United States Government Accountability Office

GAO

Report to Congressional Requesters

June 2011

BIOFUELS

Challenges to the Transportation, Sale, and Use of Intermediate Ethanol Blends

GAO-11-513

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GAO Highlights

Accountability • Integrity • Reliability

Highlights of GAO-11-513, a report to congressional requesters

Why GAO Did This Study

U.S. transportation relies largely on oil for fuel. Biofuels can be an alternative to oil and are produced from renewable sources, like corn. In 2005, Congress created the Renewable Fuel Standard (RFS), which requires transportation fuel to contain 36 billion gallons of biofuels by 2022. The most common U.S. biofuel is ethanol, typically produced from corn in the Midwest, transported by rail, and blended with gasoline as E10 (10 percent ethanol). Use of intermediate blends, such as E15 (15 percent ethanol), would increase the amount of ethanol used in transportation fuel to meet the RFS. The Environmental Protection Agency (EPA) recently allowed E15 for use with certain automobiles.

GAO was asked to examine (1) challenges, if any, to transporting additional ethanol to meet the RFS, (2) challenges, if any, to selling intermediate blends, and (3) studies on the effects of intermediate blends in automobiles and nonroad engines. GAO examined government, industry, and academic reports; interviewed Department of Energy (DOE), EPA, and other government and industry officials; and visited research centers.

What GAO Recommends

GAO recommends, among other things, that EPA determine what additional research is needed on the effects of intermediate blends on UST systems. EPA agreed with the recommendation after GAO revised it to clarify EPA's planned approach.

View GAO-11-513 or key components.
For more information, contact Frank Rusco at (202) 512-3841 or ruscof@gao.gov.

What GAO Found

According to government and industry officials, the nation's existing rail, truck, and barge infrastructure should be able to transport an additional 2.4 billion gallons of ethanol to wholesale markets by 2015—enough to meet RFS requirements. Later in the decade, however, a number of challenges and costs are projected for transporting additional volumes of ethanol to wholesale markets to meet peak RFS requirements. According to EPA estimates, if an additional 9.4 billion gallons of ethanol are consumed domestically by 2022, several billion dollars would be needed to upgrade rail, truck, and barge infrastructure to transport ethanol to wholesale markets.

GAO identified three key challenges to the retail sale of intermediate blends:

- *Compatibility.* Federally sponsored research indicates that intermediate blends may degrade or damage some materials used in existing underground storage tank (UST) systems and dispensing equipment, potentially causing leaks. However, important gaps exist in current research efforts—none of the planned or ongoing studies on UST systems will test actual components and equipment, such as valves and tanks. While EPA officials have stated that additional research will be needed to more fully understand the effects of intermediate blends on UST systems, no such research is currently planned.
- *Cost.* Due to concerns over compatibility, new storage and dispensing equipment may be needed to sell intermediate blends at retail outlets. The cost of installing a single-tank UST system compatible with intermediate blends is more than $100,000. In addition, the cost of installing a single compatible fuel dispenser is over $20,000.
- *Liability.* Since EPA has only allowed E15 for use in model year 2001 and newer automobiles, many fuel retailers are concerned about potential liability issues if consumers misfuel their older automobiles or nonroad engines with E15. Among other things, EPA has issued a proposed rule on labeling to mitigate misfueling.

DOE, EPA, and a nonfederal organization have provided about $51 million in funding for ten studies on the effects of intermediate blends on automobiles and nonroad engines—such as weed trimmers, generators, marine engines, and snowmobiles—including effects on performance, emissions, and durability. Of these studies, five will not be completed until later in 2011. Results from a completed study indicate that such blends reduce a vehicle's fuel economy (i.e., fewer miles per gallon) and may cause older automobiles to experience higher emissions of some pollutants and higher catalyst temperatures. Results from another completed study indicate that such blends may cause some nonroad engines to run at higher temperatures and experience unintentional clutch engagement, which could pose safety hazards.

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Abbreviations

CRC	Coordinating Research Council, Inc.
DOE	Department of Energy
DOT	Department of Transportation
E10	fuel blend containing approximately 10 percent ethanol
E15	fuel blend containing approximately 15 percent ethanol
E20	fuel blend containing approximately 20 percent ethanol
E85	fuel blend containing 70 percent to 83 percent ethanol
EISA	Energy Independence and Security Act
EPA	Environmental Protection Agency
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
RFS	Renewable Fuel Standard
UL	Underwriters Laboratories
USDA	Department of Agriculture
UST	underground storage tank

GAO
Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

June 3, 2011

The Honorable Fred Upton
Chairman
The Honorable Joe Barton
Chairman Emeritus
Committee on Energy and Commerce
House of Representatives

The Honorable Cliff Stearns
Chairman
Subcommittee on Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

The Honorable Michael C. Burgess
The Honorable Greg Walden
House of Representatives

The U.S. transportation sector is almost entirely dependent on petroleum products refined from crude oil—primarily gasoline and diesel fuels. In 2009, this sector consumed the equivalent of about 14 million barrels of oil per day, or over 70 percent of total U.S. consumption of petroleum products. To meet the demand for crude oil and petroleum products, the nation imported, on a net basis, about 52 percent of the petroleum products consumed in 2009.[1]

Biofuels can be an alternative to petroleum-based transportation fuels and are produced from renewable sources, primarily corn, sugar cane, and soybeans. The United States is the world's largest producer of biofuels. The federal government has promoted the domestic production and use of biofuels through tax incentives since the 1970s and, more recently, through a Renewable Fuel Standard (RFS). The Energy Policy Act of 2005,

[1]The United States consumed about 18.8 million barrels of petroleum and petroleum products per day in 2009. The nation imported about 11.7 million barrels of petroleum and petroleum products per day in 2009—primarily crude oil but also petroleum products such as refined gasoline and jet fuel. The United States exported roughly 2 million barrels of petroleum and petroleum products per day in 2009—primarily refined products such as diesel fuel, residual fuel oil, and petroleum coke. Only 2 percent of exports were crude oil. Net imports (total imports minus exports) equaled 9.7 million barrels of petroleum and petroleum products per day in 2009.

which created the RFS, generally required transportation fuels in the United States to contain renewable fuels, such as ethanol and biodiesel.[2] The Energy Independence and Security Act (EISA) of 2007 expanded the RFS by requiring that U.S. transportation fuels contain 9 billion gallons of renewable fuels in 2008, with renewable fuels increasing annually to 36 billion gallons in 2022.[3] The Environmental Protection Agency (EPA) is responsible for administering the RFS.

Ethanol is the most commonly produced biofuel in the United States. In 2010, the nation produced 13.2 billion gallons of ethanol, the vast majority of which came from corn. Most U.S. corn is grown in the Midwest, and ethanol is generally produced in relatively small biorefineries near corn-producing areas. Unlike petroleum products, which are primarily transported to wholesale terminals by pipelines, ethanol is transported to wholesale terminals by a combination of rail, tanker truck, and barge. At the terminals, most ethanol is currently blended as an additive in gasoline to make fuel blends containing up to 10 percent ethanol (called E10). Finally, the blended fuel is transported via tanker truck to retail fueling outlets.

In a 2009 report, we identified fuel-blending limits as a challenge to expanded ethanol consumption.[4] We stated that the nation may soon reach a "blend wall"—the upper limit to the total amount of ethanol that can be blended into U.S. gasoline, given current constraints. At the time, the blend wall existed partly because under EPA's implementation of the Clean Air Act, fuels containing more than 10 percent ethanol were prohibited from being introduced for use with the vast majority of U.S. automobiles.[5] This created a blend wall at approximately 10 percent of

[2]Pub. L. No. 109-58, § 1501 (2005). The act authorizes the Administrator of the EPA, in consultation with the Secretaries of Agriculture and Energy, to waive the RFS levels established in the act, by petition or on the Administrator's own motion, if meeting the required level would severely harm the economy or environment of a state, a region, or the United States, or there is an inadequate domestic supply. Throughout this report, the RFS levels established in the act are referred to as requirements, even though these levels could be waived by the Administrator.

[3]Pub. L. No. 110-140, § 201 (2007).

[4]GAO, *Biofuels: Potential Effects and Challenges of Required Increases in Production and Use*, GAO-09-446 (Washington, D.C.: Aug. 25, 2009).

[5]In this report, we use the terms "automobiles" and "motor vehicles" to refer to (1) light-duty vehicles, including passenger cars; (2) light-duty trucks, including pickup trucks, minivans, passenger vans, and sport-utility vehicles; and (3) medium-duty passenger vehicles, including large sport-utility vehicles and passenger vans.

total U.S. fuel consumption. If the volume of renewable fuels required by the RFS increased above this 10 percent threshold, the fuel industry would not be able to meet the RFS using only E10. We noted that one option to address the blend wall is to use "intermediate" ethanol blends such as E15 or E20 (generally 15 percent or 20 percent ethanol).[6]

In March 2009, a group of ethanol manufacturers petitioned EPA to allow E15 into commerce. The Clean Air Act prohibits the introduction of fuels that are not substantially similar to gasoline. However, the Act authorizes EPA to grant a waiver of this prohibition for a fuel if it does not cause vehicles or engines to exceed emission standards over their useful life. EPA issued two decisions on E15. The first, issued in October 2010, allowed E15 for use in model year 2007 and newer automobiles. The second, issued in January 2011, allowed E15 for use in model years 2001 through 2006 automobiles. EPA did not allow E15 for use in older automobiles or nonroad engines (such as lawn mowers, chainsaws, and boats), motorcycles, or heavy-duty gasoline engines. EPA cited insufficient test data to support the use of E15 in these engines, as well as engineering concerns that older vehicles and nonroad engines may not maintain compliance with emission standards if operated on E15.[7]

In light of the potential use of intermediate ethanol blends, you asked us to review their potential effects. Our objectives were to (1) determine the challenges, if any, associated with transporting additional volumes of ethanol to wholesale markets to meet RFS requirements; (2) determine the challenges, if any, associated with selling intermediate ethanol blends at the retail level; and (3) examine research by federal agencies into the effects of intermediate ethanol blends on the nation's automobiles and nonroad engines.

[6]According to DOE's Office of Energy Efficiency and Renewable Energy, intermediate ethanol blends include E15 and E20 and are defined as having an ethanol content greater than 10 percent and less than 85 percent.

[7]In this report, we use the term "nonroad engines" to refer to nonroad products with gasoline engines, including (1) lawn and garden equipment, such as lawn mowers, weed trimmers, leaf blowers, chainsaws, and snowblowers; (2) recreational engines and vehicles, such as all-terrain vehicles, dirt bikes, and snowmobiles; (3) recreational marine vehicles; (4) construction and industrial equipment and vehicles, such as forklifts and paving equipment; (5) commercial equipment, such as generators and air compressors; (6) farm equipment, such as tractors and combines; and (7) logging equipment.

To determine the challenges associated with transporting additional volumes of ethanol to wholesale markets to meet RFS requirements, we reviewed relevant literature and reports from federal government agencies—including EPA, the Department of Energy (DOE), and the Department of Transportation (DOT)—industry associations, and academic organizations and interviewed their relevant officials and representatives. To determine the challenges associated with selling intermediate ethanol blends at the retail level, we reviewed relevant literature and reports from federal and state government agencies—including EPA, DOE, the Department of Labor's Occupational Safety and Health Administration (OSHA), and the California Air Resources Board—government laboratories, and industry associations and interviewed their relevant officials and representatives. To examine research by federal agencies into the effects of intermediate ethanol blends on the nation's automobiles and nonroad engines, we reviewed relevant reports and studies from government and private laboratories, including DOE's National Renewable Energy Laboratory (NREL) in Colorado and Oak Ridge National Laboratory (ORNL) in Tennessee and interviewed their relevant officials. We also conducted site visits to NREL, ORNL, and a private laboratory to discuss testing results. Due to ongoing litigation over EPA's decision to allow E15 for use in certain automobiles, we did not make any determination in this report of the adequacy of federal testing efforts for automobiles. In addition, we interviewed officials from EPA, DOE, and representatives from relevant industry associations. A more detailed description of our scope and methodology is presented in appendix I.

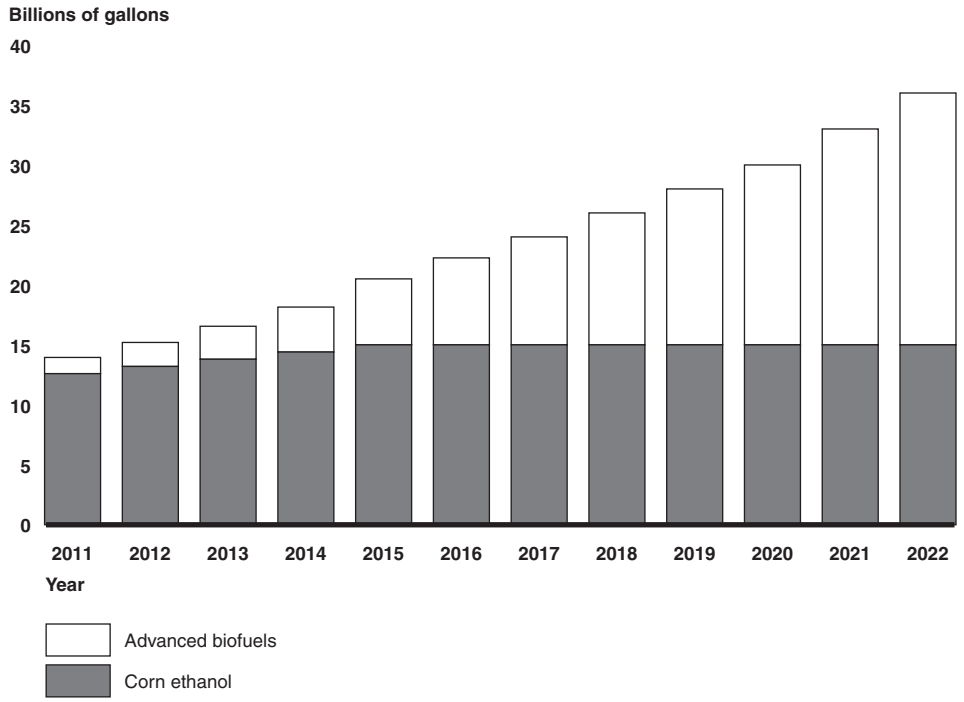
We conducted this performance audit between April 2010 and June 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The RFS, as defined by EISA, distinguishes between ethanol derived from corn starch (known as corn ethanol) and advanced biofuels—defined as a renewable fuel other than corn ethanol that meets certain criteria. For example, to qualify as an advanced biofuel, a biofuel must reduce lifecycle

greenhouse gas emissions by at least 50 percent compared to the gasoline or diesel fuel it displaces.[8] According to the RFS, most advanced biofuels must be produced from cellulosic materials, which can include perennial grasses, crop residue, and the branches and leaves of trees. In addition, some advanced biofuels must be produced from biomass-based diesel, which generally includes any diesel made from biomass feedstocks, such as soybeans. As shown in figure 1, the volume of corn ethanol included under the RFS is capped at 15 billion gallons by 2015 and is fixed thereafter. However, the volume of advanced biofuels continues to grow to a total of 21 billion gallons by 2022. By comparison, the U.S. transportation sector consumed about 14 million barrels of oil per day in 2009, which translates to more than 99 billion gallons of gasoline consumed for the entire year.

Figure 1: Volume Requirements Established by the Renewable Fuel Standard under the Energy Independence and Security Act



Source: EISA, Pub. Law No. 110-140 § 202 (2007).

[8]The advanced biofuel category includes ethanol imported from some member nations of the Caribbean Basin Initiative and Brazil, which primarily use sugarcane to make ethanol.

The RFS generally requires that U.S. transportation fuels in 2022 contain 36 billion gallons of biofuels. In addition, at least 16 billion of the 36 billion gallons of biofuels must be cellulosic biofuels—including ethanol and diesel derived from cellulosic materials. However, under EISA, EPA is required to determine the projected available volume of cellulosic biofuel production for the year, and if that number is less than the volume specified in the statute, EPA must lower the standard accordingly. Pursuant to this provision, EPA has already lowered the RFS requirements for cellulosic biofuel, from 250 million gallons to 6.6 million gallons for 2011, mostly due to the small number of companies with the potential to produce cellulosic biofuel on a commercial scale.[9]

As shown in figure 2, the infrastructure used to transport petroleum fuels from refineries to wholesale terminals in the United States is different from that used to transport ethanol. Petroleum-based fuel is primarily transported from refineries to terminals by pipeline.[10] In contrast, ethanol is transported to terminals via a combination of rail cars, tanker trucks, and barges.[11] According to DOE estimates, there are approximately 1,050 terminals in the United States that handle gasoline and other petroleum products. At the terminals, most ethanol is currently blended as an additive in gasoline to make E10 fuel blends. A relatively small volume is also blended into a blend of between 70 percent to 83 percent ethanol (E85) and the remainder gasoline. E85 has a more limited market, primarily in the upper Midwest, and can only be used in flexible-fuel vehicles, which are vehicles that have been manufactured or modified to accept it.[12] After blending, the fuel is moved to retail fueling locations in tanker trucks.

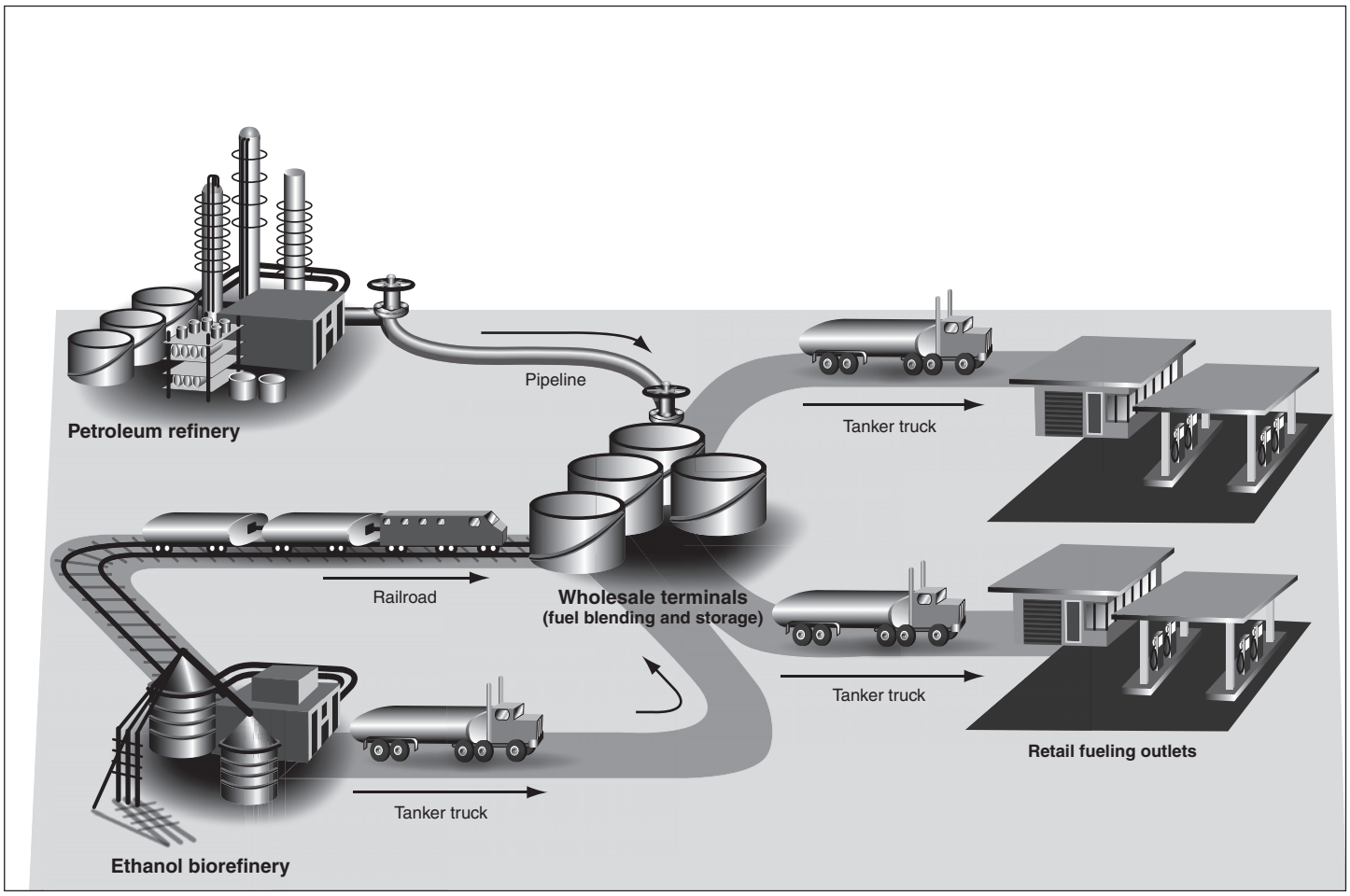
[9]75 Fed. Reg. 76790 (Dec. 9, 2010).

[10]Terminals on the East Coast are large integrated facilities with marine, pipeline, and tanker truck receiving and dispatching capabilities. Although some terminals have rail access, they were not originally designed to support rail as a major mode for transporting fuel.

[11]Ethanol transported for fuel is referred to as fuel-grade ethanol and typically contains 2 percent denaturant, such as gasoline, to render it unfit for human consumption.

[12]According to DOE documentation, there were more than 8 million light-duty flexible-fuel vehicles on U.S. roads as of May 2010 and 2,051 retail fueling locations offering E85 as of June 2010. Because a gallon of ethanol contains only about two-thirds the energy of a gallon of gasoline, the use of E85 results in an approximately 25 percent reduction in fuel economy.

Figure 2: Primary Transportation of Petroleum Products and Ethanol from Refineries to Retail Fueling Outlets



Source: GAO.

Note: Other means of transportation are also used to move petroleum and ethanol products to wholesale terminals. For example, for ethanol, barges are also used to a limited extent.

There are approximately 159,000 retail fueling outlets in the United States, according to 2010 industry data.[13] This total included more than 115,000 convenience stores, which sold the vast majority of all the fuel purchased in the United States, according to industry estimates; a number of large retailers that sell fuel, such as Walmart, Costco, and several grocery chains; and some very low-volume retailers, such as marinas. In terms of

[13]As reported in NPN, *MarketFacts 2010*, (Park Ridge, Ill., 2010) www.npnweb.com.

ownership, single-store businesses—that is, businesses that own a single retail outlet—account for about 56 percent of the convenience stores selling fuel in the United States.

There are three primary supply arrangements between fuel retailers and their suppliers:

- *Major oil owned and operated.* About 1 percent (or 1,175) of convenience stores selling fuel in the United States are owned and operated by four major integrated oil companies—ExxonMobil, Chevron, BP, and Shell.[14]

- *Branded independent retailer.* About 52 percent of retail fueling outlets are operated by independent business owners who sell fuel under the brand of one of the major oil companies or refineries (such as CITGO, Sunoco, or Marathon).[15] These retailers sign a supply and marketing contract with their supplier to sell fuel under the brand of that supplier.

- *Unbranded independent retailer.* The remaining retail fueling outlets (about 48 percent) are operated by independent business owners who do not sell gasoline under a brand owned or controlled by a refining company. These retailers purchase gasoline from the unbranded wholesale market, which is made up of gallons not dedicated to fulfill a refiner's contracts with branded retailers.

Federal safety and environmental regulations govern the dispensing and storage of fuel at retail fueling locations. First, OSHA requires that equipment used to dispense gasoline—including hoses, nozzles, and other related aboveground components, shown in figure 3—be certified for safety by a nationally recognized testing laboratory.[16] According to OSHA officials, OSHA recognizes 17 laboratories, although Underwriters Laboratories (UL) is the main one that currently certifies equipment sold for dispensing gasoline.[17] In addition, under the Solid Waste Disposal Act,

[14]The Nielsen Company (Washington, D.C., May 2010) www.nielsen.com.

[15]As reported in NPN's *MarketFacts 2010*.

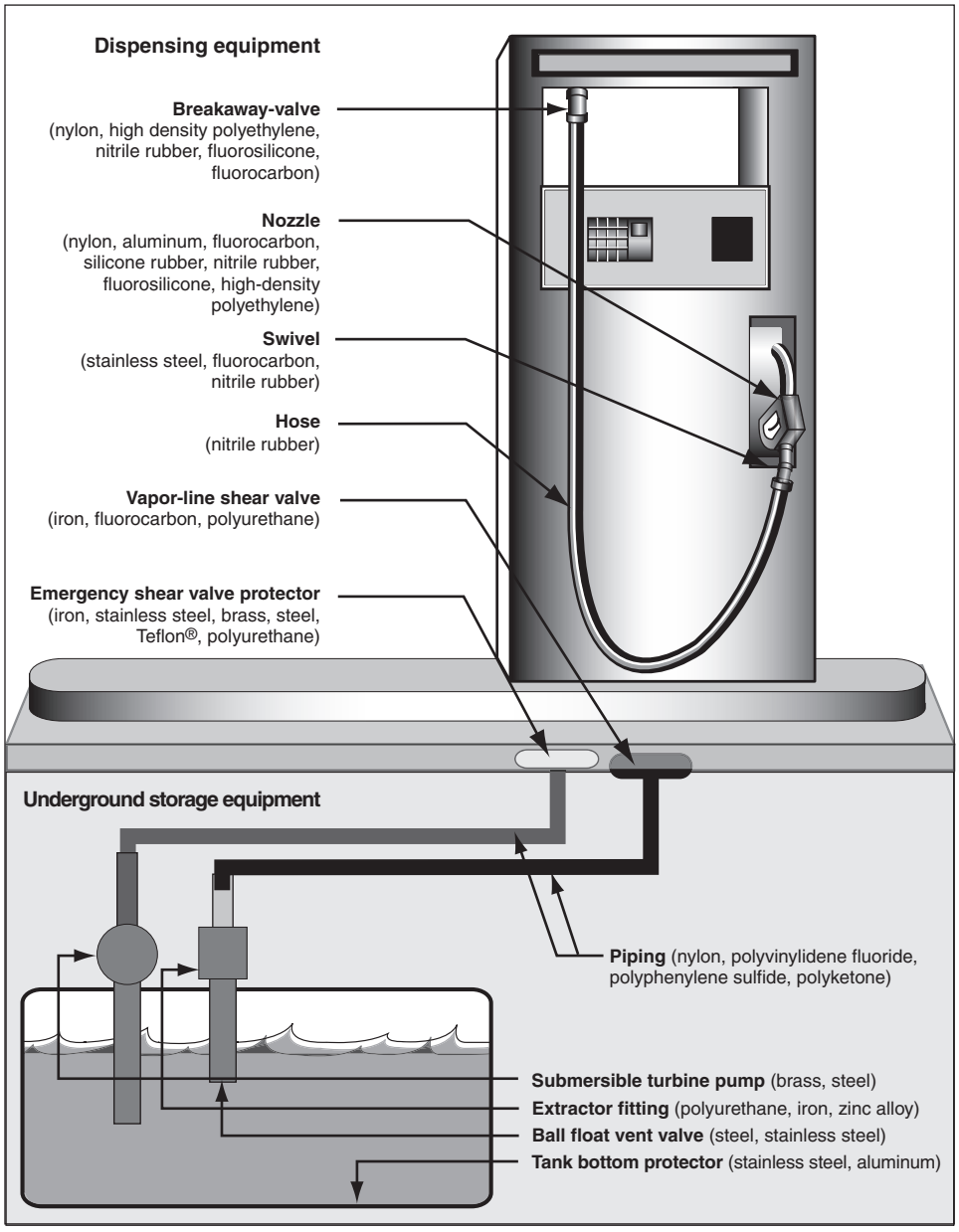
[16]29 C.F.R § 1910.106(g)(3)(iv).

[17]UL is a standards development organization that certifies (e.g., tests and approves) equipment based on standards it develops. According to OSHA officials, two other laboratories—CSA International and Intertek Testing Services NA, Inc.—also certify dispensing equipment based on UL's standards. However, representatives from these two laboratories told us that they are currently conducting little, if any, certification activities for dispensing equipment.

EPA requires that underground storage tank (UST) systems—including storage tanks, piping, pumps, and other related underground components, shown in figure 3—must be compatible with the substance stored in them to protect groundwater from releases from these systems. Historically, UL certification has been the primary method for determining the compatibility of USTs with EPA requirements.[18] EPA also requires fuel retailers to install equipment to detect leaks from UST systems. In total, EPA regulates approximately 600,000 active USTs at about 215,000 sites in the United States.

[18]According to EPA and OSHA officials, OSHA's requirements for dispensing equipment and EPA's requirements for UST systems overlap at the submersible turbine pump, which delivers fuel from the UST to the dispenser. Therefore, along with meeting EPA's compatibility requirements, these pumps must also be certified for safety by a nationally recognized testing laboratory, such as UL, per OSHA requirements. OSHA also has compatibility requirements for UST systems, but unlike its requirements for dispensing equipment, OSHA does not require UST equipment to be certified by a nationally recognized testing laboratory.

Figure 3: Examples of Typical Components and Materials in Retail Dispensing and Underground Storage Equipment



Source: GAO analysis of DOE and EPA information.

State and local governments also play a role in regulating the safety of dispensing equipment and in implementing EPA's requirements for USTs. For example:

- The Occupational Safety and Health Act allows states to develop and operate their own job safety and health programs. OSHA approves and monitors state programs and plans, which must adopt and enforce standards that are at least as effective as comparable federal standards. According to OSHA officials, there are currently 21 states with approved plans covering the private sector that enforce health and safety standards over the dispensing of gasoline within their respective states. Four additional states operate approved state plans that are limited in coverage to the public sector.

- Various state and local fire-safety codes—which aim to protect against fires—also govern the dispensing of fuel at retail fueling outlets. While state fire marshals or state legislatures are usually responsible for developing the fire code for their respective states, some states allow local municipalities to develop their own fire codes. Fire codes normally reference or incorporate standards developed by recognized standards-development organizations, such as the National Fire Protection Association and the International Code Council.[19] State, county, and local fire marshals are responsible for enforcing the applicable fire code within their respective jurisdictions. Local officials, such as fire marshals, typically inspect dispensing equipment for compliance with both state and local fire codes.

- States are largely responsible for implementing EPA's requirements under its UST program. EPA has approved 36 states, plus the District of Columbia and Puerto Rico, to operate programs in lieu of the federal program. The remaining states have agreements with EPA to be the primary implementing agency for their programs. Typically, states rely on UL certification as the primary method for determining the compatibility of UST systems with EPA requirements. Some states also allow compatibility to be demonstrated in other ways, including through the manufacturer's approval or a professional engineering certification.

[19]The mission of the international nonprofit National Fire Protection Association is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. The International Code Council is a membership association dedicated to building safety and fire prevention. The council develops the codes and standards used to construct residential and commercial buildings, including homes and schools.

Consumers in the United States use retail fueling locations to fuel hundreds of millions of automobiles and nonroad products with gasoline engines. According to DOT data, Americans owned or operated almost 256 million automobiles, trucks, and other highway vehicles in 2008, while about 91 percent of all households owned at least 1 automobile the same year, according to U.S. Census data. Americans also owned and operated over 400 million products with nonroad engines in 2009, according to one industry association estimate. According to EPA documentation, nonroad engines are typically more basic in their engine design and control than engines and emissions control systems used in automobiles, and commonly have carbureted fuel systems[20] and air cooling, whereby extra fuel is used in combustion to help control combustion and exhaust temperatures. According to representatives from industry associations for nonroad engines, most of the small nonroad engines manufactured today rely on older technologies and designs to keep retail costs low, and all of the small nonroad engines currently being produced are designed to perform successfully on fuel blends up to E10. According to industry representatives, while it is possible to design small nonroad engines to run on a broad range of fuels, such designs would not be cost effective and could add hundreds of dollars to the price.

Challenges to Transporting Additional Volumes of Ethanol to Wholesale Markets May Require Large Investments in Infrastructure over the Next Decade

Existing ethanol infrastructure should be sufficient to transport the nation's ethanol production through 2015, according to DOT officials and industry representatives, but large investments in transportation infrastructure may be needed to meet 2022 projected consumption, according to EPA documentation. One option for doing so may be to construct a dedicated ethanol pipeline, but this option presents significant challenges.

[20]In a carbureted fuel system, the air-to-fuel ratio is preset at the factory based on the expected operating conditions of the engine such as ambient temperature, atmospheric pressure, speed, and load.

Investments in Transportation Infrastructure May Be Needed to Meet 2022 Ethanol Consumption Levels

According to knowledgeable DOT officials and industry representatives we met with, the existing rail, truck, and barge transportation infrastructure for shipping corn ethanol to wholesale markets should be sufficient through 2015, when the volume of corn ethanol in the RFS is effectively capped at 15 billion gallons annually. This volume represents roughly a 2.4 billion gallon increase from 2011 RFS consumption targets for corn ethanol. Specifically, for rail, which transports about 66 percent of corn ethanol to wholesale markets, several DOT officials and representatives from the Association of American Railroads told us that the addition of a few billion gallons of ethanol over the near term is not expected to have a significant impact. Railroads hauled more than 220,000 rail carloads of ethanol in 2008 (the most recent year for which data are available)—which was about 0.7 percent of all the rail carloads and about 1 percent of the total rail tonnage transported that year in the United States, according to data from the Association of American Railroads. Similarly, knowledgeable DOT officials and industry representatives said there is sufficient capacity in the short term to transport additional volumes of corn ethanol via trucks, which transport about 29 percent of corn ethanol to wholesale markets, and barges, which transport roughly 5 percent, to meet RFS requirements.

In contrast, the existing infrastructure may not be sufficient to handle the ethanol production that is projected after 2015. The RFS generally requires transportation fuels in the United States to contain 21 billion gallons of advanced biofuels, including a large quantity of cellulosic ethanol, by 2022. In a 2010 regulatory impact analysis, EPA assessed the impacts of an increase in the production, distribution, and use of ethanol and other biofuels sufficient to meet this requirement.[21] In its assessment, EPA used three scenarios or "control cases" to project the amounts and types of renewable fuels to be produced domestically and imported from 2010 through 2022.[22] Under its "primary" control case, EPA projected that by

[21]EPA, *Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis*, EPA-420-R-10-006 (Washington, D.C., February 2010).

[22]EPA used three control cases—high-ethanol, primary or mid-ethanol, and low-ethanol—to account for different levels of projected cellulosic biofuel production. EPA then compared each of its control cases against a "reference" case based on estimates made by the Energy Information Administration in its 2007 *Annual Energy Outlook* for ethanol production by 2022. EPA focused on scenarios in which ethanol consumption increased greatly in all 50 states. While not discussed in EPA's report, an additional option would be increased use of E85, primarily in the Midwest. However, additional E85 fueling stations in the Midwest would be needed for this option.

2022, the United States would produce and import over 22 billion gallons of ethanol, comprising 15 billion gallons of domestically produced corn ethanol, almost 5 billion gallons of domestically produced cellulosic ethanol, and over 2 billion gallons of imported ethanol.[23] EPA also estimated the number of facilities that would need to be built or modified, as well as the number of additional vehicles that would need to be purchased. Under its primary control case, EPA estimated that the necessary spending on transportation infrastructure due to increased ethanol consumption would be approximately $2.6 billion. According to EPA's analysis:

- *For rail.* EPA estimated that approximately $1.2 billion would be needed for an additional 8,450 rail tanker cars ($760 million) and the construction of new train facilities ($446 million). EPA projected that biofuels transport will constitute approximately 0.4 percent of the total tonnage for all commodities transported by the freight rail system through 2022. Sixteen percent of the nation's freight rail system would be affected by biofuels shipments, and that portion (mostly along rail corridors radiating out of the Midwest) would see a 2.5 percent increase in traffic.

- *For trucks.* EPA estimated that approximately $87 million would be needed for an additional 480 tank trucks.

- *For barges.* EPA estimated that approximately $198 million would be needed for an additional 32 barges ($45 million), and the configuration of barge facilities (a projected $153 million). EPA stated that it does not anticipate a substantial fraction of biofuels will be transported via barge over the inland waterway system. In addition, the agency projected that a total of 30 ports will receive significant quantities of imported ethanol from Brazil and Caribbean Basin Initiative countries by 2022.

- *For wholesale terminals.* EPA estimated that $1.15 billion in investments would be needed, primarily to modify vapor recovery equipment (at a cost of $1 million for each terminal that does not already handle ethanol). Other modifications would include the installation of new storage tanks, modification of existing tanks, and modification of tank-truck unloading facilities.

[23]According to EPA's analysis, there is significant uncertainty regarding its estimate for the production of cellulosic biofuels by 2022.

EPA stated that the United States will face significant challenges in accommodating the projected increases in biofuels production by 2022, but it concluded that the task would be achievable at the wholesale level. For example, the agency stated that it believed overall freight-rail capacity would not be a limiting factor to the successful implementation of RFS requirements.

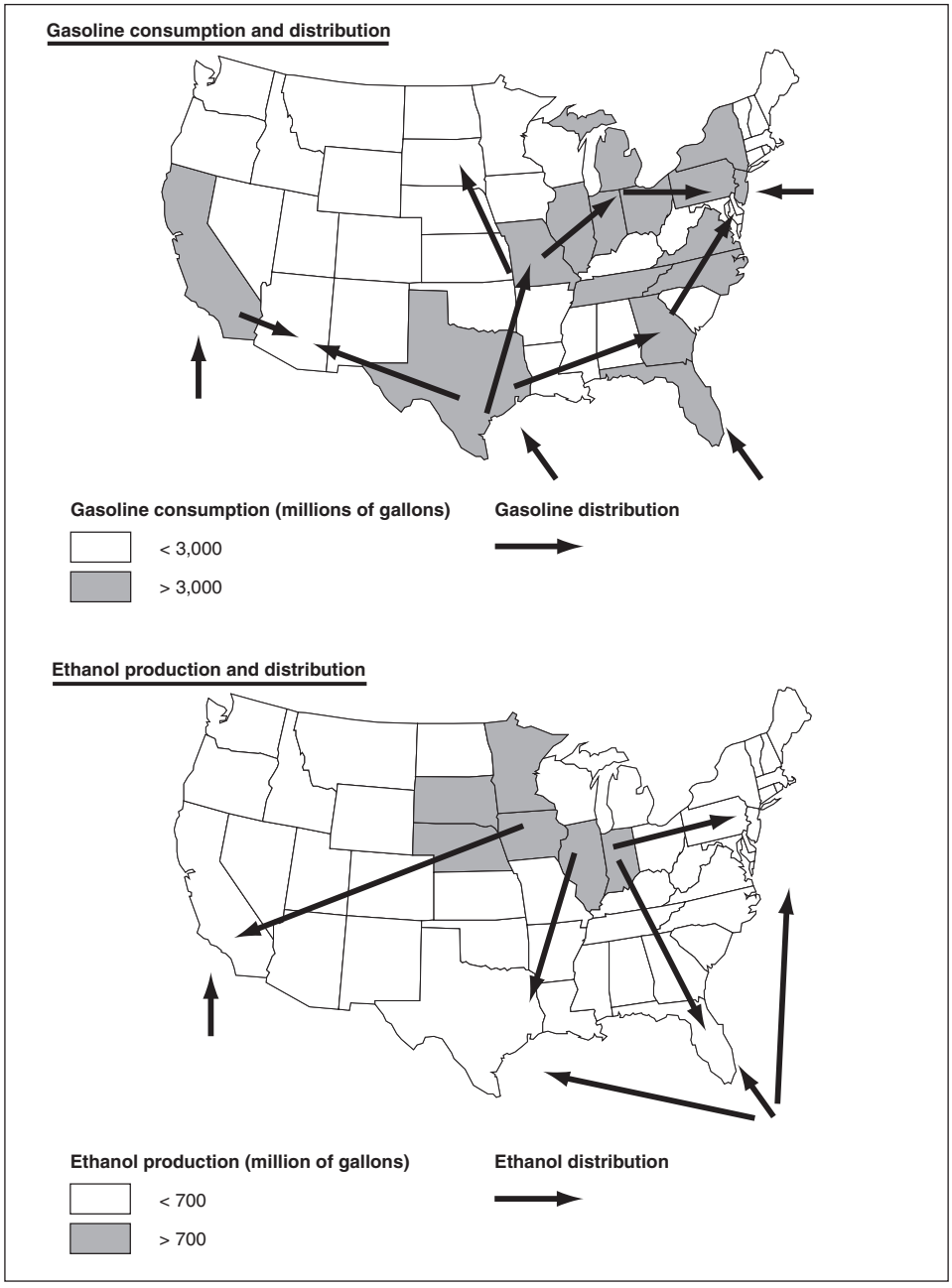
However, while this task may be achievable, it is likely to be increasingly difficult because of congestion on U.S. transportation networks. We and others have reported that congestion is constraining the capacity and increasing the costs of U.S. rail and highway transportation. For example, we reported in 2008 that neither rail nor highway capacity had kept pace with recent increases in demand, leading to increased costs.[24] We also cited a study by the Association of American Railroads, which predicted that without system improvements, the expected increases in rail volume by 2035 will cause 30 percent of primary rail corridors to operate above capacity and another 15 percent at capacity. The study stated the resulting congestion might affect the entire country and could shut down the national rail network. In addition, we noted that many of the highways used heavily by trucks to move freight are already congested, and congestion is expected to become a regular occurrence on many intercity highways. Finally, we noted that ports are likely to experience greater congestion in the future as more and larger ships compete for limited berths.

[24]GAO, *Freight Transportation: National Policy and Strategies Can Help Improve Freight Mobility*, GAO-08-287 (Washington, D.C.: Jan. 7, 2008).

One Option for Transporting Additional Volumes of Ethanol—Constructing a Dedicated Pipeline—Presents Significant Challenges

If overall ethanol production increases enough to fully meet the RFS over the long term, one option to transport it to wholesale markets would be through a dedicated ethanol pipeline. Over many decades, the United States has established very efficient networks of pipelines that move large volumes of petroleum-based fuels from production or import centers on the Gulf Coast and in the Northeast to distribution terminals along the coasts. However, the existing networks of petroleum pipelines are not well suited for the transport of billions of gallons of ethanol. Specifically, as shown in figure 4, ethanol is generally produced in the Midwest and needs to be shipped to the coasts, flowing roughly in the opposite direction of petroleum-based fuels. The location of renewable fuel production plants (such as biorefineries) is often dictated by the need to be close to the source of the raw materials and not by proximity to centers of fuel demand or existing petroleum pipelines.

Figure 4: Distribution Patterns for Gasoline and Ethanol



Source: DOE, *Report to Congress: Dedicated Ethanol Pipeline Feasibility Study* (Washington, D.C., March 2010).

Existing petroleum pipelines can be used to ship ethanol in some areas of the country. For example, in December 2008, the U.S. pipeline operator Kinder Morgan began transporting commercial batches of ethanol along with gasoline shipments in its 110-mile Central Florida Pipeline from Tampa to Orlando. However, pipeline owners would face the same technical challenges and costs that Kinder Morgan representatives reported facing, including the following:[25]

- *Compatibility.* Ethanol can dissolve dirt, rust, or hydrocarbon residues in a petroleum pipeline and degrade the quality of the fuel being shipped. It can also damage critical nonmetallic components, including gaskets and seals, which can cause leaks. In order for existing pipelines to transport ethanol, pipeline operators would need to chemically remove residues and replace any components that are not compatible with ethanol. According to DOT officials, the results from two research projects sponsored by that agency have identified specific actions that must be taken on a wide variety of nonmetallic components commonly utilized by the pipeline industry.[26]

- *Stress corrosion cracking.* Tensile stress and a corrosive environment can combine to crack steel. The presence of ethanol increases the likelihood of this in petroleum pipelines. Over the past 2 decades, approximately 24 failures due to stress corrosion cracking have occurred in ethanol tanks and in production-facility piping having steel grades similar to those of petroleum pipelines. According to DOT officials, the results from nine research projects sponsored by that agency have targeted these challenges and produced guidelines and procedures to prevent or mitigate stress corrosion cracking. As a result, pipelines can safely transport ethanol after implementing the identified measures, according to DOT officials.[27]

[25]According to company representatives, Kinder Morgan invested approximately $10 million to modify its Central Florida Pipeline for ethanol shipments, which included chemically cleaning the pipeline, replacing equipment that was incompatible with ethanol, and expanding storage capacity at its Orlando terminal.

[26]This research can be found at http://primis.phmsa.dot.gov/matrix/ after typing “ethanol” into the search feature.

[27]This research can be found at http://primis.phmsa.dot.gov/matrix/ after typing “ethanol” into the search feature.

- *Attraction of water.* Ethanol attracts water. If even small amounts of water mix with gasoline-ethanol blends, the resulting mixture cannot be used as a fuel or easily separated into its constituents. The only options are additional refining or disposal.

Some groups have proposed the construction of a new pipeline dedicated to the transportation of ethanol. For example, in February 2008, Magellan Midstream Partners, L.P. (Magellan) and Buckeye Partners, L.P. (Buckeye) proposed building a new pipeline from the Midwest to the East Coast.[28] According to this proposal, the pipeline would gather ethanol from three segments: (1) Iowa, Nebraska, and South Dakota; (2) Illinois, Michigan, and Minnesota; and (3) Indiana and Ohio. Ethanol would be transported to demand centers in New England, the Mid-Atlantic, Virginia, and West Virginia.

The federal government has studied the feasibility of building a pipeline similar to the one proposed by Magellan. Specifically, under section 243 of EISA, DOE (in collaboration with DOT) issued a study in March 2010 that examined the feasibility of constructing an ethanol pipeline linking large East Coast demand centers with refineries in the Midwest.[29] The report identified a number of significant challenges to building a dedicated ethanol pipeline, including the following:

- *Construction costs.* Using recent trends in and generally accepted industry estimates for pipeline construction costs, DOE estimated that an ethanol pipeline from the Midwest to the East Coast could cost about $4.5 million per mile. While DOE assumed that the construction of 1,700 miles of pipeline would cost more than $3 billion, it did not model total project costs beyond $4.25 billion in the report.

- *Higher transportation rates.* Based on the assumed demand for ethanol in the East Coast service area and the estimated cost of construction, DOE estimated the ethanol pipeline would need to charge an average tariff of 28

[28]Since the February 2008 announcement, Buckeye has discontinued its role in the proposal. In March 2009, Magellan and POET signed a joint development agreement to continue assessing the feasibility of a dedicated 1,700 mile pipeline moving ethanol from the Midwest to the major Northeastern markets. Pipeline costs were estimated to exceed $3.5 billion. A revised press release, issued in January 2010, increased the estimated length of the pipeline to 1,800 miles and the cost estimate to $4 billion.

[29]DOE, *Report to Congress: Dedicated Ethanol Pipeline Feasibility Study* (Washington, D.C., March 2010).

cents per gallon, substantially more than the current average rate of 19 cents per gallon, for transporting ethanol using rail, barge, and truck along the same transportation corridor.

- *Lack of eminent domain authority.* DOE estimated that siting a new ethanol pipeline of any significant length will likely require federal eminent domain authority, which currently does not exist for ethanol pipelines.

DOE's report concluded that a dedicated ethanol pipeline can become a feasible option if there is (1) adequate demand for the ethanol (approximately 4.1 billion gallons per year for the hypothetical pipeline assessed) and (2) government financial incentives to help defray the large construction costs.

Challenges Due to Regulations, Technical Issues, and Cost Could Slow the Retail Sale of Intermediate Ethanol Blends

We identified several challenges to selling intermediate ethanol blends at the retail level. First, federal and state regulations governing health and environmental concerns must be met before these blends are allowed into commerce, and fuel-testing requirements to meet these regulations may take 1 year or more to complete. Second, according to knowledgeable federal officials and UL representatives, federal safety standards do not allow ethanol blends over E10 to be dispensed at most retail fueling locations, and federally sponsored research has indicated potential problems with the compatibility of intermediate ethanol blends with existing dispensing equipment. Third, according to EPA and several industry representatives, the compatibility of many UST systems with these fuels is uncertain, and retailers will need to replace any components that are not compatible if they choose to store intermediate blends. Fourth, industry associations representing various groups, such as fuel retailers and refiners, are concerned that, in selling intermediate ethanol blends, fuel retailers may face significant costs and risks, such as upgrading or replacing equipment.

Federal and State Regulations Need to Be Met Prior to the Introduction of Intermediate Blends

According to knowledgeable EPA officials within the Office of Transportation and Air Quality, the regulatory process for allowing an intermediate ethanol blend into commerce could take 1 year or more. As described in table 1, the Clean Air Act, among other things, establishes a comprehensive regulatory program aimed at reducing harmful emissions from on- and off-road vehicles and engines and the fuels that power them. According to EPA officials, this regulatory program would apply to the introduction of new fuels, including E15 and other intermediate blends.

Table 1: Federal Fuel Requirements that Affect the Introduction of New Fuels

Type of requirement	Description
Fuel waiver	Under the Clean Air Act, the introduction into commerce of new fuels and fuel additives that are not substantially similar to the fuels and fuel additives specified by EPA regulations for testing the compliance of vehicles and engines with EPA emission standards is prohibited. However, EPA may waive this prohibition if a demonstration is made that the fuel or fuel additive will not cause or contribute to vehicles and engines failing to meet emission standards over their useful lives.
Detergent certification	EPA regulations implementing the Clean Air Act require fuel manufacturers to certify any detergent added to gasoline to prevent the accumulation of deposits in engines and fuel systems. Fuel manufacturers must use EPA-approved test fuels to certify the effectiveness of new detergents. EPA regulations currently require these test fuels to contain 10 percent ethanol by volume.
Fuel registration and health-effects testing	The Clean Air Act and EPA regulations require fuel manufacturers and importers to register new fuels and fuel additives prior to introducing them into commerce. Registration involves providing a chemical description of the product and certain technical, marketing, emissions, and health-effects information, which EPA uses to identify likely combustion and evaporative emissions that may pose concerns about health risk. However, EPA regulations allow registrants to submit evidence that prior health-effects testing is reasonably comparable to the results expected for a new fuel or fuel additive.
Reformulated gasoline certification	The Clean Air Act requires reformulated gasoline to be sold in areas of the country with the worst smog pollution, which include large areas of California and the Northeast. Reformulated gasoline must meet specific EPA emission standards. Fuel manufacturers must use an EPA-approved model to certify that new reformulated fuels meet applicable standards.

Source: GAO analysis of EPA information.

Although intermediate ethanol blends higher than E15 would need to meet all of these requirements, E15 has already partly met the first two. EPA partially granted a fuel waiver allowing E15 for use in model year 2001 and newer automobiles, and EPA officials told us the agency has no plans to revise its regulations for certifying detergents for E15 because it currently has not determined any detergent-related issues different from E10. According to EPA officials, the remaining two requirements have not yet been completed for E15 but are in the process of being addressed, specifically:

- Health-effects testing similar to that performed for E10 could take 2 years or more to register intermediate ethanol blends, depending on variables such as the availability of testing laboratories. According to EPA officials, EPA received information on February 18, 2011, from an ethanol industry representative contending that the health-effects testing previously performed for E10 is an adequate substitute for E15. According to recent

Congressional testimony, EPA expects to finish reviewing the information by the middle of 2011.[30]

- EPA would have to update the regulations for its reformulated gasoline program, which do not currently allow fuel manufacturers to certify batches of gasoline containing greater than 10 percent ethanol by volume. In November 2010, EPA proposed a rule that would, among other things, update the model to allow for reformulated gasoline containing up to 15 percent ethanol by volume.[31] According to EPA officials, EPA expects to issue a final rule sometime in 2011.

In addition to federal regulations, many states have established regulations or statutes related to transportation fuels, according to a 2010 industry report.[32] In particular, many state regulations or statutes contain references to specific industry standards for fuel published by a recognized standards development organization, including ASTM International and the National Institute of Standards and Technology (NIST), according to the report and knowledgeable NIST officials we interviewed. These standards, however, are only relevant to E10, and neither organization has published any standards related to the use of intermediate ethanol blends up to E85. Therefore, before allowing intermediate ethanol blends into commerce, the states that reference existing ASTM International or NIST standards would have to either (1) enact new statutes or regulations that no longer reference the existing standards or (2) wait for ASTM International or NIST to update their standards related to intermediate ethanol blends. Either option could take more than a year to implement, according to knowledgeable officials from NIST and the California Air Resources Board.

[30]EPA, *Testimony of Lisa Jackson, Administrator, U.S. Environmental Protection Agency, before the Committee on Agriculture, United States House of Representatives* (Washington, D.C., Mar. 10, 2011).

[31]75 Fed. Reg. 68044 (Nov. 4, 2010).

[32]Sierra Research, Inc., *Identification and Review of State/Federal Legislative and Regulatory Changes Required for the Introduction of New Transportation Fuels*, Report No. SR2010-08-01 (Sacramento, Calif., Aug. 4, 2010), prepared for the American Petroleum Institute.

OSHA Regulations Prohibit Using Most Existing Dispensing Equipment with Intermediate Blends, and Research Suggests Compatibility Issues

In general, federal safety standards do not allow ethanol blends over E10 to be dispensed with existing equipment at most retail fueling locations. Specifically, OSHA requires that all equipment used to dispense gasoline be certified for safety by a nationally recognized testing laboratory. UL, the only such laboratory that has developed standards for certifying dispensing equipment, did not publish safety standards specifically for intermediate ethanol blends until August 2009,[33] and no UL-certified dispensing equipment was available for use with these blends until 2010.[34] Dispensing equipment manufactured earlier has been certified for blends up to E10, and UL does not recertify equipment that has already been certified to an existing UL standard, according to several UL representatives. Moreover, UL does not retroactively certify manufactured or installed equipment to new safety standards because it cannot monitor whether the equipment has been modified by, for example, aging or maintenance. As a result, according to knowledgeable OSHA officials and several UL representatives, the vast majority of existing retail dispensers in the United States are not approved for use with intermediate ethanol blends under OSHA's safety regulations.

Until recently, UL and OSHA were each exploring ways to allow fuel retailers to use existing dispensing equipment with intermediate ethanol blends while still meeting OSHA's safety regulations. For example, in a February 2009 announcement, UL stated that existing dispensing equipment—certified for use with E10—could be used with blends containing up to 15 percent ethanol, based on data the company had collected. According to the announcement, UL did not find any significant incremental risk of damage to existing equipment between E10 and fuels with a maximum of 15 percent ethanol. In addition, several OSHA officials told us in November 2010 that the agency was at the early stages of evaluating several options—such as implementing a grace period on planned enforcement activities or developing an enhanced inspection and maintenance program for a limited time—that would allow existing dispensing equipment to be approved for use with E15.

[33]These standards cover blends with up to 25 percent ethanol (E25). UL published safety standards for certifying dispensing equipment for blends up to E85 in October 2007.

[34]UL certified dispensers from two manufacturers in March 2010 for use with blends up to E25, and in June 2010 for blends up to E85. According to knowledgeable OSHA officials, if employees covered by OSHA used or worked on unapproved equipment dispensing higher ethanol blends, it would likely constitute a violation of OSHA requirements. However, these officials said that OSHA is not aware of any complaints, referrals, or notifications of serious accidents involving this equipment.

However, results from federally sponsored research indicate potential problems with the use of intermediate ethanol blends with some existing dispensing equipment. A DOE-commissioned report prepared by UL was issued in November 2010 on the compatibility of intermediate blends with new and used dispensing equipment certified for blends up to E10.[35] According to the report, although various components generally performed well with the testing fluid, some of the components tested (including valve assemblies and nozzles) demonstrated a reduced level of safety, performance, or both when exposed to the testing fluid. This was mostly due to the failure of certain nonmetal components, such as gaskets and seals. In March 2011, DOE's ORNL published a report stating that, although metal samples experienced very little corrosion, all elastomer samples (such as fluorocarbon, nitrile rubber, and polyurethane) exhibited some level of swelling and the potential to leak when exposed to testing fluids.[36]

This research has led UL and OSHA to reconsider support for the use of existing dispensing equipment with intermediate ethanol blends. In a December 2010 announcement based on this research, UL stated that it advised against the use of intermediate ethanol blends with dispensing equipment certified for E10 and, instead, recommended the use of new equipment designed and certified for use with intermediate ethanol blends. The announcement stated that UL was particularly concerned that blends over E10 could lead to the degradation of gaskets, seals, and hoses and could cause leaks. In addition, several OSHA officials told us that, as a result of this research, the agency is re-evaluating its plan to explore ways to allow fuel retailers, under certain conditions, to use existing dispensing equipment with intermediate blends.

However, OSHA's position on this issue remains unclear, and it is uncertain when the agency will establish a definitive position. On the one

[35]According to DOE officials, this research used a testing fluid containing 17 percent ethanol, acids, water, and minerals to represent worst-case scenarios for fuel. See UL, *Dispensing Equipment Testing With Mid-Level Ethanol/Gasoline Test Fluid* (Washington, D.C., November 2010), prepared for DOE.

[36]This research was on the exposure of common dispenser materials to testing fluids containing 17 and 25 percent ethanol, plus acids, water, and minerals. See ORNL, *Intermediate Ethanol Blends Infrastructure Materials Compatibility Study: Elastomers, Metals, and Sealants*, ORNL/TM-2010/326 (Oak Ridge, Tenn., March 2011). According to DOE, elastomers are a class of polymers widely used in fuel dispenser systems as o-rings and gasket-type seals.

hand, according to several OSHA officials we talked with, the vast majority of existing retail dispensers in the United States are not approved for use with intermediate ethanol blends under OSHA's safety regulations. On the other hand, these officials also stated that OSHA is still developing its position on the use of existing dispensing equipment with intermediate blends. While these officials said that strict enforcement of current OSHA requirements for dispensing equipment seems more like an option now, they did not provide any time frames for when OSHA would finalize its position, nor how it planned on communicating a decision to fuel retailers and other interested parties.

The Compatibility of Many UST Systems with Intermediate Blends Is Unclear

According to our discussions with knowledgeable federal officials and several industry association representatives, the compatibility of many existing UST systems with intermediate ethanol blends is unclear for two main reasons—many fuel retailers have older equipment and lack records, and recent federally sponsored research indicates potential problems with the use of intermediate blends. Retail fueling outlets generally have two or more UST systems, according to industry association representatives, and each system contains a large number of components and materials. According to EPA documentation and knowledgeable EPA officials within the Office of Underground Storage Tanks, many existing USTs range in age from 1 to 40 years and contain components certified to a range of UL standards, which typically have evolved over time, or have been approved by the manufacturer for varying uses.[37] Because these systems are buried underground, visually inspecting some components for compatibility is impossible without excavating them. Thus, fuel retailers, along with state and federal inspectors, primarily rely on recordkeeping to verify UST system compatibility with the fuel stored in them.

However, inadequate recordkeeping may make it difficult for retailers with older stations to verify UST system compatibility with intermediate ethanol blends. For example, according to EPA documentation, knowledgeable EPA officials, and a representative from the Society of Independent Gasoline Marketers of America, many fuel retailers do not have complete records of all their UST equipment, particularly those with stations having several previous owners. Furthermore, many installation

[37]According to knowledgeable EPA officials, it is possible to purchase a new UST system meeting EPA requirements for compatibility with all ethanol blends. However, according to EPA officials, most tank owners still purchase some components that are only approved for use with E10.

companies and component manufacturers may have gone out of business, according to EPA documentation, which could make verification particularly challenging. Recognizing this issue, EPA announced in November 2010 that it plans to issue guidance that would clarify its compatibility requirements for UST systems storing ethanol blends higher than 10 percent.[38] In its announcement, EPA also solicited public feedback on the extent of the challenges fuel retailers face in demonstrating existing UST systems' compatibility with intermediate ethanol blends and on alternatives that would sufficiently protect human health and the environment. EPA officials said the agency expects to issue guidance sometime in 2011.

Determining compatibility may be important because ongoing federal research indicates potential problems with the use of intermediate ethanol blends with some UST components. For example, according to a recent DOE report and additional results from DOE research, certain elastomers, rubbers, and other materials used in UST systems may degrade or swell excessively when exposed to intermediate ethanol blends, becoming ineffective as gaskets or seals.[39] DOE testing also indicates that a pipe-thread sealant commonly used in UST piping in the past is not compatible with any ethanol blends, which raises concerns that these components may leak when exposed to ethanol—even in lower blends, such as E10. According to the report, DOE expects to conclude this research in the near future. In addition, DOE officials said they do not expect to conduct additional research on UST components or equipment.

However, important gaps exist in current federal research efforts in this area. For example, several officials within EPA's Office of Underground Storage Tanks told us that DOE's research efforts to date have focused only on testing materials (e.g., elastomers and rubbers) and not actual components and equipment (e.g., valves and tanks) found in UST systems. In addition, according to EPA officials, while the agency plans to study the compatibility of E15 with UST systems, this research will be based on interviews with experts and not on actual testing of materials, components, or equipment. Moreover, EPA officials characterized this research effort as more of a "modeling" or scoping effort to determine the extent of any potential problems. EPA officials stated that the ability to determine the compatibility of legacy equipment with intermediate blends

[38]75 Fed Reg. 70241 (Nov. 17, 2010).

[39]ORNL, ORNL/TM-2010/326.

is limited. Nevertheless, they acknowledged that additional research will be necessary to facilitate a transition to storing intermediate ethanol blends in UST systems, including the suitability of specific UST components with intermediate blends. EPA officials told us that they are working with industry officials and federal partners to understand the impact of intermediate blends in UST systems. However, to date EPA has not developed a plan to undertake such research.

It is also unclear whether leak-detection equipment will properly detect leaks of intermediate ethanol blends. According to knowledgeable EPA officials and UL representatives, UL has not developed performance standards for leak-detection equipment used in UST systems. EPA officials explained that, while some leak-detection equipment has been approved by the manufacturer for the compatibility of its materials with intermediate ethanol blends, EPA is not certain whether the ethanol content of the fuel, in general, would affect the operability of this equipment. To address this potential problem, EPA is sponsoring research, in collaboration with manufacturers and other stakeholders, to determine which of these devices works properly with ethanol. EPA officials currently expect test results to be available by the end of 2011.

Retailers May Face Significant Costs and Risks in Selling Intermediate Blends

According to several industry associations representing various groups, such as fuel retailers and refiners, many fuel retailers may face significant costs and risks in selling intermediate ethanol blends. According to these industry representatives, retailers make very little money selling fuel—for example, the national average profit from selling gasoline last year was 9 cents per gallon, according to industry data. Most retailers make most of their profit selling merchandise such as food, beverages, and tobacco products, according to these industry representatives, and gasoline is sold below cost in some markets to attract customers to buy more profitable goods. As a result, according to several industry representatives, most retailers do not upgrade their fuel-storage and -dispensing equipment without a significant market opportunity.

For these fuel retailers, the prospect of selling intermediate ethanol blends presents several potential challenges. The first is cost. Some fuel retailers may have to spend hundreds of thousands of dollars to upgrade their equipment to store and dispense intermediate ethanol blends, for the following reasons:

- Under current OSHA regulations, most fuel retailers will need to replace at least one dispenser system to sell intermediate ethanol blends. According

to estimates from EPA and several industry associations, installing a new dispenser system compatible with intermediate ethanol blends will cost over $20,000.[40] According to some industry association representatives, a typical fuel retailer has four dispensers and, therefore, would face costs exceeding $80,000 to upgrade an entire retail facility.

- Fuel retailers with inadequate records of their UST systems may have to upgrade certain UST components to demonstrate compatibility with intermediate ethanol blends. According to some industry association representatives and information from DOE's NREL, upgrading some components would be less expensive than installing an entirely new UST system. Taking this into consideration, EPA estimated an average cost of $25,000 per retail facility to make the needed changes to underground storage components.[41] However, EPA cautioned that this cost scenario is very speculative, given that the costs of modifying underground components could vary greatly. According to EPA officials, most tank owners will be able to demonstrate compatibility by replacing certain portions of the UST system that are easily accessible (such as submersible pumps, tank probes, pipe dope, and overfill valves). The costs for these upgrades, including labor, can be as low as a few thousand dollars but may increase if more extensive upgrades are required.

- According to EPA and industry estimates, the total cost of installing a new single-tank UST system compatible with intermediate ethanol blends is more than $100,000. In addition to the high costs, some industry association representatives stated that fuel retailers who have recently installed new UST systems may be particularly reluctant to replace them, especially since UST warranties can last for several decades, and the useful life of these systems can be even longer. In Florida, for example, fuel retailers were required to replace or upgrade all single-wall USTs by December 31, 2009.

A second potential challenge consists of financial and logistical limitations on the types of fuel a retailer may be able to sell. According to representatives from several industry associations, most retail fueling

[40]DOE recently estimated that modifying fuel pumps to make them compatible with E15 should cost $1,000 or less per pump, depending on pump-specific variables. See DOE, *Statement of Dr. Henry Kelly, Acting Assistant Secretary For Energy Efficiency, U.S. Department of Energy, Before the Committee on Environment and Public Works, United States Senate* (Washington, D.C., Apr. 13, 2011).

[41]EPA, Office of Transportation and Air Quality, EPA-420-R-10-006.

locations have only two UST systems, and many fuel retailers cannot install additional UST systems due to space constraints, permitting obstacles, or cost.[42] Currently, fuel retailers with two UST systems can sell three grades of gasoline: regular, midgrade, and premium. To accomplish this, they typically use one of their tanks to store regular gasoline and the other for premium, both of which are preblended with up to 10 percent ethanol. They then use their dispensing equipment to blend fuel from both tanks into midgrade gasoline. If fuel retailers with two UST systems want to sell intermediate ethanol blends, however, they may face certain limitations. For example, fuel retailers with two UST systems who want to sell regular, midgrade, and premium gasoline could use the tanks to store regular and premium grades of an intermediate blend, such as E15. However, since EPA has only allowed E15 for use in model year 2001 and newer automobiles, these retailers would not be able to sell fuel to consumers for use in older automobiles and nonroad engines.

A third potential challenge relates to legal uncertainty among industry groups, who are concerned they could be held liable for selling intermediate ethanol blends. For example, according to representatives we interviewed from several industry associations, fuel retailers have received conflicting or confusing messages from different authorities as to whether existing dispensing equipment can be lawfully used with intermediate ethanol blends. According to these industry representatives, this confusion is partly the result of UL's 2009 announcement supporting the use of blends containing up to 15 percent ethanol with existing dispensing equipment.[43] However, even if state or local officials—such as fire marshals—approve the use of intermediate blends with existing dispensers, the retailers selling these blends would still be effectively ignoring OSHA's regulations, which require the use of equipment that has been certified for safety by a nationally recognized testing laboratory, such as UL. As a result, several industry representatives raised concerns that fuel retailers could expose themselves to lawsuits for negligence and invalidate important business agreements that may reference these safety

[42]EPA officials told us that it does not collect data on tank configurations at retail locations. As a result, we relied on information from industry representatives to illustrate this potential challenge.

[43]Several UL representatives told us that the announcement did not mean that UL was recertifying existing equipment for use with intermediate blends or that existing equipment could be used with E15 (because the ethanol content of a specific blend, like E15, may vary and potentially could exceed 15 percent under normal business conditions).

requirements, such as tank insurance policies, state tank-fund policies, and business loan agreements.

In addition, according to representatives from several industry associations we interviewed, many fuel retailers are concerned that consumer misfueling—using intermediate ethanol blends in nonapproved engines—could raise liability issues, especially if the misfueling is associated with negative outcomes, such as diminished engine performance and safety problems. Because EPA has only allowed E15 for use in model year 2001 and newer automobiles, representatives from several industry associations stated that consumers may not be aware of the distinction between approved and nonapproved engines, or they may be confused about which fuel to use, thus complicating their experience at retail fueling outlets and increasing opportunities for misfueling. According to some industry and state government representatives, since many automobile manufacturer warranties do not cover the use of intermediate ethanol blends, even for the model year vehicles approved by EPA for E15, consumers could be held responsible for the cost of any repairs attributed to the use of E15.

One proposed method of mitigating the potential for misfueling is to label fuels at retail outlets. In November 2010, EPA issued proposed labeling requirements for ethanol blends as high as E15.[44] According to its proposed requirements, EPA is coordinating with the Federal Trade Commission, which in March 2010 proposed labeling requirements for ethanol blends containing greater than 10 percent and less than 70 percent ethanol by volume.[45] However, representatives from several industry associations have raised concerns that labeling will not adequately address potential misfueling. For example, some industry association representatives stated that some consumers will not understand the label, or the label might get lost among the other labels commonly found on dispensers. Furthermore, industry association representatives said some consumers will intentionally misfuel their automobiles if intermediate ethanol blends are cheaper. For example, industry association representatives stated some of their members have witnessed consumers using E85 in nonflex-fuel vehicles, presumably because E85 is cheaper than E10.

[44]75 Fed. Reg. 68044 (Nov. 4, 2010).

[45]75 Fed. Reg. 12470 (Mar. 16, 2010).

Federally Sponsored Studies Are Evaluating Effects of Using Intermediate Ethanol Blends in Automobiles and Nonroad Engines

With the possibility of introducing intermediate ethanol blends in the nation's motor-fuel supply, DOE began to study the effects of these fuels in automobiles and nonroad engines in 2007. Specifically, in March 2007, DOE's Office of Energy Efficiency and Renewable Energy convened a workshop of experts to evaluate progress and develop a strategy for meeting the Bush Administration's "20 in 10" initiative. The goal of the initiative was to reduce U.S. gasoline usage by 20 percent over the next 10 years through increased use of alternative fuels and improved fuel economy. One conclusion from the workshop was that increasing the ethanol content in motor fuel to E15 or E20 would be the most effective strategy over the short term. However, based on a review of existing research, DOE's ORNL found that almost no data existed on the effects of E15 on automobiles, while only limited data existed on the effects of E20.[46]

To address this data gap, DOE began working with EPA, the Coordinating Research Council, Inc. (CRC), and other groups in 2007 to develop a list of research projects to test the effects of E15 and E20 on automobiles and nonroad engines.[47] DOE, EPA, and CRC have provided about $51 million in funding (for fiscal years 2007 through 2010) for ten research projects (see table 2).[48]

[46]See ORNL, *Technical Issues Associated with the Use of Intermediate Ethanol Blends (>E10) in the U.S. Legacy Fleet: Assessment of Prior Studies* (Oak Ridge, Tenn., August 2007).

[47]CRC is a nonprofit organization supported by the petroleum and automotive equipment industries. CRC operates through committees made up of technical experts from industry and government who voluntarily participate.

[48]Of this total amount, DOE has provided about $45 million, including less than $65,000 for NREL and ORNL to review studies conducted by the Minnesota Center for Automotive Research at Minnesota State University, Mankato; and the Center for Integrated Manufacturing Studies at Rochester Institute of Technology. These efforts are not included in table 2.

Table 2: Status of DOE- and EPA-Sponsored Research on Effects of Intermediate Ethanol Blends in Automobiles and Nonroad Engines

DOE project number[a]	Description	Status (as of Mar. 1, 2011)
Research on automobiles		
V1	Short-term "quick-look" emissions study	Completed. Published reports: • NREL, ORNL, *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines,* Report 1 – Updated (Golden, Colo., February 2009). • Keith Knoll, et al., "Effects of Mid-Level Ethanol Blends on Conventional Vehicle Emissions" (paper presented at SAE 2009 Powertrains Fuels and Lubricants Meeting, San Antonio, Tex., November 2009).
V2	Detailed exhaust emissions study	Ongoing. Expected date for completion of testing is May 2011. Expected date for issuing a report is October 2011.
V3	Evaporative emissions study	Completed. Published reports: • Harold Haskew & Associates, Inc., *Evaporative Emissions from In-Use Vehicles: Test Fleet Expansion* (CRC E-77-2b) Final Report EPA-420-R-10-025, a technical report prepared for the EPA, October 2010. • CRC, *Study to Determine Evaporative Emission Breakdown, Including Permeation Effects and Diurnal Emissions, Using E20 Fuels on Aging Enhanced Evaporative Emissions Certified Vehicles* (Alpharetta, Ga., December 2010).
V4	Full-life emissions study	Ongoing. Testing completed in December 2010. Expected date for issuing a report is summer 2011.
V5	Drivability study	Ongoing. Expected date for completion of testing is March 2011. Expected date for issuing a report is August 2011.
V6	Fuel-system materials compatibility study	Ongoing. Expected date for issuing a report is summer 2011.
Research on nonroad engines		
SE1	"Quick-look" emissions and temperature study	Completed. Published report: NREL, ORNL, *Effects of Intermediate Ethanol Blends.*
SE2	Full useful-life emissions and durability study	Completed. Published report: NREL, ORNL, *Effects of Intermediate Ethanol Blends.*
SE3	Chainsaw safety study	Canceled.

DOE project number[a]	Description	Status (as of Mar. 1, 2011)
SE4	Marine and snowmobile durability, emissions, and drivability study	Ongoing. Expected date for completion of testing is March 2011 (for marine engines) and August 2011 (for snowmobiles). Expected date for issuing a report is October 2011.

Source: GAO analysis of DOE, EPA, and CRC information.

[a]CRC project numbers associated with these efforts include E-77 (for V3), E-87 (for V4), E-89 (for V2), CM-138 (for V5), and AVFL-15 (for V6).

Of the six federally sponsored projects on automobiles, four projects are ongoing and are expected to be completed in 2011. Two projects have been completed—Project V1, which looked primarily at the effects of E15 and E20 on tailpipe emissions from automobiles, and Project V3, which looked primarily at the effects of E20 on evaporative emissions from automobiles. According to published reports, project findings included the following:

- *Exhaust emissions.* According to the 2009 DOE report for Project V1, regulated tailpipe emissions from 16 automobiles (including model years ranging from 1999 to 2007) remained largely unaffected by the ethanol content of the fuel.[49] Increasing the ethanol content of the fuel, however, resulted in increased emission of ethanol and acetaldehyde. DOE has also released all of the testing data from Project V4, which is looking at emissions testing and aging on 82 automobiles (including model years ranging from 2000 to 2009). EPA based its decision to allow E15 for use in certain automobiles partly on these results. According to EPA's decision, model year 2000 and older automobiles do not have the sophisticated emissions control systems of more recently manufactured automobiles, and there is an engineering basis to believe they may experience emissions increases if operated on E15.

- *Fuel economy.* According to DOE's report for Project V1, ethanol has about 67 percent of the energy density of gasoline on a volumetric basis. As a result, automobiles running on intermediate ethanol blends exhibited a loss in fuel economy commensurate with the energy density of the fuel. Specifically, when compared to using gasoline containing no ethanol, the average reduction in fuel economy was 3.7 percent using E10, 5.3 percent using E15, and 7.7 percent using E20.

[49]EPA regulates the emissions of air pollutants—which are known or reasonably anticipated to endanger public health or welfare—from mobile sources such as automobiles. These pollutants include hydrocarbons (such as benzene and acetaldehyde), carbon monoxide, nitrogen oxides, and volatile organic compounds.

- *Catalyst temperatures.* According to the 2009 report for Project V1, 9 of the 16 automobiles adjusted their air-to-fuel ratio at full power to compensate for the increased oxygen content in the ethanol-blended fuel. In these cases, the catalyst temperatures at equivalent operating conditions were lower or unchanged with ethanol. Seven of the 16 tested automobiles failed to adequately adjust their air-to-fuel ratio for the increase in oxygen with E20 fuel compared with 100 percent gasoline at full power. As a result, catalyst temperatures for these automobiles at full power were between 29ºC and 35ºC higher with E20 relative to gasoline. According to the report, the long-term effect of this temperature increase on catalyst durability is unknown and requires further study.

- *Evaporative emissions.* According to its 2010 report for Project V3, CRC found that intermediate ethanol blends may increase evaporative permeation emissions—fuel-related emissions that do not come from the tailpipe—in older automobiles. CRC's report was not based on statistically significant comparisons, but it noted certain trends—for example, compared to pure gasoline, E10 and E20 were associated with increased evaporative emissions.

Of the four federally sponsored projects on nonroad engines, one (SE4) is ongoing, and one (SE3) has been canceled. According to DOE, the objective of Project SE4 is to determine the effects of E15 on the safety, performance, and emissions of several popular marine and snowmobile engines. The objective of Project SE3 was to assess the effects of intermediate ethanol blends, including E15, on the safety and performance of handheld small nonroad engines, including chainsaws. However, according to DOE officials, the department decided in the summer of 2010 to defer Project SE3 indefinitely because the Outdoor Power Equipment Institute—an industry association representing small nonroad engine manufacturers and DOE's major partner on the project—declined to submit a proposal for conducting the testing. According to one official with the Institute, this decision was based, in part, on EPA's indication that it would not allow E15 for use in small nonroad engines.

The two federally sponsored projects on nonroad engines that have been completed—SE1 and SE2—were not conclusive, but indicated potential problems with the use of intermediate ethanol blends in small nonroad engines. Project SE1 was a pilot study of six commercial and residential small nonroad engines, and Project SE2 tested 22 engines over their full

useful lives. According to the 2009 DOE report, the projects found that with increasing levels of ethanol:[50]

- For all engines tested, exhaust and engine temperatures generally increased.
- Three handheld trimmers had higher idle speeds and experienced unintentional clutch engagement, which DOE laboratory officials identified as a potential safety concern that can be mitigated in some engines by adjusting the carburetor.
- For all engines tested, emissions of nitrogen oxides increased and emissions of carbon monoxide decreased, while emissions of hydrocarbons decreased in most engines, but increased for some.

EPA cited results from Projects SE1 and SE2 in its decision to not allow the use of E15 in nonroad engines and other equipment. Specifically, in its October 2010 decision, EPA stated that the results of these projects indicated reasons for concern with the use of E15 in nonroad engines, particularly regarding long-term exhaust and evaporative emissions durability and materials compatibility. Moreover, the agency stated that the application for use of E15 did not provide information to broadly assess the nonroad engine and vehicle sector. EPA concluded that since there are important differences in design between the various types of nonroad engines, and since the agency was not aware of other information that would allow it to fully assess the potential impacts of E15 on the emission performance of nonroad products, it could not allow the use of E15 in these engines.

Due to ongoing litigation, we did not evaluate the adequacy of these federally sponsored projects. In November 2010, several trade groups representing the oil and gas sector and the food and livestock industries filed a lawsuit with the U.S. Court of Appeals for the District of Columbia Circuit challenging EPA's E15 waiver decision. According to the plaintiffs' statement filed in January 2011, one key issue in the lawsuit is whether EPA acted arbitrarily, capriciously, and in excess of its statutory authority by relying on data that do not provide adequate support for its conclusions, while ignoring extensive data contradicting its position. In addition, in December 2010, several trade groups representing automobile

[50]NREL, ORNL, *Effects of Intermediate Ethanol Blends*.

and small-engine manufacturers filed another lawsuit with the U.S. Court of Appeals for the District of Columbia Circuit challenging EPA's E15 waiver decision. The initial court documents did not provide details on these groups' rationale for challenging EPA's waiver decision.

In addition to these federally sponsored projects, some nonfederal organizations are conducting research on the effects of intermediate ethanol blends in automobiles. Appendix II provides a description of these organizations and a list of some of their published research. We did not evaluate the results of these studies.

Conclusions

The RFS calls for increasing amounts of biofuels to be blended in the nation's transportation fuel supply, including up to 15 billion gallons of ethanol made from corn starch and potentially billions of gallons of additional ethanol made from cellulosic sources. EPA is responsible for establishing and implementing regulations to ensure that the nation's transportation fuel supply contains the volumes of biofuels required by the RFS. The agency is also tasked with ensuring that new fuels do not cause or contribute to noncompliance with existing emissions standards when used in automobiles and nonroad products. EPA recently allowed an intermediate ethanol blend, E15, for use in model year 2001 and newer automobiles, after determining that it would not cause these automobiles to be out of compliance with emissions standards.

EPA, along with OSHA, is also responsible for ensuring that fuels are compatible and safe for use with infrastructure at fueling locations. However, the effects of intermediate ethanol blends on key components of the nation's retail fueling infrastructure—such as gaskets and seals in dispensing equipment and UST systems—are not fully understood. A recently published DOE report found that materials commonly used in these gaskets and seals can swell when exposed to certain intermediate ethanol blends, potentially causing leaks.

In the case of fuel-dispensing equipment, some newer equipment meets OSHA safety regulations for use with intermediate ethanol blends, as this equipment has been tested and certified by UL for compatibility. Most existing equipment at retail fueling locations in the United States, however, is not approved for use with intermediate blends. Until recently, OSHA had been exploring ways to allow fuel retailers to use existing equipment with intermediate blends while still meeting OSHA's safety requirements. In light of the recent DOE-sponsored research, OSHA officials are re-evaluating the use of existing equipment with intermediate

blends. However, the agency has not clarified when it will make an official decision. Without clarification from OSHA on how its safety regulations on fuel-dispensing equipment should be applied to fuel retailers selling intermediate ethanol blends, the retail fuel industry faces uncertainty in how it can provide such blends to consumers while meeting OSHA safety regulations.

In the case of UST systems, fuel retailers can purchase new equipment—certified by UL or the equipment manufacturer for use with intermediate ethanol blends—to meet EPA regulations for compatibility. However, many existing UST systems may not be fully compatible with intermediate blends, and inadequate records may make it difficult for many retailers to verify the compatibility of their UST systems. Due to these concerns, and in light of the recent DOE-sponsored research, EPA is in the process of issuing guidance to clarify how its UST regulations apply to the use of intermediate blends. While DOE is conducting studies on the compatibility of UST materials with intermediate blends, and while EPA plans to conduct a study limited to experts' views on the subject, EPA officials have acknowledged that additional research, including research on the suitability of specific UST components with intermediate blends, will be needed to facilitate a transition to storing intermediate ethanol blends. Without this effort, the retail fuel industry faces uncertainty in how it can provide intermediate blends to consumers.

Recommendations for Executive Action

We are making the following two recommendations:

- To reduce uncertainty about the applicability of federal safety regulations, we recommend that the Secretary of Labor direct the Assistant Secretary for Occupational Safety and Health to issue guidance clarifying how OSHA's safety regulations on fuel-dispensing equipment should be applied to fuel retailers selling intermediate ethanol blends.

- To reduce uncertainty about the potential environmental impacts of storing intermediate ethanol blends at retail fueling locations, we recommend that the Administrator of EPA determine what additional research, such as research on the suitability of specific UST components, is necessary to facilitate a transition to intermediate ethanol blends, and work with other federal agencies to develop a plan to undertake such research.

Agency Comments and Our Evaluation

We provided copies of our draft report to EPA, the Department of Labor, DOE, and DOT for comment. In written comments, EPA generally agreed with the information and findings but expressed concern about our recommendation (as worded in the draft report). Specifically, EPA stated that while it believed a targeted approach to conducting additional research will be important to accommodate the move to higher ethanol blends, there will always be uncertainty concerning the compatibility of legacy UST equipment with intermediate ethanol blends given the multitude of factors involved (e.g., the age and prior use of UST equipment, and the number of UST system components). EPA stated that it planned to continue to work with other federal agencies and stakeholders to assist tank owners in safely transitioning to new fuels, and that additional research may be necessary to facilitate that transition. We agree with this characterization of the issue and have revised the draft recommendation to reflect EPA's suggestions. In addition, in written comments, the Department of Labor concurred with our findings and our recommendation. EPA's written comments are reprinted in appendix III, and the Department of Labor's written comments are reprinted in appendix IV. EPA and the Department of Labor also provided technical clarifications, which we incorporated as appropriate. DOE and DOT did not provide formal written comments but provided technical clarifications, which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of the report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees; the Administrator of EPA; Secretaries of Energy, Transportation, and Labor; and other interested parties. In addition, this report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or ruscof@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 V.

Frank Rusco
Director, Natural Resources and Environment

Appendix I: Scope and Methodology

To determine the challenges associated with transporting additional volumes of ethanol to wholesale markets to meet Renewable Fuel Standard (RFS) requirements, we interviewed relevant government, industry, academic, and research officials. We also reviewed relevant government reports and studies, industry reports, and academic and research literature. In particular, we asked a nonprobability sample of knowledgeable stakeholders, among other things, to discuss the challenges, if any, associated with transporting additional volumes of ethanol to wholesale markets. We also asked these stakeholders to identify key studies and other knowledgeable stakeholders on this topic. We selected these stakeholders using a "snowball sampling" technique, whereby each stakeholder we interviewed identified additional stakeholders and stakeholder organizations for us to contact. Specifically, based, in part, on our recent work, we first interviewed stakeholders from the Environmental Protection Agency (EPA); the Departments of Agriculture (USDA), Energy (DOE), and Transportation (DOT); the Renewable Fuels Association; the American Petroleum Institute; the Alliance of Automobile Manufacturers; the Association of Oil Pipe Lines; and the Outdoor Power Equipment Institute.[1] We then used feedback from these interviews to identify additional stakeholders to interview.[2] Over the course of our work, we interviewed officials from the following federal agencies: DOE Office of the Biomass Program, DOE Office of Vehicle Technologies Program, DOT Research and Innovative Technology Administration, DOT Pipeline and Hazardous Materials Safety Administration, DOT Federal Railroad Administration, DOT Federal Motor Carrier Safety Administration, DOT Maritime Administration, EPA Office of Research and Development, EPA Office of Solid Waste and Emergency Response, EPA Office of Transportation and Air Quality, USDA Agricultural Research Service, and USDA Economic Research Service. We also interviewed state officials from the Minnesota State Fire Marshal

[1]GAO-09-446.

[2]The information gathered from these interviews cannot be used to generalize findings or make inferences about the entire population of knowledgeable stakeholders on intermediate ethanol blends and related topics. Although the sample provides some variety, it is unlikely to capture the full variability of knowledgeable stakeholders, and it cannot provide comprehensive insight into the views of any one group of knowledgeable stakeholders. This is because, in a nonprobability sample, some elements of the population being interviewed have no chance, or an unknown chance, of being selected as part of the sample. However, the information gathered during these interviews allows us to discuss various stakeholder views on intermediate ethanol blends, and it provides important context overall. It also helps us interpret the documentation and other testimonial evidence we have collected.

Division and the Office of North Carolina State Fire Marshal. We interviewed industry representatives from the following organizations: the American Petroleum Institute, the Association of American Railroads, the Association of Oil Pipe Lines, Growth Energy, Independent Fuel Terminal Operators Association, Kinder Morgan, the National Petrochemical and Refiners Association, the National Tank Truck Carriers, American Trucking Associations, and the Renewable Fuels Association. We also made several attempts to speak with representatives from an industry association representing barge operators but were not able to schedule an interview during the time frame of our audit. Finally, we interviewed academic and research stakeholders from Carnegie Mellon University, the Energy Policy Research Foundation, the James A. Baker III Institute for Public Policy of Rice University, the Pipeline Research Council International, and TRC Energy Services. During these interviews, knowledgeable stakeholders identified a number of studies related to our work. Of these studies, we identified the following three studies as being directly relevant to our scope of analysis: (1) the National Commission on Energy Policy's Task Force on Biofuels Infrastructure, (2) EPA's Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis, and (3) DOE's Report to Congress: Dedicated Ethanol Pipeline Feasibility Study.[3] We examined these three studies and determined that they are sufficiently reliable for our purposes based on interviews with contributors to these studies, comparisons of estimates with other sources, and checking selected calculations.

To determine the challenges associated with selling intermediate ethanol blends at the retail level, we reviewed relevant presentations, analyses, reports, and other documents from various federal and state agencies, federal research laboratories, and industry associations, including the American Petroleum Institute and the National Association of Convenience Stores. We also selected a nonprobability sample of knowledgeable stakeholders to interview using the same "snowball sampling" technique described for our first objective. In particular, we asked these stakeholders, among other things, to discuss the challenges, if any, associated with selling intermediate ethanol blends at the retail level. We also asked these stakeholders to identify key studies and other knowledgeable stakeholders on this topic. Over the course of our work, we interviewed officials from the following federal laboratories and

[3]National Commission on Energy Policy, *Task Force on Biofuels Infrastructure*; EPA-420-R-10-006; and DOE, *Report to Congress: Dedicated Ethanol Pipeline Feasibility Study*.

agencies: DOE National Renewable Energy Laboratory (NREL), DOE Oak Ridge National Laboratory (ORNL), DOE Office of the Biomass Program, DOE Office of Vehicle Technologies Program, EPA Office of Research and Development, EPA Office of Transportation and Air Quality, EPA Office of Underground Storage Tanks, the Department of Labor's Occupational Safety and Health Administration, the National Institute of Standards and Technology, USDA Agricultural Research Service, and USDA Economic Research Service. We also interviewed state officials from the California Air Resources Board, the Minnesota State Fire Marshal Division, Northeast States for Coordinated Air Use Management,[4] and the Office of North Carolina State Fire Marshal. We interviewed representatives from the following industry associations: Growth Energy, the Renewable Fuels Association, the American Petroleum Institute, the National Association of Convenience Stores, the Society of Independent Gasoline Marketers of America, the National Association of Truck Stop Operators, the Petroleum Marketers Association of America, and the National Petrochemical and Refiners Association. Finally, we interviewed stakeholders from the following research and standards development organizations: ASTM International, Sierra Research, Inc., and Underwriters Laboratories (UL). We also conducted site visits to the research centers responsible for coordinating federal studies on the effects of intermediate ethanol blends on materials and components used in retail fuel storage and dispensing equipment. Specifically, we visited NREL facilities in Golden, Colorado; and ORNL facilities near Knoxville, Tennessee. During these site visits, we interviewed researchers conducting studies on the effects of intermediate ethanol blends on materials and components used in retail fuel-storage and -dispensing equipment. We asked these researchers to discuss available test results and the status of their testing efforts for these studies. We also toured some of the research facilities where testing was being conducted for these studies.

To examine research by federal agencies into the effects of intermediate ethanol blends on the nation's automobiles and nonroad engines, we reviewed relevant presentations, analyses, reports, and other documents from various federal and state agencies; NREL; ORNL; and industry associations, including the American Coalition for Ethanol, the National Marine Manufacturers Association, and the Outdoor Power Equipment

[4]Northeast States for Coordinated Air Use Management is an association of the state air quality agencies from Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

Institute. In addition, we reviewed relevant studies and reports from academic groups and private research organizations, including the Coordinating Research Council, Inc., Minnesota State University, Mankato; and the Rochester Institute of Technology. We also selected a nonprobability sample of knowledgeable stakeholders to interview using the same "snowball sampling" technique described for our first objective. In particular, we asked these stakeholders, among other things, to identify research by federal agencies and others into the effects of intermediate ethanol blends on the nation's automobiles and nonroad engines. Over the course of our work, we interviewed officials from the following federal agencies and laboratories: DOE Office of Vehicle Technologies Program, NREL, ORNL, EPA Office of Research and Development, and EPA Office of Transportation and Air Quality. We also interviewed state officials from the California Air Resources Board and Northeast States for Coordinated Air Use Management. We interviewed representatives from the following industry associations: the American Petroleum Institute, Growth Energy, the Renewable Fuels Association, the Alliance of Automobile Manufacturers, the Association of International Automobile Manufacturers, Inc.,[5] the Outdoor Power Equipment Institute, the Engine Manufacturers Association, the National Marine Manufacturers Association, and the International Snowmobile Manufacturers Association. Finally, we interviewed stakeholders from the following academic and research organizations: the Coordinating Research Council, Inc.; the Rochester Institute of Technology; and Minnesota State University, Mankato. We also conducted site visits to the research centers responsible for coordinating federal studies on the effects of intermediate ethanol blends on automobiles and nonroad engines. Specifically, we visited NREL facilities in Golden, Colorado; and ORNL facilities near Knoxville, Tennessee. We also visited a private research facility in Aurora, Colorado, where some of the automobile testing for federal studies has taken place. During these site visits, we interviewed researchers conducting studies on the effects of intermediate ethanol blends on automobiles and nonroad engines. We asked these researchers to discuss available test results and the status of their testing efforts for these studies. We also toured some of the research facilities where testing was being conducted for these studies. Due to ongoing litigation over EPA's decision to allow ethanol blends with 15 percent ethanol (E15) for use with certain automobiles, we did not evaluate any research by federal

[5]The Association of International Automobile Manufacturers, Inc. is now known as the Association of Global Automakers, Inc.

agencies and others into the effects of intermediate ethanol blends on automobiles and nonroad engines.

We conducted this performance audit from April 2010 to June 2011, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Studies by Nonfederal Organizations on the Effects of Intermediate Ethanol Blends in Automobiles

Nonfederal organizations are conducting research on the effects of intermediate ethanol blends in automobiles. For example, in addition to the research the Coordinating Research Council, Inc. (CRC) is conducting, in coordination with DOE and EPA, it has both ongoing and completed research projects on a range of related topics, including evaporative and exhaust emissions for various intermediate ethanol blends. A CRC representative told us that it expects to complete these projects by early 2012. Based on this research, CRC has published 10 reports as of March 2011 (see table 3).

Table 3: Published CRC Reports on Effects of Intermediate Ethanol Blends in Automobiles

Research topic	Reports
Catalyst durability	• *Mid-Level Ethanol Blends Catalyst Durability Study Screening*, June 2009.
Drivability performance	• *2006 CRC Hot-Fuel-Handling Program*, January 2007 • *2008 CRC Cold-Start and Warmup E85 and E15/E20 Driveability Program*, October 2008 • *2010 CRC Altitude Hot-Fuel-Handling Program*, January 2011
Evaporative emissions	• *Fuel Permeation from Automotive Systems*, September 2004. • *Fuel Permeation from Automotive Systems: E0, E6, E10, E20 and E85*, December 2006. • *Vehicle Evaporative Emission Mechanisms: A Pilot Study*, June 2008 • *Enhanced Evaporative Emission Vehicles*, March 2010
Exhaust emissions	• *Effects of Vapor Pressure, Oxygen Content, and Temperature on CO Exhaust Emissions*, May 2009.
Onboard diagnostic systems	• *Impact of E15/E20 Blends on OBDII Systems – Pilot Study*, March 2010.

Source: GAO analysis of CRC information.

Two academic organizations have also conducted research on intermediate ethanol blends in automobiles. Specifically, the Minnesota Center for Automotive Research at Minnesota State University, Mankato, has issued five studies looking at the effects of ethanol blends containing 20 percent ethanol (E20) on fuel system components.[1] These studies received funding from the Minnesota Department of Agriculture and

[1]Bruce Jones, et al., *The Effects of E20 on Elastomers Used in Automotive Fuel System Components*, (Mankato, Minn., Feb. 22, 2008); Bruce Jones, et al., *The Effects of E20 on Plastic Automotive Fuel System Components*, (Mankato, Minn., Feb. 21, 2008); Bruce Jones, et al., *The Effects of E20 on Metals Used in Automotive Fuel System Components*, (Mankato, Minn., Feb. 22, 2008); Nathan Hanson, et al., *The Effects of E20 on Automotive Fuel Pumps and Sending Units*, (Mankato, Minn., Feb. 21, 2008); and Gary Mead, et al., *An Examination of Fuel Pumps and Sending Units During a 4000 Hour Endurance Test in E20*, (Mankato, Minn., Mar. 25, 2009).

appear on the department's Web site.[2] In addition, the Center for Integrated Manufacturing Studies at Rochester Institute of Technology in New York has studied the effects of E20 on automobile exhaust, drivability, and maintenance, with funding from DOT. To date, the center has published one report and expects to publish at least two more later in 2011, along with a final summary report to DOT.[3]

[2]*E20 Test Results*, in the Minnesota Department of Agriculture database, http://www.mda.state.mn.us/en/renewable/ethanol/e20testresults.aspx (accessed Apr. 4, 2011).

[3]B. Hilton and B. Duddy, "The Effect of E20 Ethanol Fuel on Vehicle Emissions," *Proceedings of the Institute of Mechanical Engineers*, *Part D: Journal of Automobile Engineering*, vol. 223 no. 12 (2009).

Appendix III: Comments from the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAY 20 2011

OFFICE OF
SOLID WASTE AND
EMERGENCY RESPONSE

Mr. Frank Rusco
Director, Natural Resources and Environment
Government Accountability Office
Washington, DC 20548

Dear Mr. Rusco:

Thank you for the opportunity to comment on the draft report entitled "Biofuels: Challenges to the Transportation, Sale, and Use of Intermediate Ethanol Blends (GAO-11-513)." I am responding on behalf of the Office of Solid Waste and Emergency Response (OSWER) as well as the Office of Air and Radiation (OAR). Their comments have been incorporated into this consolidated Environmental Protection Agency (EPA or Agency) response. Below are our most significant comments on the report's one recommendation for EPA and on the information provided in the report itself. Other technical comments are included in the Enclosure.

Recommendation

To reduce uncertainty about the potential environmental impacts of storing intermediate ethanol blends at retail refueling locations, we recommend that the Administrator of EPA determine what additional research is necessary to better understand the compatibility of intermediate ethanol blends with UST systems, including the compatibility of specific UST components, and develop a plan to undertake such research.

EPA agrees with the importance of ensuring that the owners and operators of underground storage tank (UST) systems, when and if they choose to move to store higher blends of ethanol, are able to demonstrate that their UST systems are compatible with the stored fuel. Efforts are underway to evaluate the suitability of current UST systems to store new fuels. One project involves evaluating the functionality of current UST leak detection technologies when used with ethanol-blended fuels. We are also working with Department of Energy labs to understand the impacts of mid-level ethanol blends on materials used in tank systems. In addition, EPA is working to assess the impact of biofuel releases to the environment, and to adapt remediation tools to account for the differences in ethanol-blended fuels.

While EPA believes that a targeted approach to research will be important to accommodate the move to higher ethanol blends, we also acknowledge that there will always be uncertainty concerning the compatibility of legacy equipment with these fuel blends. Due to a multitude of factors, including age and prior use of equipment, number of UST system

components, variation of products available on the market over time, and the sheer multitude of possible configurations of UST systems, the ability to determine compatibility with the approximately 600,000 UST systems currently in use is limited.

After carefully weighing the need to fully understand the compatibility issues of the higher blends of ethanol against a realistic appraisal of the ability of research to address all the permutations of UST configurations, EPA has chosen a policy approach to provide certainty to the UST market. Those UST owners, who cannot demonstrate compatibility of their systems with the higher blends of ethanol, cannot store those fuels. We are in the final stages of developing guidance for UST owners on how to determine the compatibility of their tank systems if they wish to store higher blends of ethanol. We have had extensive conversations with UST stakeholders, including the equipment industry, states, and the regulated community in developing this guidance. This guidance will provide the certainty the industry needs to safely store higher ethanol blends, while meeting the federal requirement for compatibility and ensuring protection of human health and the environment.

Rather than developing a plan to undertake additional compatibility research, EPA will continue to work with other federal agencies, industry and other stakeholders to assist tank owners to safely transition to new fuels. We anticipate that additional, targeted research may be necessary to facilitate that transition. The Agency will consider how to best partner with these groups to advance that research.

General Comments

There is a great deal of interest in alternative fuels, prompted by federal law (i.e., the Renewable Fuel Standard), by the concern of the impact of the continued use of petroleum based fuels and by the rise in the price at the pump. It is, however, not mandatory for a tank owner to move to the intermediate blends of ethanol (such as E15). If a tank owner chooses to sell E15, and therefore store that blend in their UST system, they may need to upgrade certain components in order to ensure that their UST system is compatible. Tank owners who are unable to prove their UST systems are compatible also have the option to not store E15 – that is to continue to store E10. As E15 is only legal for use in a subset of motor vehicles, we believe there will be a continued demand for E10.

We believe most tank owners will be able to demonstrate compatibility for the major components of their UST systems, including tanks and piping, and will only need to upgrade smaller components such as the submersible pump, tank probes, seals, and gaskets. These components are typically accessible under sump covers. For that reason, the references to "excavation" in the draft report are not accurate. Further, most owners, who wish to upgrade their systems, will need to make less costly targeted upgrades to readily accessible components, at a cost substantially less than the cost of an entire tank system replacement.

In closing, we believe that providing owners and operators of UST systems clarity on the implementation of existing federal regulations with emerging biofuels, including higher blends of ethanol, is critical as we continue to transition to these fuels. It is clear that close collaboration with our federal and state partners and working with our stakeholders in industry

will lead to the most comprehensive and useful approach in assisting with the transition to biofuels.

If you have any questions or concerns regarding our comments or response to the recommendation, EPA would be happy to meet with you prior to GAO finalizing this report. Please feel free to contact me or Mark Barolo at 703-603-7141 if there is any additional follow up required.

Sincerely,

Lisa Feldt for

Mathy Stanislaus
Assistant Administrator

Enclosure

cc: Gina McCarthy, OAR
Karl Simon, OAR
Bob Trent, OCFO
Carolyn Hoskinson, OSWER
Mark Barolo, OSWER
Linda Gerber, OSWER
Johnsie Webster, OSWER

3

Appendix IV: Comments from the Occupational Safety and Health Administration

U.S. Department of Labor

Assistant Secretary for
Occupational Safety and Health
Washington, D.C. 20210

MAY 13 2011

Mr. Frank Rusco, Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Rusco:

Thank you for the opportunity to comment on the Government Accountability Office's (GAO) proposed report, *BIOFUELS: Challenges to the Transportation, Sale, and Use of Intermediate Ethanol Blends*. OSHA appreciates the time and effort that GAO took in its evaluation of the ethanol industry.

OSHA is addressing the worker safety-related uncertainties that are attached to the complex issues surrounding biofuels and will address GAO's recommendation in depth in its Statement of Executive Action. We anticipate that the many challenges associated with the use, sale and transportation of biofuels can be addressed by our agency working in conjunction with the Environmental Protection Agency, the Department of Transportation, the Department of Energy and all other relevant organizations. We appreciate the opportunity to review and respond to GAO's draft report.

Sincerely,

David Michaels, PhD, MPH

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

Frank Rusco, (202) 512-3841or ruscof@gao.gov

Staff Acknowledgments

In addition to the contact named above, Tim Minelli (Assistant Director), Nirmal Chaudhury, Cindy Gilbert, Chad M. Gorman, Jason Holliday, Michael Kendix, Ben Shouse, Barbara Timmerman, and Jack Wang made key contributions to this report.

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