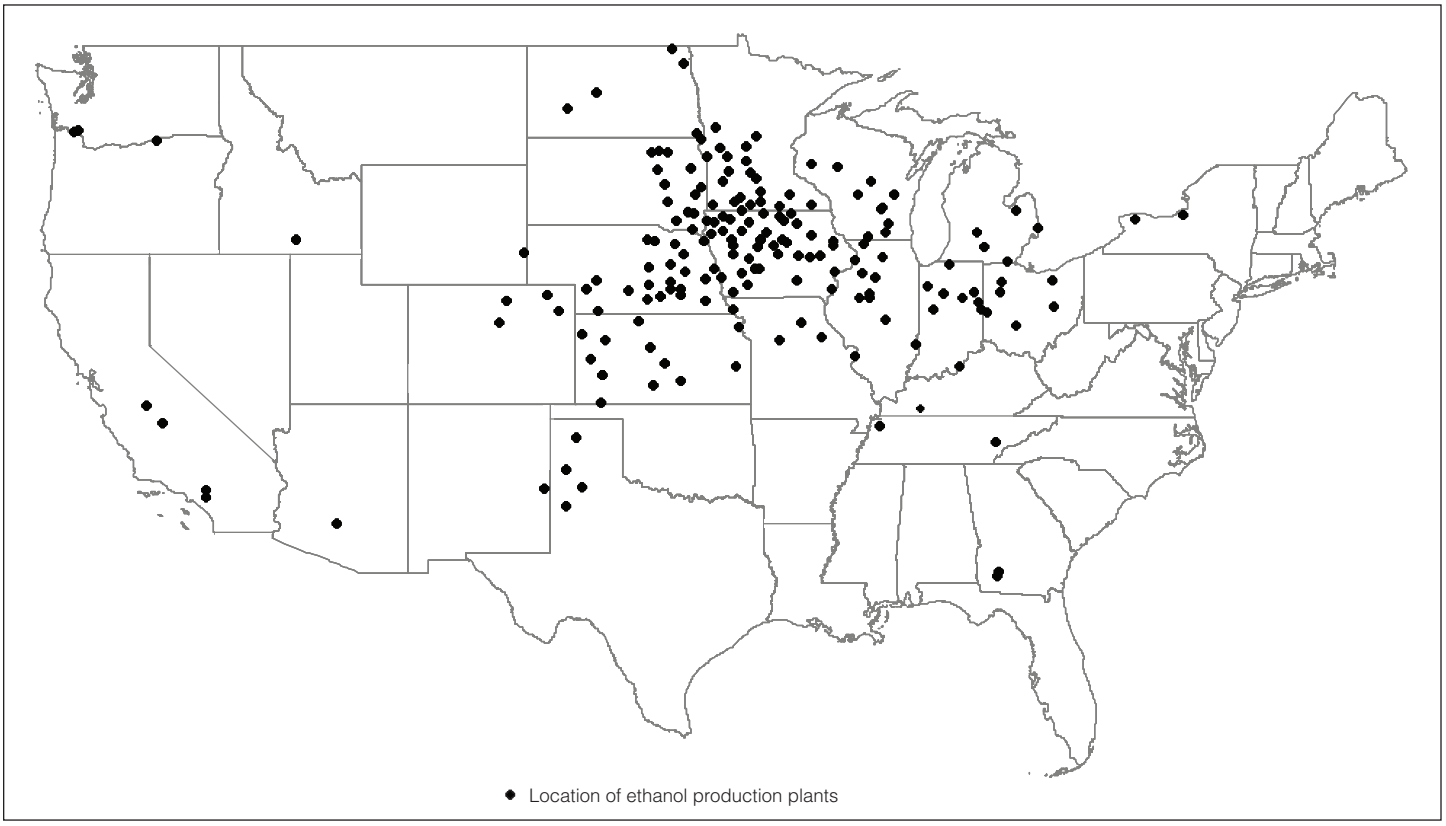
[17]"Gallon of gasoline equivalent" equates the energy content of a gallon of ethanol to that of a gallon of gasoline.

[18]According to USDA, the estimated production cost for ethanol is based on the cost of the corn feedstock and processing costs. USDA used the early 2007 corn cost of about $3.50 per bushel. The production cost for gasoline includes at a minimum, the cost of crude oil and refining costs. According to EIA, the crude oil cost is the average price of crude oil purchased by refiners. The refining costs are derived from a calculation of the difference between the monthly average spot market price of gasoline and the average price of crude oil purchased by refiners, and includes an undetermined amount of refiner profits.

about 102 percent more expensive on a gallon of gasoline equivalent basis. In addition to the higher cost of production, the higher wholesale price for ethanol in 2006 was also attributable, to a certain extent, to the high demand for ethanol caused by the MTBE phaseout, as well as the general rise in petroleum and natural gas prices.

Feedstocks such as corn and soybean oil are the largest costs of biofuel production, and the high prices of these feedstocks are impediments to reducing ethanol and biodiesel production costs. According to EIA, the U.S. ethanol industry relies almost exclusively on corn, and as shown in figure 1, production facilities are concentrated in the Midwest, where the feedstock is most plentiful. According to USDA, prices for corn have risen sharply, likely because of increased demand for its use in ethanol. Prices for soybean oil have increased recently in anticipation of reduced soybean planted area in 2007 because of increased planting of corn. For example, in the 2005-to-2006 marketing year corn cost $2.00 per bushel, which we estimate was about 62 percent of the cost of producing ethanol. According to USDA, corn prices are projected to average between $3.00 to $3.40 per bushel in the 2006-to-2007 marketing year and according to our analysis make up an estimated 74 percent of the cost of producing ethanol. For biodiesel production, in the 2005-to-2006 marketing year soybean oil cost on average 23 cents per pound, which we estimate was about 79 percent of the cost of producing biodiesel in 2006. USDA projects soybean oil prices to rise to between an average of 27 cents per pound to 29 cents per pound in the 2006-to-2007 marketing year and according to our analysis make up an estimated 82 percent of the cost to produce biodiesel.

**Figure 1: Location of Ethanol Production Plants in 2007**




Source: Renewable Fuels Association data.

Limits on both the total production of feedstocks and the amounts of those feedstocks that are available for energy production are also impediments to significantly increasing biofuel production. For example, in 2006, an estimated 15 percent of the corn available in the 2005-to-2006 marketing year was used to produce about 4.9 billion gallons of ethanol, which composed 3.4 percent of total gasoline consumption.[19] Assuming that ethanol production continues to expand as projected by EIA, by 2012, about 30 percent of the corn crop will be needed to produce 11.2 billion gallons of ethanol, which would constitute 7.4 percent of projected total gasoline consumption.[20] Since corn crop yields have historically only

[19]EIA includes ethanol as a component in its calculation of total gasoline consumption.

[20]This calculation is based on USDA's projected corn supply in the 2012-to-2013 marketing year, which is about 13.5 billion bushels.

increased at a rate of about 2 percent per year, the corn needed to significantly increase ethanol production will come from planting more acres of corn by putting pastureland and idle land into production, planting corn where other crops were previously grown, or using corn that is currently exported or used as feed for livestock or other purposes. Concerns exist about the potential impacts of such actions on food prices and the environment. For example, using more corn for energy production will likely exert additional upward pressure on corn prices, potentially influencing livestock feed markets and meat prices. Furthermore, environmental concerns exist regarding greater water use and impacts on wildlife if land set aside for purposes such as water conservation or wildlife habitat is put into production. Because of these limitations and concerns, DOE and industry experts generally agree that approximately 15 billion to 16 billion gallons is the maximum amount of ethanol production that can be derived from the U.S. corn supply. Similar concerns exist regarding the impacts of devoting larger proportions of the soybean crop to biodiesel production, although the impacts are likely to be smaller because of the smaller scale of increases to biodiesel production projected by EIA.

According to DOE, producing cellulosic ethanol from alternative feedstocks could greatly expand the amount of ethanol produced, but currently the costs of facility construction and production are significantly greater than those of corn ethanol. According to a DOE study, there is sufficient biomass in feedstocks such as wood chips and corn stalks to potentially produce roughly 60 billion gallons of ethanol per year by 2030, or about 30 percent of the amount of gasoline EIA projects to be consumed in that year. Biomass that could be used in cellulosic ethanol production is plentiful and relatively inexpensive nationwide, and plants built in proximity to the feedstocks would help to lessen the cost of obtaining the feedstocks as well as distributing biofuels nationwide. However, according to DOE's National Renewable Energy Laboratory (NREL), the total project investment for a cellulosic ethanol plant with a production capacity of 50 million gallons per year is estimated at about $250 million dollars, as compared to a total project investment of $76 million for a corn ethanol plant of similar capacity.[21] Furthermore, according to DOE, the cost of producing a gallon of cellulosic ethanol is

[21]Total project investment figures are in 2007 dollars and include plant construction, equipment, installation, site development, and other costs such as startup costs and permits.

about twice the cost of corn-based ethanol. The cost to produce cellulosic ethanol is higher than that of corn-based ethanol because of processing costs, enzyme costs, and the cost to collect the feedstocks. Considerable research and development by NREL and its partners has significantly reduced the estimated cost of producing the enzyme used to break down cellulose into sugar to make ethanol, but according to DOE further successes in research and development are needed to make cellulosic ethanol a viable economic option for expanded ethanol production.[22]

## Several Policy Options, Including Support for Cellulosic Ethanol Production Technology, Could Help Overcome Some of the Impediments to Increasing Biofuel Production

One policy option for increasing biofuel production is raising the amount or extending the duration of tax incentives for ethanol and biodiesel production. This option provides the advantage to producers of offsetting a greater portion of their costs. However, a disadvantage is the potential for significant additional federal revenue losses, depending on the level of increase or the length of the extension. Furthermore, according to some economists, it is difficult to predict the effect of revised tax incentives. If the incentives are set too low to offset production costs, biofuel production will not rise significantly; if incentives are set too high, producers will receive windfall profits if production costs decline or oil prices increase significantly.

Linking the level of biofuel tax incentives to the price of petroleum fuels could provide the advantage of limiting government revenue losses by providing tax credits only when biofuels are not cost competitive with petroleum fuels. For example, one proposal for a variable tax credit would provide 5 cents in ethanol tax credits for every $1 the price of oil is below the trigger price of $45 per barrel.[23] However, according to some economists with whom we spoke, establishing a variable tax credit would be challenging due to the difficulty of determining the correct trigger price for oil as well as constructing the variable subsidy to deal with constantly fluctuating corn prices. Another form of variable tax credit could be based on the renewable energy content of the biofuel, taking into account the net energy balance of production. Such a credit could provide greater support to fuels that displace a greater amount of petroleum and yield greater environmental benefits. One economist with whom we spoke noted that a variable tax credit could also support other biofuels, in addition to ethanol

[22]NREL, managed by Midwest Research Institute and Batelle, is the principal research laboratory for DOE's Office of Energy Efficiency and Renewable Energy.

[23]Senate Bill 162, National Fuels Initiative, 110th Cong., 1st Sess. (2007).

and biodiesel, stressing the importance of not excluding other promising biofuels.[24] However, the economists with whom we spoke noted a disadvantage to any production incentives for biofuels. Assuming lower costs are passed on to consumers, they may be encouraged to drive more miles or purchase less efficient vehicles, resulting in little or no reduction in petroleum fuel consumption.

Another option for increasing biofuel production is raising the level of the RFS. This option offers the advantage of virtually guaranteeing increased biofuel production and use to a specific predetermined level. Furthermore, a higher RFS could ensure a larger market for biofuels, thus mitigating risks for investors and encouraging expenditures for developing new production technology. A disadvantage of this option is that if biofuel prices significantly increase with an RFS mandate in place, then the price of fuel for consumers could also significantly increase. Corn prices have risen sharply recently with rapid increases in ethanol production, and could be expected to increase further under a higher RFS as demand for fuel production creates greater competition with other feedstock users. If the costs of biofuel production increase, the costs of complying with the RFS for blenders who integrate biofuels into the transportation fuel supply will also increase, and these costs could be expected to be passed on to consumers. Advances in production technology that have the potential to lower costs—such as cellulosic ethanol production that uses lower-cost feedstocks—could help meet a higher RFS with cost-competitive biofuels, but it is currently unclear exactly when such technological advances will be achieved.

A third option for increasing biofuel production is to provide support for the development of cellulosic ethanol production technology. This could involve ensuring continued funding for research and development, increasing federal cost-sharing efforts to reduce risk to producers, and adding incentives for the production of biomass feedstocks. These policy options have the advantage of potentially resulting in a huge increase in cost-competitive biofuel production. The disadvantages are that such policies could require significant federal expenditures and there are no guarantees as to when or if cost-competitive cellulosic ethanol will be produced. According to the NREL officials with whom we spoke, DOE's

[24]For example, biobutanol is a next-generation biofuel that can be made from corn or cellulosic biomass, has similar energy content to gasoline, and could be distributed through existing fuel pipelines.

research and development efforts for cellulosic ethanol are currently funded and on schedule toward the goal of making production commercially viable by 2012.[25] However, they said that technological uncertainties remain and it is therefore essential that research funding continue to meet this goal.[26]

According to NREL, the primary nontechnological barrier to expanding cellulosic ethanol production is the perceived financial risk, making it difficult for companies to secure funding to build facilities. To initially reduce financial risk, DOE provided grants in 2002 totaling $80 million dollars to fund six small-scale cellulosic ethanol biorefineries that support the technology in the demonstration phase. Then, in February 2007, DOE announced it would give $385 million in grants to six cellulosic ethanol biorefineries over a 4-year period to help the industry develop larger-scale pilot production facilities.[27] Another measure that would help producers to mitigate the financial risks of full-scale commercial production is a federal insurance program that would pay cellulosic ethanol producers a settlement if they did not achieve their first-year production goals. According to one NREL official with whom we spoke, the advantage of an insurance program is that it can be based on well-defined performance metrics that limit potential government payments to specific outcomes, as opposed to the potentially larger losses from defaults under a loan guarantee program for producers. Another option suggested by NREL is a program to provide direct payments to growers of cellulosic feedstock,

[25]DOE established this goal to meet the objectives of the President's 2006 Advanced Energy Initiative, aimed at reducing the nation's dependence on foreign sources of energy.

[26]NREL recently completed a draft assessment of the market drivers and technology needs to achieve the goal of supplying 30 percent of 2004 motor gasoline fuel demand with biofuels by 2030. See NREL, *A National Laboratory Market and Technology Assessment of the 30x30 Scenario*, NREL Technical Report /TP-510-40942, January 2007.

[27]Cellulosic ethanol producers can also take advantage of a loan guarantee program created by EPAct 2005. We recently evaluated the program and reported that DOE has not completed key steps to ensure that the program will be well managed and able to accomplish its objectives, and that there are risks to the government because of DOE's potential to underestimate loan guarantee subsidy and administrative costs. See GAO, *The Department of Energy: Key Steps Needed to Help Ensure the Success of the New Loan Guarantee Program for Innovative Technologies by Better Managing Its Financial Risk*, GAO-07-339R (Washington, D.C.: Feb. 28, 2007). There is also a special depreciation deduction for cellulosic ethanol plants contracted to be acquired after December 20, 2006, that allows producers to take a depreciation deduction of 50 percent of the adjusted basis of a new cellulosic ethanol plant in the year it is put in service. In addition, EPAct 2005 authorized DOE to make per gallon incentive payments to cellulosic ethanol producers until production reaches 1 billion gallons, or 2015, whichever comes first.

such as switchgrass, in order to ensure that an adequate supply of those feedstocks is available when cellulosic ethanol plants begin full-scale production. The insurance and grower payment programs both have the potential advantage of helping to increase initial cellulosic ethanol production but could end up being costly.

Other policy options, while not directly related to biofuel production, could nevertheless influence the availability and use of biofuels. For example, removing the existing 54 cent per gallon import duty on ethanol could have the advantage of significantly increasing the availability of biofuels for blending into the U.S. transportation fuel supply, largely because of the huge potential for increased imports of low-cost biofuels from South America. However, this could present a threat to the continued development of domestic biofuel production and would no longer provide an offset to the payment of biofuel excise tax credits to blenders of foreign ethanol. According to a recent survey of economists conducted by the Wall Street Journal, as well as several economists with whom we spoke, additional taxes on petroleum fuels or taxes on carbon dioxide emissions would be the most economically efficient means of increasing biofuel use.[28] Taxes would allow biofuels to be used at the level where they provide the greatest economic, environmental, and other benefits for the least cost, rather than at a mandated level that is, according to an economist with whom we spoke, difficult to correctly determine. Such an approach has the potential advantages of making all biofuels more cost competitive with petroleum fuels, and the added cost of petroleum fuels could encourage conservation. The potential disadvantage of this approach is that it is likely to be unpopular with consumers facing higher prices at the pump and with businesses that extract fossil fuels, such as the oil and coal industries.

[28]*Wall Street Journal*, "Politics & Economics: Economists Back Fossil-Fuel Tax To Spur Alternative Energies," February 9, 2007.

## The Biofuel Distribution Infrastructure Has Limited Capacity to Transport the Fuels and Deliver Them to Consumers, and Expanding the Distribution System Faces a Variety of Impediments

Currently biofuels are transported primarily on the freight rail system, and this system has limited capacity to transport greater amounts of biofuels if production significantly increases. We estimate that in early 2007, about 1 percent of fueling stations in the United States offered E85—primarily in the Midwest—or high blends of biodiesel (B20 through B100). Under current conditions, significant growth in the number of stations that offer high blends of biofuels beyond the regions where the fuels are produced appears unlikely. Increasing the availability of biofuels at fueling stations is impeded in large part by the limited supplies of ethanol and biodiesel and the cost of storage and dispensing equipment for biofuels. Several policy options could help to increase the number of stations that offer biofuels, but until a larger supply of cost-competitive biofuels is available, it is doubtful that a greater number of stations would lead to greater use of biofuels.

### Limited Capacity Exists to Transport Biofuels, and the Costs Are Higher than for Petroleum Fuels

According to DOE, biofuels are not transported through the petroleum product pipeline system because of concerns that, for example, ethanol will attract water in the pipes, rendering it unfit to blend with gasoline, and no dedicated biofuel pipeline system exists. Furthermore, according to DOE, the existing petroleum product pipelines are generally not configured to transport ethanol from regions where it is currently produced to regions where it is consumed. Therefore, ethanol is transported primarily by rail, but also by truck and barge, and biodiesel is transported by rail and truck—a distribution system that is more complicated than for petroleum fuels and has contributed to regional supply shortages. For example, while ethanol production is concentrated in the Midwest largely because of the proximity of large corn feedstock supplies, demand for ethanol as a blend component to replace MTBE in gasoline is high on the east and west coasts. In California gasoline is blended with about 5.7 percent ethanol. According to EIA, limited rail and truck capacity complicated the delivery of ethanol between April and June 2006, contributing to regional ethanol supply shortages and price spikes.

The current biofuel transport system is also more costly than for petroleum fuels. According to NREL, the overall cost of transporting ethanol from production plants to fueling stations is estimated to range from 13 cents per gallon to 18 cents per gallon, depending on the distance traveled and the mode of transportation. In contrast, the overall cost of transporting petroleum fuels from refineries to fueling stations is estimated on a nationwide basis to be about 3 to 5 cents per gallon.

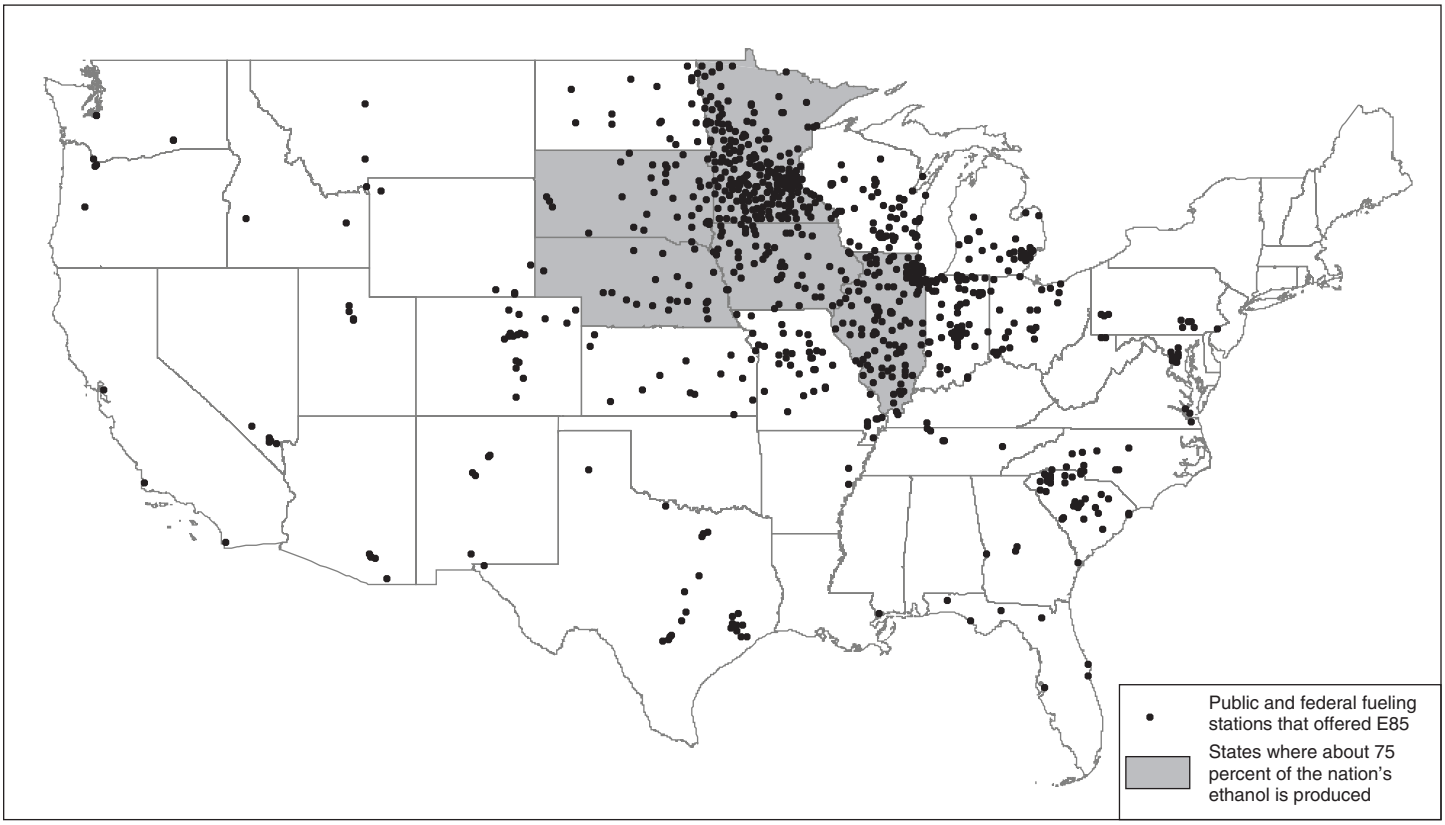
The key challenges to meeting biofuel transport needs are potential capacity limitations in the freight rail system and the cost of developing a dedicated ethanol pipeline system if one is needed. Looking to the future, DOE and ethanol industry experts are concerned about transporting greater amounts of biofuels if production significantly increases. Substantial increases in overall freight traffic are forecast, and as we recently reported, the freight railroad industry's ability to meet the growing demand is largely uncertain.[29] Replacing, maintaining, and upgrading the existing aging rail infrastructure are extremely costly, and while railroads told us that they plan to make substantial investments in infrastructure, the extent to which these investments will increase capacity as freight demand increases is unclear. Alternatively, existing petroleum pipelines could be used in certain areas to transport ethanol if ongoing efforts by operators to identify ways to modify their systems to make them compatible with ethanol or ethanol-blended gasoline are successful. Building dedicated pipelines to transport ethanol would be extremely expensive, according to a 2006 NREL report, which estimates the current costs of constructing pipelines at roughly $1 million per mile, although the cost can vary dramatically based on right-of-way issues, the number of required pumping stations, and other considerations.

## The Relatively Small Number of Fueling Stations Offering E85 Are Concentrated in the Midwest, while Stations Offering Biodiesel Are More Widely Dispersed

In early 2007, approximately 1,100 public and federal fueling stations offered E85, concentrated largely in the Midwest, as shown in figure 2. The number of fueling stations that offered E85 increased by an average of about 350 per year between 2004 and 2006. Despite this rapid increase, we estimate that the number of fueling stations that offered E85 was only about 0.6 percent of the total number of all fueling stations. According to industry experts, most fueling stations with E85 are located in proximity to ethanol plants in order to minimize distribution costs. For example, in early 2007, 55 percent of the fueling stations that offered E85 were concentrated in five midwestern states—Minnesota, Illinois, Iowa, South Dakota, and Nebraska—where about 75 percent of the nation's ethanol is produced (see fig. 2). Of the total number of fueling stations that offered E85, in early 2007, 57 were federally operated for use by government fleet vehicles and were distributed nationwide.

[29]See GAO, *Freight Railroads: Industry Health Has Improved, but Concerns about Competition and Capacity Should Be Addressed*, GAO-07-94 (Washington, D.C.: Oct. 6, 2006).

**Figure 2: Location of Public and Federal Fueling Stations That Offered E85 in 2007**




Sources: Congressional Research Service and DOE's Alternative Fuels Data Center data.

In early 2007, approximately 400 public and federal fueling stations across the country offered biodiesel blends of B20 through B100, as shown in figure 3.[30] The number of fueling stations that offered biodiesel increased by an average of about 186 per year between 2004 and 2006. Despite this rapid increase, we estimate that the number of fueling stations that offered biodiesel was only about 1 percent of the total number of fueling stations that offered diesel. Biodiesel fueling stations are dispersed nationwide because production facilities are not concentrated in any specific region. Biodiesel is commonly used in low blends—B20 is a popular blend because it provides better mileage than pure biodiesel yet still provides

[30]DOE collects full data on stations that offer B20 through B100, and limited data on stations that offer lower blends of biodiesel. Many stations offer a low blend. For example, all diesel fuel sold in Minnesota is 2 percent biodiesel by law.

some of its benefits, such as good lubricity. In addition, B20 is common because federal fleet vehicles that use the blend earn credits toward meeting the statutory requirements for the acquisition of alternative fuel vehicles by federal agencies.[31] Of the approximately 400 public and federal fueling stations that offered biodiesel in early 2007, 75 were federally operated, and were for use by the government fleet of vehicles.

**Figure 3: Location of Public and Federal Fueling Stations That Offered B20 through B100 in 2007**


Source: DOE's Alternative Fuels Data Center data.

According to DOE and officials from state governments, the increase in the number of fueling stations that offered E85 is due in part to federal

[31]The Energy Conservation Reauthorization Act of 1998 amended the Energy Policy Act of 1992 to allow federal fleets to generate one alternative fuel vehicle acquisition credit for every 450 gallons of pure biodiesel (equivalent to 2,250 gallons of B20) purchased for use in diesel vehicles with a gross vehicle weight rating of more than 8,500 pounds.

grants to states and private businesses distributed through DOE's Clean Cities Program. This program was established in 1993 as part of the department's efforts to advance the nation's economic, environmental, and energy security by supporting local decisions to adopt practices that contribute to reduced petroleum consumption and is the department's only program aimed at expanding the biofuel infrastructure. Between 1999 and 2006, Clean Cities provided $11 million in grants to 33 states to install biofuel infrastructure. Clean Cities' criteria for awarding the grants include, for example, the ability of the grantee to (1) access and dispense a significant amount of biofuel, and (2) share at least 50 percent of the project costs, as well as the grantee's record of past success with alternative fuel infrastructure development. The $7.2 million in 2006 grants, with private and state or local cost sharing, will result in biofuel dispensers in 210 locations—primarily for E85—being installed in 21 states, such as California, Colorado, Georgia, and Iowa, and biofuel blending infrastructure being added in 9 states. According to a Clean Cities official, the program has successfully targeted grants to locations where grantees have a high probability of increasing biofuel use. However, significant increases in ethanol production would create the need for greater infrastructure expansion, thus placing much greater demands on this program.

In addition, certain states have provided significant funding to install E85 fuel dispensers at stations. For example, from 2005 to 2006, at least 29 E85 dispensers were added to stations in Iowa, partially funded with grants provided by a 2-year state program, and 64 E85 dispensers were added in Illinois, partially funded with grants from a private foundation, but administered by the state Department of Commerce and Economic Opportunity. According to a Clean Cities official, the increase in the number of fueling stations that offered biodiesel was due in part to federal grants to states and private businesses distributed by the Clean Cities Program and significant additional funding provided by state governments. Furthermore, the state mandate in Minnesota that all diesel fuel contain at least 2 percent biodiesel by volume required that all stations provide biodiesel as B2, and in future years, B2 mandates in the states of Washington and Louisiana will likely contribute to increased availability of biodiesel blends in those states. While EPAct 2005 provided a tax credit of up to $30,000 toward the cost of installing biofuel dispensers and related equipment, the impact of this tax credit on the number of biofuel dispensers installed in 2006 is not yet known.

## The Limited Supply of Ethanol Available for Use as E85 and the Need for Specialized Storage and Dispensing Equipment Are among the Key Impediments to Providing Biofuels at More Fueling Stations

The limited amount of ethanol made available for use in E85 is the primary impediment to significantly expanding the number of stations that offer the fuel. According to EIA, in 2006, about 1 percent of the ethanol produced in 2006 was used in E85. Little ethanol was available for E85 because producers prefer to sell ethanol at a higher price for use in low blends rather than selling ethanol at a discount for use in E85. High demand for ethanol in low blends as an oxygenate and fuel extender has contributed to wholesale ethanol prices that are significantly higher than the wholesale price of gasoline. An additional incentive to selling ethanol in blends of 10 percent or lower, according to one major fuel blender with whom we spoke, is that the fuel economy reduction at that level is too small for consumers to notice; hence, the fuel can be sold at the same price as conventional gasoline at fueling stations. On the other hand, to attract customers, fueling stations must generally sell E85 at a discount to conventional gasoline to offset the noticeably lower miles per gallon that drivers experience when using the fuel. For example, in 2006, according to DOE's Alternative Fuel Price Reports, E85 sold for 11 percent less on average than regular gasoline at a sample of fueling stations nationwide. However, few producers are willing to discount ethanol so that fueling stations can price E85 lower than gasoline. Consequently, EIA projects that use of ethanol for E85 will continue to be limited until the market for blends of 10 percent and under is nearly saturated.

For biodiesel, the low overall production levels are the primary impediment to significantly expanding the number of fueling stations that offer biodiesel blends. According to our estimate, in 2006, the approximate amount of biodiesel produced was only 0.6 percent of the amount of diesel fuel used and, according to EIA, by 2030 is projected to remain at 0.6 percent of the amount of diesel used, or 395 million gallons. Furthermore, according to EIA, if production reaches 300 million gallons to 600 million gallons annually, competition with food and feed markets for soybeans may make biodiesel production more expensive and further reduce its competitiveness with diesel. Even without additional competition over soybeans, according to DOE's Alternative Fuel Price Reports, in 2006, pure biodiesel sales prices were on average 26 percent higher than those of diesel fuel at a sample of biodiesel fueling stations nationwide. According to EIA, the higher price of biodiesel relative to diesel contributes to low demand for biodiesel. Finally, using biodiesel can result in clogged fuel filters—the solvent properties of biodiesel can loosen accumulated settlements in fuel tanks left by diesel—and performance problems under certain conditions, such as gelling in cold weather, which are further impediments to increasing the number of stations that sell biodiesel.

The cost of specialized storage and dispensing equipment is an impediment to further expanding the number of fueling stations that offer biofuels. While this is a lesser impediment for biodiesel, it may be a significant impediment for potential E85 retailers because the corrosive characteristics of ethanol in high concentrations may, for example, cause metal equipment parts made of zinc and aluminum to degrade and contaminate the fuel over time, potentially harming the engines of vehicles that use the fuel.[32] Station owners may modify equipment at relatively little cost or may spend significantly more for new specialized equipment due to concerns about equipment safety and liability. For example, Illinois state officials told us that the costs to convert existing gasoline storage tanks and dispensers to E85 at 64 fueling stations from 2005 to 2006 averaged a relatively low $3,354. This generally involved simply replacing some dispenser parts, although it sometimes included cleaning the storage tank. According to a major manufacturer of fuel-dispensing equipment, the cost to purchase a new dispenser designed for E85 is about $13,000—about $7,000 more than for a regular gasoline dispenser. Further, according to a study commissioned by DOE, a completely new installation including items such as an underground tank, a dispenser, associated piping, and concrete work costs up to about $62,400. An associated impediment is the lack of a dispenser that has been certified for E85 use by Underwriters Laboratories (UL).[33] According to representatives of Wal-mart, BP, and Marathon Petroleum, the lack of a UL-approved E85 dispenser has been a greater barrier than the potential cost of the equipment and has caused them to defer plans to offer the fuel at their respective company-owned stations until such a dispenser is available. According to UL, the organization is in the process of developing safety requirements for E85 dispensers and components, although initial results of a survey it conducted indicate that E85 fuel exposures have not resulted in significant safety or maintenance problems for existing equipment.

Finally, the marketing policies of some major oil companies may limit the availability of biofuels at fueling stations. According to our estimate, roughly 37 percent of the 169,000 fueling stations in the United States—including company and franchise operations—are under the brand of one of the five major oil companies we spoke to—BP America, Chevron

[32]In cold climates the tanks and lines used for higher biodiesel blends need to be warmed to prevent gelling of the fuel.

[33]UL is an independent, not-for-profit product safety certification organization that tests products and writes standards for safety.

Products Company, ConocoPhillips, ExxonMobil, and Shell Oil Products US. However, according to information provided by DOE's Alternative Fuels Data Center, in early 2007, only about 9 percent of the fueling stations that offered E85 and about 8 percent of the stations that offered higher blends of biodiesel were under the brand of one of the five oil companies. According to representatives of the five major oil companies, while no stations are prohibited from selling biofuels, none of the companies offer E85 to their stations as a branded product and none of the companies offer biodiesel except where required to by state mandate. Industry experts with whom we spoke told us that branded stations that offer E85 procure their own supply of the fuel from other sources. For this reason, officials from one of the five oil companies told us that their company policy prohibits branded stations from advertising E85 on their marquees. All five of the companies require E85 to be labeled to differentiate it from branded fuels. Company representatives said that they require labeling E85 fuel dispensers to protect their brand name, since the company does not control product quality, and to ensure that consumers do not misfuel vehicles that are not designed to operate on E85.

## A Number of Policy Options Could Help Increase the Number of Stations That Offer Biofuels, but Increased Use Is Unlikely without a Larger Supply of Cost-Competitive Biofuels

Members of Congress have proposed various policy options to increase the number of fueling stations that offer biofuels, including the following:

- Mandating major oil companies to install at least one E85 dispenser at their fueling stations. Such a mandate could also require the percentage of company-owned properties with an E85 dispenser to gradually increase over time, eventually to 50 percent.
- Increasing the amount of the alternative fueling infrastructure tax credit to greater than the current limit of 30 percent of the cost of any qualified alternative vehicle refueling property or $30,000.
- Allowing the public to access biofuel dispensers located on federal properties.
- Using fines from CAFE penalties paid by automobile manufacturers to provide grants for biofuel dispensers.[34]
- Prohibiting biofuel marketing restrictions on fueling station franchisees and restrictions on selling biofuels only in certain areas of their property.

[34]Automobile manufacturers are required to pay penalties for not complying with CAFE standards. According to the Department of Transportation, in 2005 these penalties amounted to $27,472,539.

While any one of these mandates, incentives, or other strategies would likely increase the number of stations that offer biofuels to the public, absent the availability of a large supply of cost-competitive biofuel where they are located, it is unlikely that they would significantly increase biofuel use. Efforts to increase the number of stations that provide biofuels have primarily been successful in areas where large amounts of biofuels are produced, and the fuel is more likely to be sold for less than gasoline. For example, in Minnesota, which in early 2007 had about 28 percent of the nation's E85 stations and almost 10 percent of the nation's ethanol production capacity in-state, cost-competitive E85 is provided largely as a result of local ethanol producers' willingness to sell ethanol below its market price for E85 blending, the state's 13 cents per gallon ethanol production incentive payment, and the state's 5.8 cents per gallon excise tax exemption for stations that sell E85. Minnesota has already saturated its E10 market, making the state's excess supply of ethanol available for use in higher blends, such as E85. Outside of the Midwest, few regions have an available supply of cost-competitive ethanol to allow for E85 price discounts, and blenders generally choose to use available ethanol in E10 or lower blends because it is more profitable than higher blends. Until other regions of the United States have large supplies of cost-competitive ethanol or biodiesel, it is unlikely that increasing the number of stations that offer biofuels in those regions will result in significantly greater biofuel use.

## The Number of Biofuel Compatible Vehicles Is Projected to Increase, but Challenges, such as Limited Consumer Demand, Remain

The relatively few biofuel compatible vehicles in use in the United States could increase substantially in the near future because of planned production increases by major automobile manufacturers. Nonetheless, according to some manufacturers with whom we spoke, further production increases are impeded by limited consumer demand for FFVs and the additional costs of producing them. Increasing the number of diesel vehicles is impeded by the additional costs to make the vehicles compliant with emissions regulations. Several policy options have been proposed to address these challenges. These may increase the number of biofuel compatible vehicles but would be unlikely to increase biofuel use until the fuels are less expensive and more widely available.

## The Relatively Small Number of Biofuel Compatible Vehicles in Use May Increase Substantially in the Near Future

According to data provided by the Alliance of Automobile Manufacturers and DOE, in 2006, there were an estimated 4.5 million FFVs in use capable of operating on ethanol blends up to E85. We estimate that this number accounts for about 1.8 percent of the 244 million U.S. vehicles. EIA's most recent estimate projects FFV sales to increase from about 600,000 in 2006 to about 1.8 million per year in 2012 and compose about 10 percent of sales of new light duty vehicles.[35] EIA projects FFV sales to reach about 2 million per year by 2030 and remain at about 10 percent of total light duty vehicle sales. However, these numbers could increase significantly due to a March 2007 commitment by DaimlerChrysler, Ford, and General Motors to increase FFV production to compose about 50 percent of their annual production by 2012.

According to data provided by the Alliance of Automobile Manufacturers and DOE, in 2006, there were an estimated 4.9 million diesel vehicles generally capable of operating on biodiesel blends. We estimate that this number accounts for about 2 percent of the total number of vehicles in the United States. EIA's most recent estimate projects diesel vehicle sales to increase from about 360,000 in 2006 to about 424,000 per year in 2012 and make up about 2.4 percent of sales of total light duty vehicles. EIA projects diesel vehicle sales to reach about 1.2 million per year by 2030, which is about 6 percent of total light duty vehicle sales.

The federal fleet of vehicles contains large numbers of FFVs and diesel vehicles. According to the General Services Administration, in fiscal year 2006, federal fleet FFVs numbered 96,229, composing about 15 percent of the total number of federal fleet vehicles and about 99 percent of the alternative fuel vehicles acquired by federal agencies.[36] In fiscal year 2006, diesel vehicles numbered 79,954, composing nearly 13 percent of the total federal fleet of vehicles.

According to EIA, automakers produced virtually all FFVs since 1992 for the sole purpose of acquiring credits toward the fuel economy requirements of the Department of Transportation's CAFE program. Under

[35]Light duty vehicles have a gross vehicle weight of 8,500 pounds or less. Common examples include cars, pickup trucks, and sport utility vehicles.

[36]Federal alternative fuel vehicles in fiscal year 2006 included vehicles that can operate on compressed natural gas, E85, electricity, liquefied natural gas, or liquefied petroleum gas. However, in fiscal year 2006, alternative fuel vehicles acquired by federal fleets only included FFVs and compressed natural gas capable vehicles.

this program FFVs are treated as though they attain higher fuel economy than they necessarily would for the purpose of encouraging manufacturers to produce them. The Energy Policy Act of 1992 (EPAct 1992) required federal agencies to purchase FFVs. Specifically, it required that at least 25 percent of federal vehicle purchases be alternative fuel vehicles in 1996, increasing to 75 percent by 1999.[37] The Energy Conservation and Reauthorization Act of 1998, which amended EPAct 1992, encouraged federal agencies to use biodiesel by allowing them to partially meet the EPAct 1992 vehicle acquisition requirements by using biodiesel in federal fleet diesel vehicles.

## Limited Consumer Demand and Additional Production Costs Are Impediments to Increasing the Number of Biofuel Compatible Vehicles

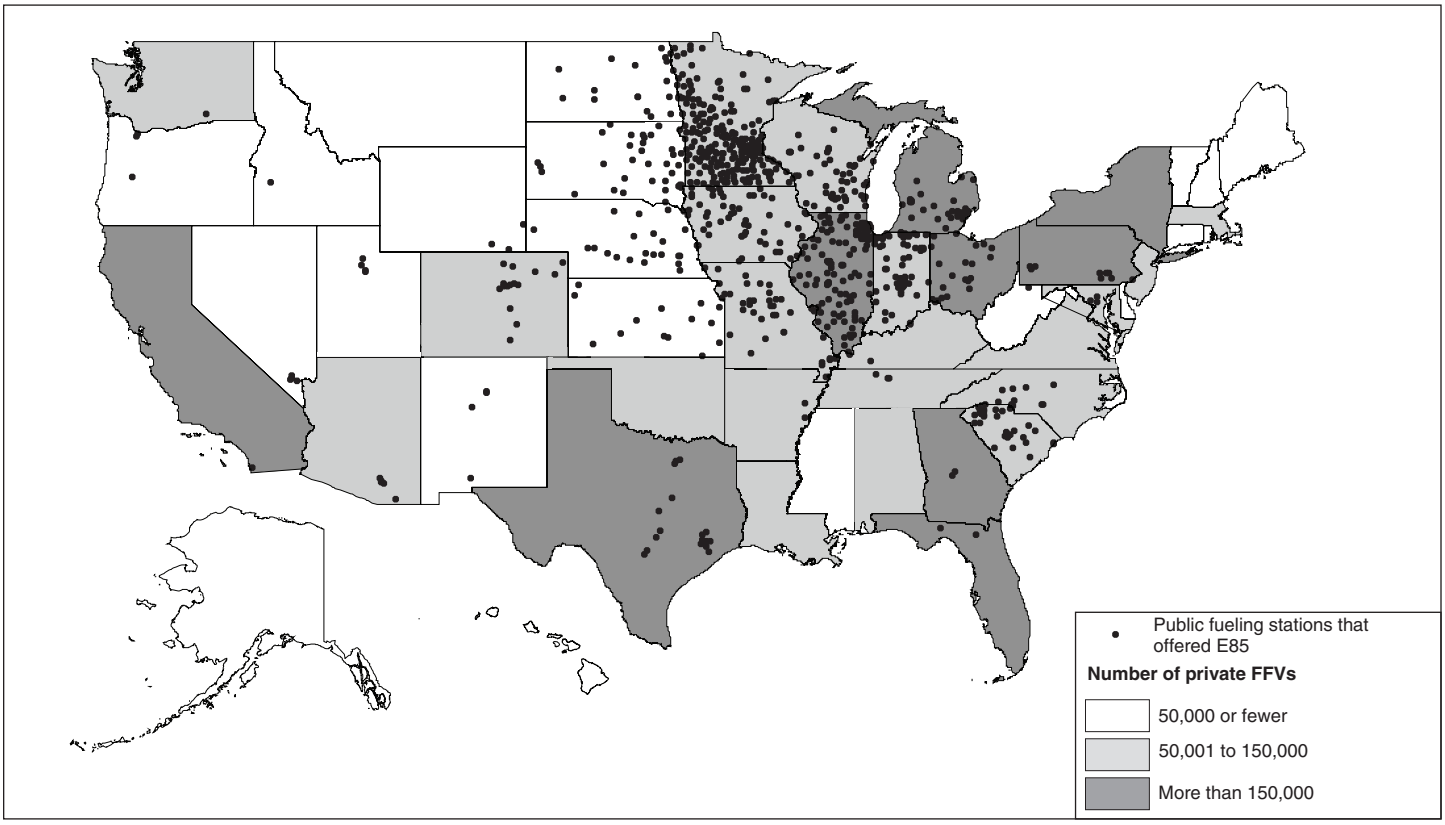
According to some automobile manufacturer representatives with whom we spoke, consumers have limited awareness of FFVs. As a result, few potential vehicle purchasers visit dealerships looking for FFVs. Furthermore, according to some manufacturers and EIA, consumers who purchase FFVs are often unaware that their vehicles are capable of using E85. According to a manufacturer representative with whom we spoke, awareness is increasing in part because of increased advertising in 2006 designed to educate potential buyers about FFVs. Accordingly, a survey of new vehicle buyers by Harris Interactive and Kelley Blue Book found that buyer awareness of FFVs increased from 42 percent in January 2006 to 63 percent in November 2006.

However, consumers looking for an FFV to purchase have a relatively narrow range of vehicles to select from. Currently, few models of smaller, more fuel efficient vehicles are flex-fuel capable. According to EPA and DOE, only 3 FFVs available in model year 2007 were compact or midsize cars, while 23 were large cars, pickup trucks, vans, minivans, or sport utility vehicles. Some automobile manufacturer representatives with whom we spoke said that they have limited the models and total numbers of FFVs they make because of the additional production cost per vehicle, ranging between $30 and $300, depending on the manufacturer. In addition, one automobile manufacturer representative with whom we spoke told us that the significant research and development costs associated with designing flexible fuel systems for different engines and model types limited the models of FFVs the company makes.

[37]EPAct 1992 also required certain state government and alternative fuel provider fleets to acquire alternative fuel vehicles.

Despite increasing consumer awareness and commitments from manufacturers to produce more FFVs, consumer demand may continue to be limited by the lack of E85 fueling stations in areas where the largest numbers of vehicles are located, as shown in figure 4. For example, according to data provided by the Alliance of Automobile Manufacturers, in 2006, the largest numbers of privately owned FFVs were located in Texas, Florida and California. While there were about 415,000 privately owned FFVs in Texas, in early 2007 only 18 publicly accessible fueling stations offered E85. In Florida there were about 307,000 privately owned FFVs but only 2 publicly accessible fueling stations offered E85 in early 2007, and in California, there were an estimated 257,000 FFVs but only 1 publicly accessible fueling station—located in the San Diego area—offered E85.

**Figure 4: Location of Public Fueling Stations That Offered E85 in 2007 and Number of Privately Owned FFVs by State in 2006**




Sources: DOE's Alternative Fuels Data Center and Alliance of Automobile Manufacturers data.

Increasing the availability of diesel vehicles is impeded by the additional costs to make the vehicles compliant with emissions regulations. Biodiesel contains oxygen, which aids in combustion but results in emissions of nitrogen oxides that can lead to increased ground-level ozone. According to an industry expert with whom we spoke, the compliance cost of meeting current emissions standards for diesel vehicles adds about $3,000 to the cost of the vehicles.

## Several Policy Options Could Help Address Impediments to Increasing the Number of Biofuel Compatible Vehicles, but the Effect on Biofuel Use Is Unknown

A number of policies to increase the production of biofuel compatible vehicles have been proposed by members of Congress. The proposals include the following:

- providing a production cost tax credit of about $100 per vehicle to automobile manufactures for each FFV they produce;
- mandating that automobile manufacturers produce FFVs, for example, by requiring the percentage of vehicles that are biofuel compatible to gradually increase over time to eventually 100 percent of the manufacturer's fleet;
- and taxing conventionally fueled vehicles.

On the basis of the impediments we have identified, it is unlikely that increasing the number of biofuel compatible vehicles would increase biofuel use until there is a large enough supply of cost-competitive fuel that is readily available to drivers. Regarding FFVs, increasing the number of such vehicles may actually increase gasoline usage if E85 is not readily available because the FFVs currently on the road—and potentially those that are added in the future—are larger vehicles that get relatively poor gas mileage and are operating mainly on gasoline. According to a report from the Department of Transportation, DOE, and EPA, automobile manufacturers have used CAFE incentives to produce less fuel efficient FFVs that consumers generally do not operate with biofuels, resulting in increased petroleum use. The report projected in 2003 that 9 billion gallons of additional gasoline would be used between 2005 and 2008 as a result of the CAFE credit for FFVs. We have also reported that the CAFE program's effectiveness in reducing oil consumption is hampered by the provision that grants credits to manufacturers for selling FFVs because these vehicles often run on regular gasoline.[38]

[38]See GAO, *Passenger Vehicle Fuel Economy: Preliminary Observations on Corporate Average Fuel Economy Standards*, GAO-07-551T (Washington, D.C.: Mar. 6, 2007).

The lack of access to E85 for federal fleet FFVs illustrates the potential pitfalls of putting FFVs on the road without a sufficient number of stations to provide the fuels. While there were about 96,000 FFVs in the federal fleet in fiscal year 2006, there are only 57 fueling stations dedicated to supplying them with E85 in early 2007. Federal fleet FFVs were distributed nationwide, but the largest numbers were in the states of California, Texas, and Florida, as shown in figure 5. In California, there were 8,146 federal fleet FFVs, but only 3 stations—2 federal and 1 public—that provide E85. Similarly, there are only 24 E85 stations in Texas to serve 6,810 federal FFVs, and only 8 stations in Florida to serve 6,606 federal FFVs. This situation can lead to greater petroleum fuel usage by federal agencies. As we reported in February 2007, the U.S. Postal Service was required to purchase FFVs even though the available vehicles had larger engines than were needed. Because the Postal Service found that E85 was generally 17 percent more expensive than gasoline, and that E85 stations were sometimes too far away to justify the travel costs, it chose to fuel these vehicles with regular gasoline, resulting in increased use of petroleum fuels.[39] The agency's FFV fleet failed to create enough E85 demand to spur investment in the installation of E85 dispensers at fueling stations, even in areas where there were large numbers of Postal Service FFVs.

[39]See GAO, *U.S. Postal Service: Vulnerability to Fluctuating Fuel Prices Requires Improved Tracking and Monitoring of Consumption Information*, GAO-07-244 (Washington, D.C.: Feb. 16, 2007).

**Figure 5: Location of Federal Fueling Stations That Offered E85 in 2007 and Number of Federal Fleet FFVs by State in 2006**


Sources: DOE's Alternative Fuels Data Center and DOE's and General Services Administration's (GSA) Federal Automotive Statistical Tool data.

## DOE Has Not Yet Developed a Strategic Approach to Coordinate the Expansion of Biofuel Production with Infrastructure and Vehicles, and the Effectiveness of Biofuel Tax Expenditures Has Not Been Evaluated

Currently DOE lacks a comprehensive strategic approach to coordinate the expansion of biofuels production with biofuel distribution infrastructure development and vehicle production. While DOE's Biomass Program has a strategic approach to increasing ethanol production, DOE has not yet developed a comprehensive strategic approach for determining the infrastructure (transport system and fueling stations) and vehicles needed to distribute and use the increased production that could result from the program. A strategic approach could assist in resolving important questions, such as which blend level of ethanol—E10, E85, or something in between—would most effectively and efficiently increase the use of the fuel and which elements of the biofuel infrastructure should receive government support. In addition, federal agencies have not evaluated the performance of biofuel-related tax expenditures, making it impossible to determine their impacts on the economy, environment, or energy security.

### DOE's Strategy for Increasing Ethanol Production Is Not Coordinated with a Comprehensive Strategic Approach for Distribution Infrastructure Development and Vehicle Production

DOE has a strategic approach for increasing ethanol production, which it developed in collaboration with other federal agencies and the private sector. The agency's approach is spelled out in the multiyear plan for its Biomass Program, which describes the agency's approach to the research and development of cellulosic biomass-to-fuel technologies; provides analysis of the markets involved in each technology; lists relevant accomplishments; outlines specific goals, milestones, and barriers; and describes what the role of the federal government should be. For example, the Biomass Program focuses on technologies that have a high level of technical and economic risk but also offer significant potential rewards for the nation. In addition, Congress established the Biomass Research and Development Board (Biomass Board) to help ensure a coordinated strategic approach to research and development spending at DOE, USDA, EPA, the National Science Foundation, and other agencies. The goal of the Biomass Board is to bring coherence to federal strategic planning and to maximize the benefits from federal grants and assistance. Members of the Biomass Board, with advice from private sector stakeholders, identify gaps in fuel production technology that need to be addressed by research and development and seek to coordinate efforts in order to avoid duplication of effort.

However, DOE has not yet developed a comprehensive strategic approach to coordinate the significantly larger volume of biofuel production that

could result from the Biomass Program with distribution infrastructure development and vehicle production. DOE officials told us they recognize the importance of developing a strategic approach and have taken an initial step in that direction. According to a DOE official with whom we spoke, in March 2007, officials from DOE's Biomass Program drafted a position paper that supported moving nationwide ethanol blends beyond E10 to E15 or E20 in order to achieve the most efficient expansion of ethanol use. DOE would continue to support E85 only in areas with high ethanol production levels. However, the position paper has not yet been approved, and according to one DOE official with whom we spoke, it is still unclear how this position will affect future DOE activities and priorities related to ethanol infrastructure. After DOE finalizes its decision on ethanol blend levels, the official told us that it would then need to coordinate with other agencies to develop a strategic approach to biofuel infrastructure expansion. In that regard, DOE has recently begun working with USDA and other federal agencies through the Biomass Board to develop a plan to achieve the President's goal of displacing 20 percent of U.S. gasoline consumption in the next 10 years. According to DOE, private sector stakeholders involved in biofuel production, delivery infrastructure, and vehicles will also have a key role in the development of successful strategies for expanding biofuel production and use.

In the absence of a strategic approach, important questions—such as what distribution infrastructure and vehicles are needed to support DOE's chosen blend level, when they are needed, or what government support is needed and what will develop through market forces—remain unanswered. For example, if cellulosic ethanol production begins on a commercial scale, the expansion of biofuel infrastructure to meet the President's target level of 35 billion gallons by 2017 may be achieved through the use of E10 nationally and E85 regionally, or with the use of E20 nationally. Determining which fuel blend strategy to pursue is critical in guiding the development of distribution infrastructure because, according to several industry officials, a national E20 approach may not require much investment in new dispensers, and depending on the results of current fuel system testing, it might be accomplished with the existing automobile fleet. However, using E20 nationally may not be feasible if transportation limitations prevent the large-scale distribution of ethanol beyond its regional production centers, in which case regional expansion of E85 may make sense. For example, rail industry representatives with whom we spoke indicated that there is currently no spare capacity in the rail system to transport higher levels of biofuels. As a result, achieving even relatively small increases in biofuel use may be difficult with the current transportation infrastructure. It is also not known what roles the

government and private sector should play in the development and expansion of the nation's biofuel infrastructure and fleet of biofuel compatible vehicles. For example, DOE has not determined the extent to which the federal government needs to be involved in supporting the expansion of the E85 fueling station infrastructure or whether the needed infrastructure will continue expanding largely as a result of market forces and state support in areas that produce large amounts of ethanol.

## DOE Has Not Evaluated the Performance of Biofuel-Related Tax Expenditures

Federal biofuel tax expenditures are composed of excise tax credits for ethanol and biodiesel blenders, tax credits for small ethanol and biodiesel producers, a tax credit for alternative fueling infrastructure development, and a special depreciation deduction for cellulosic ethanol facilities.[40] Through these tax expenditures, the government forgoes a certain amount of tax revenue to encourage biofuel use because of the presumed benefits, such as reducing greenhouse gases and improving energy security and rural economies. The largest of the biofuel tax expenditures is the VEETC, which according to the Department of the Treasury, cost about $2.7 billion in forgone tax revenue in 2006.

The Government Performance and Results Act provides an impetus for executive branch agencies to evaluate tax expenditures that affect their missions. However, as we previously reported, one of the key impediments to moving forward in evaluating tax expenditure outcomes is the continuing lack of clarity about the roles of the Office of Management and Budget (OMB), Treasury, and the departments or agencies with program responsibilities, such as DOE.[41] We also reported that OMB officials said the agency did not have the expertise or resources to conduct its own comprehensive analyses of tax expenditures and that individual agencies should take responsibility for identifying tax expenditures that affect their missions, with Treasury's Office of Tax Analysis leading efforts to evaluate tax expenditures. To help evaluate whether tax expenditures are achieving the desired results, our work related to GPRA and the experience of leading organizations have shown the importance of establishing outcome-

[40]Volumetric Ethanol Excise Tax Credit §301 (Pub.L. No. 108-357), Biodiesel Tax Credit §1344 (Pub. L. No. 109-58), Small Ethanol Producer Credit §11502 (Pub. L. No. 101-508), Small Agri-Biodiesel Tax Credit §1345 (Pub. L. No. 109-58), Alternative Fuel Infrastructure Tax Credit §1342 (Pub. L. No. 109-58), Special Depreciation Allowance for Cellulosic Biomass Ethanol Plant Property §209 (Pub. L. No. 109-432).

[41]See GAO-05-690.

oriented performance goals and measures. However, DOE and Treasury have not worked together to define their roles and responsibilities for evaluating biofuel tax expenditures, nor has either agency established the performance goals or measures needed to conduct an evaluation, or gathered and reported any performance data. Consequently, there is no reporting on whether biofuel tax expenditures are achieving their desired goals.

It is important to evaluate the outcomes of biofuel tax expenditures so that the government can determine if spending on biofuels has positive results. Evaluating the outcomes of biofuel tax expenditures consists of comparing the level of forgone tax revenue to the outcomes or benefits. The outcomes or benefits would be the dollar savings resulting from improved energy security or the improvements to rural economies, for example, and should be greater than the amount of forgone tax revenue for there to be a positive result.[42] In addition, knowing the level of benefits on a measurable basis, such as per gallon of biofuel, would allow policymakers to determine the level of tax expenditure that would ensure a positive result. Being able to determine the proper level of tax expenditure per gallon is important because if it is set too high, then biofuel use would be more costly to taxpayers than the benefit it provides, and likewise, if tax expenditures are too low, not enough biofuel would be used and the potential benefits from increased biofuel use would remain unrealized. Because neither DOE nor any other executive branch agency has conducted an analysis of the benefits of the VEETC, it is impossible to know whether the 51 cent tax expenditure for every gallon of ethanol blended with gasoline is too high, too low, or at the proper level.

It is also important to evaluate the outcomes of biofuel tax expenditures so that the government can determine if there are more cost-effective means to achieve the same outcomes. Tax expenditures are not the only means to increase the production and use of biofuels. Taxes on gasoline and a RFS that requires a specified level of biofuel use are other policy options that have been implemented and could be expanded to achieve the same outcome as the VEETC is assumed to achieve, but at a lower cost to the government. For example, according to analysis conducted by DOE and USDA and some economists with whom we spoke, the current

[42]Setting targets for and monitoring the number of gallons of biofuel produced and used (outputs) does not measure the benefits of biofuels (outcomes) and therefore cannot be used to measure the performance of biofuel tax expenditures.

approach of using both an RFS and an excise tax credit, such as the VEETC, may be largely redundant because biofuel use can never be lower than the level mandated by the RFS. Consequently, most of the benefits that accrue to society from the levels of biofuel use mandated by the RFS could have been achieved without the need for any forgone tax revenue.

Although executive branch agencies have not evaluated the performance of biofuel tax expenditures, other organizations have conducted limited evaluations that have raised questions about the effectiveness of these tax expenditures. For example, in 2006, the Congressional Research Service analyzed the VEETC and biodiesel tax credits and issued a report stating that tax expenditures are generally an inefficient way to deal with environmental or energy security concerns and this was the case with biofuel tax expenditures, which do not directly address the external costs of petroleum motor fuels production, use, or importation, such as the costs of greenhouse gas emissions.[43] The report also found that with the RFS in place, the VEETC has caused substantial and unnecessary losses in federal tax revenue without providing a significant incentive for additional production. These losses could increase in the future if production increases. For example, at the current rate of subsidy, if 15 billion gallons of ethanol were produced annually, it would cost the Treasury an estimated $7.6 billion annually. In addition, a study by the Global Subsidies Initiative estimated that the government provided a total subsidy of $1.80 for each gallon of gasoline displaced with ethanol in the United States transportation sector.[44] To a large extent, this subsidy came from tax expenditures, particularly the VEETC. Because outcome goals for biofuel tax expenditures have not been established and performance data have not been gathered, it is impossible to determine if the $1.80 per gallon cost resulted in an equal or greater amount of benefits.

## Conclusions

Congress and the President have made commitments to support the development of domestically produced biofuels, biofuel fueling stations,

[43]U.S. Senate. Committee on the Budget. *Tax Expenditures: Compendium of Background Material on Individual Provisions* (S. PRT. 109-072, pp. 91). Prepared by the Congressional Research Service. Washington: 2006.

[44]See Doug Koplow, *Biofuels—At What Cost?: Government Support for Ethanol and Biodiesel in the United States*, the Global Subsidies Initiative of the International Institute for Sustainable Development, October 2006. The $1.80 estimate includes all government support for ethanol and corn, including state-level ethanol incentives and other federal nontax expenditures such as direct payments to corn producers.

and FFVs because of the expected benefits for rural economies, energy security, and the environment. However, the nation can and should think more strategically about these commitments. Because there are limits on the amount of corn ethanol that can be produced as well as market conditions that favor selling ethanol for blending as E10, it is unlikely that ethanol producers will make significant quantities of corn ethanol available for blending as E85. Without a sufficient volume of competitively priced ethanol for E85, federal investments in E85 fueling station infrastructure and FFVs would result in additional costs and yet would not likely be effective at increasing the use of the fuel. To date, DOE's Clean Cities program has made a relatively small investment in expanding the number of E85 fueling stations, but it is questionable whether even this limited federal expenditure was necessary or whether any additional federal funds should be devoted to further expansion unless ethanol production dramatically increases. Likewise, because most FFVs are larger, less fuel efficient vehicles that generally use gasoline, there are environmental costs associated with providing incentives through the CAFE program for increasing the production of these vehicles in the absence of an available, cost-competitive supply of E85.

Currently the nation lacks a comprehensive strategic approach to coordinate the expansion of biofuels production with distribution infrastructure development and vehicle production. Because such an approach does not exist, fundamental questions remain unanswered. For example, it has not yet been determined whether conventional vehicles can run on blends of more than E10 without damaging the vehicles and still meet EPA Clean Air Act requirements. The answer to this question will have a significant impact on when or if biofuel-specific infrastructure or vehicles are needed. Absent a coordinated, strategic approach, the nation runs the risk of unnecessarily investing in fueling stations or FFVs that cannot be effectively utilized or of producing significant quantities of ethanol but not having an effective way to deliver the fuel to stations and consumers. Finally, as biofuel production increases, biofuel tax expenditures will become increasingly expensive. However, because DOE and Treasury have not defined their roles and responsibilities or evaluated and reported on the performance of biofuel tax credits, policymakers have little basis for evaluating whether the benefits of these tax expenditures outweigh the costs.

## Recommendations for Executive Action

To improve biofuel-related planning and to provide Congress better information on the costs and benefits of biofuel tax expenditures, we are recommending that the Secretary of Energy:

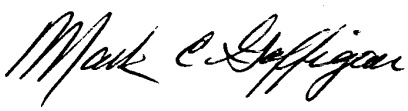
- Collaborate with public and private sector stakeholders to develop a comprehensive strategic approach to increasing the availability and use of biofuels that coordinates expected biofuel production levels with the necessary distribution infrastructure development and vehicle production.
- Collaborate with the Secretary of the Treasury to evaluate and report on the extent to which biofuel-related tax expenditures are effectively and efficiently achieving their goals, as well as the extent to which they support the department's comprehensive strategic approach for biofuels. As a first step, the Secretaries will need to define their roles and responsibilities for conducting the evaluation.

## Agency Comments and Our Evaluation

We provided a copy of our draft report to the Department of Energy for its review and comment. In its written response DOE agreed with both of our recommendations and described its key initiatives to promote cellulosic ethanol development and deployment, as well as its efforts with other federal agencies and the private sector to coordinate increased biofuels production, infrastructure development, and vehicle technology. DOE also provided technical comments, which we incorporated into the report as appropriate. DOE's comments and our detailed responses are presented in appendix I.

We are sending copies of this report to the Secretary of Energy, appropriate congressional committees, and other interested members of Congress. We also will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or gaffiganm@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix II.



Acting Director, Natural Resources
and Environment

# Appendix I: Comments from the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

**Department of Energy**
Washington, DC 20585

May 25, 2007

Mr. Mark E. Gaffigan
Acting Director, Natural Resources and Environment
Government Accountability Office
441 G Street, NW Room 2T-23A
Washington, DC 20548

Dear Mr. Gaffigan:

Thank you for the opportunity to comment on the draft Government Accountability Office Report, entitled "DOE Lacks a Strategic Approach to Coordinate Increasing Production With Infrastructure Development and Vehicle Needs." The Department of Energy, with the help of many Federal agencies, is taking a leadership role in commercializing cellulosic biofuels. Our efforts address issues that run the gamut from feedstock production to filling up at the pump. They include fuel production technologies, vehicle and delivery infrastructure, as well as vehicle testing and optimization to name a few.

The Department of Energy, together with a number of other federal agencies, is taking a leading role in the development, commercialization, and deployment of cost competitive cellulosic ethanol. We are working together with other federal agencies to identify and promote infrastructure needs that will be necessary to handle the rapid increase of ethanol, cellulosic ethanol and alternative fuels that will be necessary to meet the President's goal of displacing twenty percent of America's gasoline use in 10 years.

Let me provide you with several key initiatives which the Department of Energy has undertaken to promote cellulosic ethanol development and deployment in the short term. I then want to describe what the Department is doing with other federal agencies and the private sector to coordinate increased biofuels production and infrastructure development.

As you know, commercial scale cellulosic ethanol refineries do not yet exist. To help develop this industry and create cost competitive cellulosic ethanol, the Office of Energy Efficiency and Renewable Energy announced a solicitation under Section 932 of the EPACT of 2005, and recently selected six advanced technology biorefinery demonstrations to validate cost competitive biofuels and other products. These investments, including private capital, will infuse up to $1.2 billion toward commercializing biofuels. In addition, the Department just released a solicitation for up to $400 million, including private funding, to support the development of small-scale biorefineries that can quickly be moved to commercial scale. These public-private investments in technology of up to $1.6 billion, combined with sound business strategy, give the United States a high

See comment 1.

probability of success in commercializing biofuels. The report indicates that greater vehicle use and infrastructure deployment will not occur without a large supply of cost-competitive biofuels and we agree. However, the report does not recognize efforts underway by the Department of Energy and other Federal agencies to make the biofuels and bioproducts industry happen.

As part of our intermediate and long-term strategy, the Department of Energy is providing an additional investment of up to $375 million to back this technology development through the creation of three "Bioenergy Research Centers." The purpose of these centers will be to engage one of America's most successful industries, biotechnology, into longer term research such as plant genomics in optimizing feedstocks and conversion processes. Through its loan guarantee program, the Department is helping spur commercialization of biofuels. By providing the full faith and credit of the U.S. government, loan guarantees will enable the government to share some of the financial risks in demonstrating new biofuel-related technologies.

The Department of Energy is also formulating a biofuels infrastructure strategy that brings together our biofuels and vehicle technology programs. The purpose of this effort will be to look at vehicle performance impacts from operation on various biofuel blends. Comprehensive testing will be conducted in close coordination with the Environmental Protection Agency and may include engine optimization and integration of energy storage into bio-fueled vehicles.

The scope of the report goes beyond the mission and authority of the work by the Department of Energy. However, the Department is working very closely with the U.S. Department of Agriculture to promote biofuels and bioproducts. The Secretaries of Energy and Agriculture have recently appointed members to a reconstituted "Biomass Research and Development Board." This high level board of ten federal agencies is co-chaired by the Under Secretary for Rural Development, Department of Agriculture and the Assistant Secretary for Energy Efficiency and Renewable Energy, Department of Energy and includes:

- the Acting Deputy Secretary of Transportation;
- the Assistant Administrator for Research and Development, Environmental Protection Agency;
- the Director of the National Science Foundation;
- the Assistant Secretary, Land and Minerals Management, Department of Interior;
- Assistant Secretary for Economic Policy, Department of Treasury;
- Under Secretary of Science, Department of Energy;
- Under Secretary for Research, Education and Economics, Department of Agriculture;
- Office of Science and Technology Policy;
- Federal Environmental Executive; and

- Chief Scientist, National Institute of Standards and Technology, Department of Commerce.

This Board will look at all aspects of a biofuel-based economy and publish a National Biofuels Action Plan that communicates the government's strategies for production, delivery and end-use necessary for widespread deployment and commercialization.

This national plan will support both the President's "Twenty in Ten" initiative and his May 14, 2007, Executive Order that calls for interagency cooperation in addressing transportation sector greenhouse gas emissions. Furthermore, major stakeholders involved in biofuel production, delivery infrastructure and vehicles will be consulted on the plan and its implementation strategies. The Government Accountability Office's report failed to emphasize the key role that these private stakeholders will have on the investment and implementation of successful strategies for biofuels commercialization. We agree with the report's recommendation for the Departments of Energy and Treasury to work together on evaluating the effectiveness of tax policies.

See comment 2.

Enclosed, please find additional comments that provide more detail on the specifics of your report. If you have any questions, please contact me at 202-586-5523.

Sincerely,

Steven G. Chalk
Deputy Assistant Secretary for Renewable Energy
Office of Technology Development
Energy Efficiency and Renewable Energy

Enclosure

## GAO Comments

The following are GAO's comments on the Department of Energy's letter dated May 25, 2007.

1. While a detailed discussion of all federal programs related to biofuels and bioproducts is beyond the scope and objectives of this report, we believe that the report sufficiently recognizes the key efforts under way by DOE and other federal agencies.

2. We revised the report to indicate that private sector stakeholders will play a key role in the investment and implementation of a successful strategy for biofuels commercialization.

# Appendix II: GAO Contact and Staff Acknowledgments

## GAO Contact

Mark E. Gaffigan, (202) 512-3841or gaffiganm@gao.gov

## Staff Acknowledgments

In addition to those named above, Stephen D. Secrist, Assistant Director; Brad C. Dobbins; Winchee Lin; Robert J. Marek; and Bryan G. Rogowski made key contributions to this report. Also contributing to the report were Catherine A. Colwell, John W. Delicath, Franklin W. Rusco, MaryLynn Sergent, James A. Stack, and Barbara R. Timmerman.

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