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RENEWABLE FUEL STANDARD

Program Unlikely to Meet Production or Greenhouse Gas Reduction Targets

Statement of Frank Rusco, Director, Natural Resources and Environment

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GAO Highlights

Highlights of GAO-17-264T, a testimony before the Subcommittee on Regulatory Affairs and Federal Management, Committee on Homeland Security and Governmental Affairs, U.S. Senate

Why GAO Did This Study

Since 2006 the RFS has required that transportation fuels—typically gasoline and diesel—sold in the United States be blended with increasing volumes of biofuels to meet environmental and energy goals. Annual targets for the volumes of biofuels to be blended are set by statute. EPA is responsible for adjusting the statutory targets through 2022 to reflect expected U.S. industry production levels, among other factors, and for setting volume targets after 2022. Biofuels included in the RFS are either conventional (primarily corn-starch ethanol) or advanced biofuels (e.g., cellulosic ethanol and biomass-based diesel). Advanced biofuels emit fewer greenhouse gases than petroleum-based fuels and corn-starch ethanol.

In November 2016, GAO issued two reports on the RFS. This testimony is based on those two reports: GAO-17-94 and GAO-17-108. It provides information on whether the RFS is expected to meet its production and other targets, as well as expert views on any federal actions that could improve the RFS framework, among other things.

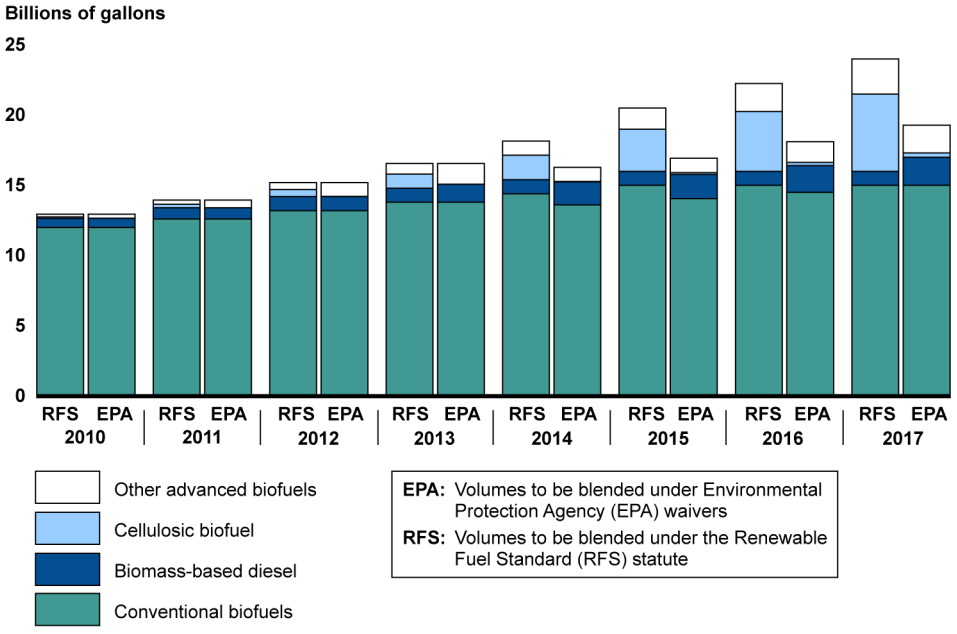
For the reports on which this testimony is based, GAO analyzed legal requirements and EPA data. In addition, GAO worked with the National Academy of Sciences to convene a meeting of experts from industry, academia, and research organizations in May 2016. GAO also contracted with the National Academy of Sciences for a list of experts on issues related to the RFS. Further information on how GAO conducted its work is contained in the reports.

View GAO-17-264T. For more information, contact Frank Rusco at (202) 512-3841 or ruscof@gao.gov

What GAO Found

It is unlikely that the goals of the Renewable Fuel Standard (RFS)—to reduce greenhouse gas emissions and expand the nation's renewable fuels sector while reducing reliance on imported oil—will be met as envisioned because there is limited production of advanced biofuels and limited potential for expanded production by 2022. Advanced biofuels, such as cellulosic ethanol and biomass-based diesel, achieve greater greenhouse gas reductions than conventional biofuels (primarily corn-starch ethanol), but the latter account for most of the biofuel blended into domestic transportation fuels under the RFS. As a result, the RFS is unlikely to achieve the targeted level of greenhouse gas emissions reductions. For example, the cellulosic biofuel blended into the transportation fuel supply in 2015 was less than 5 percent of the statutory target of 3 billion gallons. Partly as a result of low production of advanced biofuels, the Environmental Protection Agency (EPA), which administers the RFS in consultation with other agencies, has reduced the RFS targets for such fuels through waivers in each of the last 4 years (see figure). According to experts GAO interviewed, the shortfall of advanced biofuels is due to high production costs. The investments required to make these fuels more cost-competitive with petroleum-based fuels, even in the longer run, are unlikely in the current investment climate, according to experts.

Volumes of All Biofuels to Be Blended into Domestic Transportation Fuel, as Set by the Renewable Fuel Standard Statute and by EPA, 2010 through 2017



Source: GAO analysis of legal requirements and EPA data. | GAO-17-264T

Chairman Lankford, Ranking Member Heitkamp, and Members of the Subcommittee:

I am pleased to be here today to discuss our recent work on advanced biofuels and the Renewable Fuel Standard (RFS). As you know, since 2006, the RFS has required that transportation fuels—typically gasoline and diesel—sold in the United States contain annually increasing amounts of renewable fuels to achieve key environmental and energy goals.[1] For conventional renewable fuels, primarily ethanol derived from corn starch, the amount blended into transportation fuels has nearly reached the maximum called for under the RFS. To count toward this target amount, conventional renewable fuels are generally required to reduce greenhouse gas emissions by 20 percent compared with petroleum-based fuels.[2] Additional increases in the use of renewable fuels are to come from advanced biofuels, a category that the RFS requires to reduce life-cycle greenhouse gas emissions by at least 50 percent compared with petroleum-based fuels. However, production of advanced biofuels, such as cellulosic biofuels, has not kept pace with targets in the RFS.

In this context, my testimony today discusses the findings from our two November 2016 reports on the RFS. Accordingly, it provides information on (1) how the federal government has supported advanced biofuels research and development (R&D) in fiscal years 2013 through 2015 and where its efforts have been targeted, (2) expert views on the extent to which advanced biofuels are technologically understood and the factors that will affect the speed and volume of production,[3] (3) whether the RFS is expected to meet its goals, (4) expert views on any federal actions that

[1]The Environmental Protection Agency, which is responsible for implementing the RFS, defines the goals of the RFS as to (1) reduce greenhouse gas emissions and (2) expand the nation's renewable fuel (or biofuel) sector while reducing reliance on imported oil.

[2]Corn-starch ethanol plants that were in operation or under construction before December 19, 2007, are not subject to the requirement to reduce greenhouse gas emissions by at least 20 percent.

[3]GAO, *Renewable Fuel Standard: Low Expected Production Volumes Make It Unlikely That Advanced Biofuels Can Meet Increasing Targets*, GAO-17-108 (Washington, D.C.: Nov. 28, 2016).

could improve the RFS, and (5) policy alternatives experts suggested to better meet the goals of the RFS in the future.[4]

To conduct this work, we worked with the National Academy of Sciences to convene a meeting of experts from industry, academia, and research organizations in May 2016. We also contracted with the National Academy of Sciences for a list of experts on issues related to the RFS. We analyzed the content of the experts' responses to our questions, coding their responses into categories pertinent to our objectives. In addition, we reviewed the public comments from stakeholders, relevant legislation, and agency documents pertaining to annual volume requirements. We also interviewed officials from the Departments of Agriculture (USDA), Defense (DOD), and Energy (DOE); the Environmental Protection Agency (EPA); and the National Science Foundation (NSF). Our November 2016 reports include detailed explanations of the methods used to conduct our work. We conducted the work on which this testimony is based 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

Congress established the RFS as part of the Energy Policy Act of 2005, in response to concerns about the nation's dependence on imported oil. The RFS initially required that a minimum of 4 billion gallons of renewable fuels be blended into transportation fuels in 2006, ramping up to 7.5 billion gallons by 2012. Two years later, the Energy Independence and Security Act of 2007 (EISA) increased and expanded the statutory target volumes for renewable fuels and extended the ramp-up period through 2022. More specifically, the act established overall target volumes for renewable fuels that increase from 9 billion gallons in 2008 to 36 billion

[4]GAO, *Renewable Fuel Standard: Program Unlikely to Meet Its Targets for Reducing Greenhouse Gas Emissions,* GAO-17-94 (Washington, D.C.: Nov. 28, 2016).

gallons in 2022. The EISA volumes can be thought of in terms of two broad categories: conventional and advanced biofuels:[5]

Conventional biofuel: Biofuels from new facilities must achieve at least a 20-percent reduction in greenhouse gas emissions, relative to 2005 baseline petroleum-based fuels. The dominant biofuel produced to date is conventional corn-starch ethanol, although recently some conventional biodiesel has entered the fuel supply.

Advanced biofuel: Biofuels, other than ethanol derived from corn starch must achieve at least a 50-percent reduction in life-cycle greenhouse gas emissions, as compared with 2005 baseline petroleum-based fuels. Advanced biofuel is a catch-all category that may include a number of fuels, including those made from any qualified renewable feedstock that achieves at least a 50-percent reduction in lifecycle greenhouse gas emissions, such as ethanol derived from cellulose, sugar, or waste material. This category also includes the following.

- **Biomass-based diesel:** Advanced biomass-based diesel must have life-cycle greenhouse gas emissions at least 50 percent lower than traditional petroleum-based diesel fuels.
- **Cellulosic biofuel:** Advanced biofuel derived from any cellulose, hemicellulose, or lignin that is derived from renewable biomass must have life-cycle greenhouse gas emissions at least 60 percent lower than traditional petroleum-based fuels.[6] This category of fuel may include cellulosic ethanol, renewable gasoline, cellulosic diesel, and renewable natural gas from landfills that can be used to generate electricity for electric vehicles or used in vehicles designed to run on liquefied or compressed natural gas.

[5]The statutory categories are renewable fuel, advanced biofuel, cellulosic biofuel, and biomass-based diesel. Conventional biofuels are defined as renewable fuels that are ethanol derived from corn starch. A fuel may qualify for one or more categories for purposes of meeting the volume requirements. For example, cellulosic biofuel may be used to meet the cellulosic biofuel volume requirement, the advanced biofuel requirement, and the renewable fuel requirement. However, conventional biofuels such as corn-based ethanol count toward meeting only the renewable fuel volume requirement.

[6]Plant biomass is made up primarily of cellulose, hemicellulose, and lignin. Cellulose and hemicellulose are made up of potentially fermentable sugars. Lignin provides the structural integrity of plants by enclosing the tightly linked cellulose and hemicellulose molecules, which makes these molecules harder to reach.

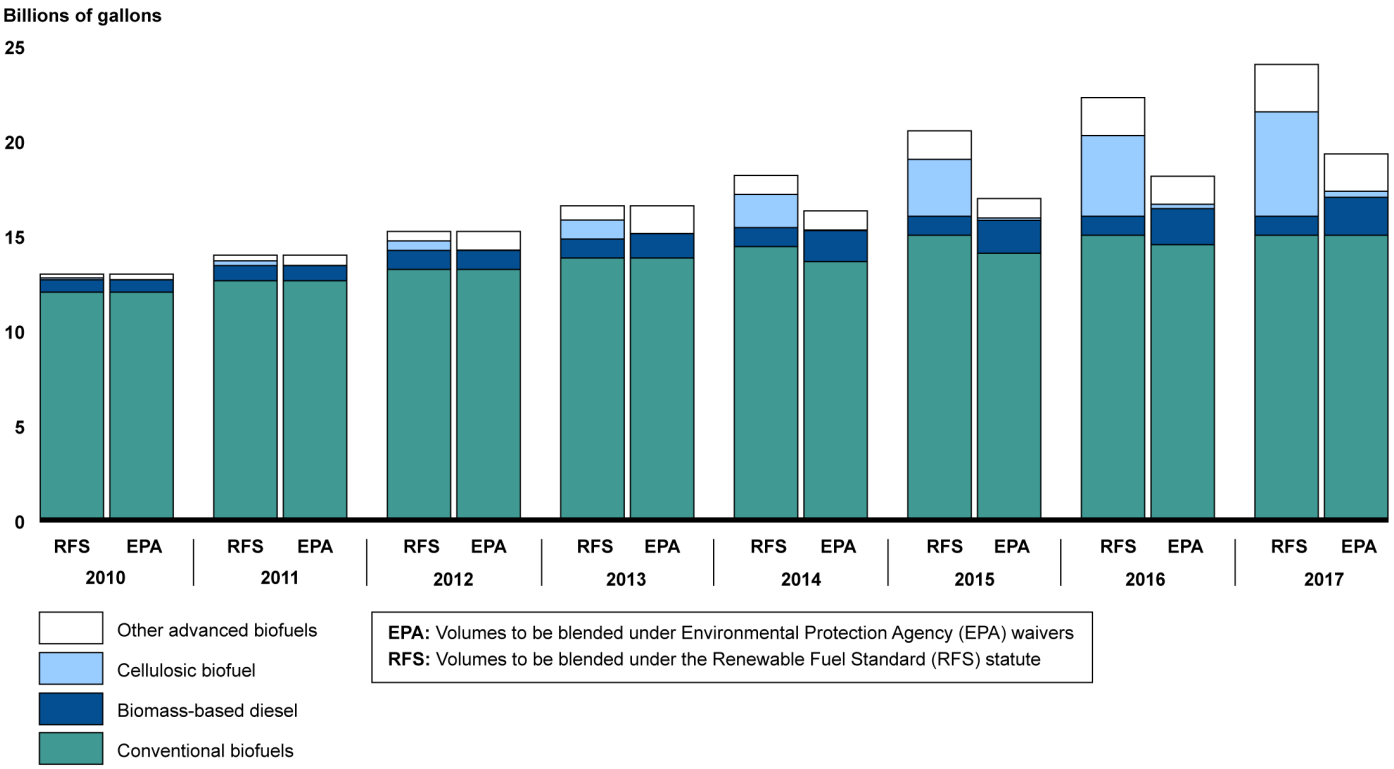
EPA administers the RFS in consultation with DOE and USDA. EPA's responsibilities for implementing the RFS include setting annual volume requirements. Each year, by November 30, EPA is required to establish via rulemaking the volumes of biofuel that must be blended into transportation fuels during the following calendar year (volume requirement).[7] The statute provides EPA with waiver authority to set volumes below the targets specified in the statute under certain circumstances, such as when there is inadequate domestic supply.[8] The structure of the volume targets emphasized conventional biofuels in the early years covered by the statute, while providing lead time for the development and commercialization of advanced, and especially cellulosic, biofuels. However, these fuels have not been produced in sufficient quantities to meet statutory targets through 2016. As a result, since 2010, EPA has used its waiver authority to deviate from the statutory target volumes and has reduced the volume requirement for cellulosic biofuel every year, citing inadequate domestic supply, among other things (see fig.1).[9]

[7]42 U.S.C. § 7545(o)(3)(B).

[8]42 U.S.C. § 7545(o)(7).

[9]The law provides that for any calendar year for which the projected volume of cellulosic biofuel production is less than the statutory volume, the Administrator of EPA must reduce the applicable volume of cellulosic biofuel to the projected volume available during that calendar year. 42 U.S.C. § 7545(o)(7)(D)(i).

Figure 1: Volumes of All Biofuels to Be Blended into Domestic Transportation Fuel, As Set by the Renewable Fuel Standard Statute and by EPA, 2010 through 2017



Source: GAO analysis of legal requirements and EPA data. | GAO-17-264T

Note: Although the figure lists "conventional biofuels" as a separate category, the statute includes conventional biofuels as part of the broader category of "renewable fuel"; thus, other categories of fuels could be used to meet the requirement for this category.

Further, in December 2015—when EPA finalized the volume requirements for 2014, 2015, and 2016—the agency reduced the total renewable fuel requirement for those years.[10] Effectively, this meant that EPA reduced the amount of conventional biofuels required under the program relative to statutory targets for those years. In this case, EPA cited constraints in the fuel market's ability to accommodate increasing volumes of ethanol. EPA's use of this waiver authority has been controversial among some RFS stakeholders, and EPA's 2015

[10]In December 2015, when EPA finalized its volume requirement for 2016, it retroactively established volumes for 2014 and 2015. *Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017; Final Rule*, 80 Fed. Reg. 77420 (2015).

requirement currently faces legal challenges from multiple parties. However, in the volume requirement it finalized in November 2016, EPA effectively set the amount of conventional biofuels required under the program at 15 billion gallons, equal to the statutory target for 2017 (see fig.1).[11]

Supported through Direct Research or Grants, Federal R&D Related to Advanced Biofuels Is Shifting toward Drop-In Fuels

In our November 2016 report, we found that the federal government has supported R&D related to advanced biofuels through direct research or grants, and the target of this R&D is shifting away from cellulosic ethanol and toward drop-in biofuels.[12] Unlike corn-starch-based or cellulosic ethanol, drop-in fuels, such as renewable gasoline, are fully compatible with existing infrastructure, such as vehicle engines and distribution pipelines. In fiscal years 2013 through 2015, the federal government obligated more than $1.1 billion for advanced biofuels R&D. Of this amount, DOE obligated over $890 million. For example, DOE's Office of Science funds three bioenergy research centers affiliated with universities and national laboratories that conduct basic research for all stages of biofuel production. In addition, USDA obligated over $168 million in fiscal years 2013 through 2015 to support advanced biofuels. For example, USDA scientists developed a novel process to increase production of butanol, a drop-in fuel that lowered production costs by over 20 percent. The remaining federal obligations during these years were through EPA, DOD, and NSF, which obligated less for such R&D. According to agency officials, agencies are shifting their focus to drop-in fuels in part because these fuels are compatible with existing infrastructure. Officials from one federal funding agency said this compatibility makes drop-in fuels more desirable than cellulosic ethanol.

[11]Renewable Fuel Standard Program: Standards for 2017 and Biomass-Based Diesel Volume for 2018; Proposed Rule, 81 Fed. Reg. 34778 (2016). The EPA Administrator signed the final rule on November 23, 2016.

[12]GAO-17-108

Experts Agreed Several Advanced Biofuels Are Technologically Well Understood but Cited Factors That Make It Challenging to Significantly Increase Production

As we reported in November 2016, experts told us that the technology to produce several advanced biofuels is well understood but noted that among those currently being produced there is limited potential for increased production in the near term.[13] Experts further cited multiple factors making it challenging to significantly increase the speed and volume of production. In addition, current advanced biofuel production is far below overall RFS target volumes, and those volumes are increasing every year. Consequently, it does not appear possible to meet statutory target volumes for advanced biofuels in the RFS under current market and regulatory conditions.

Biofuels that the experts identified as being technologically well understood include biodiesel, renewable diesel, renewable natural gas, cellulosic ethanol, and some drop-in fuels. A few of these fuels are being produced in significant volumes, but the overall volume being produced falls short of the volume target in the RFS. For example, in 2015, about 3.1 billion ethanol equivalent gallons of advanced biofuels were produced, falling short of the statutory target of 5.5 billion gallons for that year. By 2022, the advanced biofuels target increases to 21 billion gallons, so production would have to rapidly increase to meet this target. Even though a few of these fuels, such as biodiesel and renewable diesel, are being produced in significant volumes, it is unlikely that production of these fuels can expand much in the next few years because of feedstock limitations. Current production of cellulosic biofuels is far below the statutory volume targets and, according to the experts, there is limited potential for expanded production to meet future higher targets, in part because production costs are currently too high. Experts told us that technologies to produce other fuels, such as some drop-in fuels, are well understood, but that those fuels are not being produced because production is too costly.

Experts identified a number of factors that will affect the speed and volume of advanced biofuel production, including the following.

- **The low price of fossil fuels relative to that of advanced biofuels.** This disparity in price is a disincentive for consumers to adopt greater use of biofuels and also a deterrent for private investors entering the advanced biofuels market.

[13] GAO-17-108

- **Uncertainty about government policy, including whether the RFS and federal tax credits that support advanced biofuels will continue to be in effect.** While such policies should encourage investment, investors do not see them as reliable and thus discount their potential benefits when considering whether to invest.
- **High cost of converting cellulosic feedstocks.** These costs include transporting and handling feedstocks, processing them into a fuel, and disposing of wastes, among other things.
- **Time and cost to bring a new technology to commercial-scale production.** The timeline to bring a new technology from laboratory scale to commercial scale is 12 years if everything works well, and it can be considerably longer.
- **Time and cost to secure fuel certification and acceptance.** Before a fuel is brought to market, it must go through regulatory registration, certification by ASTM International, and other testing.[14]
- **Underdeveloped feedstock supply chain.** Lack of logistics for the entire feedstock supply chain—from securing a contract to delivering and storing a feedstock—is an economic barrier to the production of advanced biofuels.

The RFS Is Expected to Fall Short of Its Goals Because of Limited Production of Advanced Biofuels and Reliance on Conventional Corn-Starch Ethanol

As we found in our November 2016 report, it is unlikely that the goals of the RFS—reduce greenhouse gas emissions and expand the nation's renewable fuels sector—will be met as envisioned because there is limited production of advanced biofuels and limited potential for expanded production by 2022.[15] Advanced biofuels achieve greater greenhouse gas reductions than conventional biofuels, although the latter account for most of the biofuel blended into domestic transportation fuels under the RFS. As a result, the RFS is unlikely to achieve greenhouse gas emissions reductions as envisioned. For example, the cellulosic biofuel blended into the domestic transportation fuel supply in 2015 was less than 5 percent of the statutory target of 3 billion gallons. Partly as a result of low production of advanced biofuels, EPA has reduced the RFS targets for such fuels through waivers in each of the last 4 years. According to experts we interviewed, the shortfall of advanced biofuels is the result of high

[14]Regulatory registration takes place with EPA's Office of Transportation and Air Quality, which requires submission of information about a fuel's potential impact on public health and other information. ASTM International is an international organization that defines and sets standards for various industries and specifications for products, including biofuels.

[15]GAO-17-94.

production costs, and the investments in further R&D required to make these fuels more cost-competitive with petroleum-based fuels, even in the longer run, are unlikely in the current investment climate.

Given the relative scarcity of advanced biofuels, most of the biofuel blended under the RFS to date has been conventional corn-starch ethanol, which achieves smaller greenhouse gas emission reductions than advanced biofuels. The use of corn-starch ethanol has been effectively capped at 15 billion gallons. As a result, expanded use of biofuels will require increasing use of advanced biofuels, and experts told us the most likely advanced biofuel to be commercially produced in the near- to mid-term will be cellulosic ethanol. However, the ability to add ethanol to the transportation fuel market to meet expanding RFS requirements is limited by the incompatibility of ethanol blends above E10 (up to 10 percent ethanol) with the existing vehicle fleet and fueling infrastructure.[16] Many experts and stakeholders refer to this infrastructure limitation as the "blend wall." If ethanol continues to be the primary biofuel produced to meet the RFS, these infrastructure limitations will have to be addressed.

Several experts raised concerns about the extent to which the RFS is achieving its goal for reducing greenhouse gas emissions, given that most biofuel blended under the RFS is corn-starch ethanol. More specifically, some experts were critical of the life-cycle analysis EPA used to determine the greenhouse gas emissions reductions for corn-starch ethanol. Further, corn-starch ethanol plants that were in operation or under construction before December 19, 2007, are not subject to the requirement to reduce greenhouse gas emissions by at least 20 percent. According to an August 2016 EPA Inspector General report, grandfathered production that is not subject to any greenhouse gas reduction requirements was estimated to be at least 15 billion gallons, or over 80 percent of today's RFS blending volume.[17] Moreover, some experts told us that the RFS creates a perverse incentive to import Brazilian sugarcane ethanol. Specifically, because sugarcane ethanol qualifies as an advanced biofuel, it is more profitable to import this fuel than to domestically produce advanced biofuels. According to these

[16]Fuel retailers sell specific blends of gasoline and ethanol: E10 (up to 10 percent ethanol); E85 (51 to 85 percent ethanol); and, less typically, E15 (15 percent ethanol).

[17]Environmental Protection Agency, Office of Inspector General, *EPA Has Not Met Certain Statutory Requirements to Identify Environmental Impacts of Renewable Fuel Standard*, 16-P-0275 (Washington, D.C.: Aug. 18, 2016).

experts, the import of sugarcane ethanol, which occurs to meet RFS requirements, causes significant greenhouse gas emissions as a result of fuel burned during shipping.

Experts Suggested Multiple Federal Actions That Could Improve the RFS Framework by Incrementally Encouraging Investment in Advanced Biofuels

As we reported in November 2016, while advanced biofuels are not likely to be produced in sufficient quantities to meet the statutory targets, experts identified actions that they suggested could improve the existing RFS framework by incrementally increasing investment in advanced biofuels, which may lead to greater volumes of these fuels being produced and used in the longer term.[18] For example, some experts stated that the Second Generation Biofuel Producer Tax Credit—an incentive to accelerate commercialization of fuels in the advanced and cellulosic biofuels categories—has expired and been reinstated (sometimes retroactively) about every 2 years, contributing to uncertainty among cellulosic fuel producers and investors. One expert told us that investment in cellulosic biofuels could be encouraged, in part, by maintaining the Second Generation Biofuel Producer Tax Credit consistently, rather than allowing it to periodically lapse and be reinstated.

In addition, experts identified actions to increase compatibility of infrastructure with higher ethanol blends. For example, several experts suggested that expanding grants to encourage infrastructure improvements, such as USDA's Biofuel Infrastructure Partnership, could increase both the availability and competitiveness of higher blends at retail stations nationwide. Through this partnership, USDA is investing $100 million to install nearly 5,000 pumps offering high-ethanol blends in 21 states. However, some experts also said that blender pumps are not being installed with the density required to test demand. One expert suggested that, instead of installing blender pumps at all the transportation fuel stations of a certain brand in a region, blender pumps should be installed at all the stations at a specific road intersection. That way, these stations would be forced to compete with each other, which this expert told us would result in more competitive prices at the pump and increased incentives to improve fueling infrastructure.

[18] GAO-17-94.

Experts Suggested Policy Alternatives That Could More Efficiently Reduce Greenhouse Gas Emissions

As we reported in November 2016, several experts stated that the RFS is not the most efficient way to achieve the environmental goal of reducing greenhouse gas emissions, and they suggested policy alternatives—in particular, a carbon tax and a low carbon fuel standard (LCFS).[19] Several experts suggested that these alternatives would be more efficient at reducing greenhouse gas emissions. Specifically, some experts said that, whereas the RFS creates disincentives for the production of cellulosic fuels that achieve the greatest reductions in greenhouse gas emissions, a carbon tax or LCFS would incentivize the technologies that achieve the greatest such reductions at the lowest cost. Under a carbon tax, each fossil fuel would be taxed in proportion to the amount of greenhouse gas (carbon dioxide) released in its combustion. In addition, one expert stated that a carbon tax is preferable to the RFS because it allows market effects to increase the price of emission-causing activities, which decreases demand for those activities. As a result, a carbon tax could sustain consumers' interest in fuel-saving vehicles and result in a wide range of fuel-saving responses from all consumers (rather than just those purchasing a new vehicle). However, some experts also noted that a carbon tax would force further electrification of the light-duty vehicle fleet because the electric power sector is the cheapest sector from which to obtain greenhouse gas reductions. According to one expert, this electrification of the light-duty fleet might further limit biofuels R&D, in effect undermining the RFS goal to expand that sector.

In light of these concerns, several experts said that an LCFS would be more flexible and efficient than the RFS or a carbon tax at developing biofuels that achieve the greatest greenhouse gas reductions.[20] Specifically, an LCFS accounts for carbon in a given fuel on a cost per unit of carbon intensity, thereby supporting incremental carbon reductions. An LCFS can be implemented in one of two ways. The first involves switching to direct fuel substitutes (e.g., drop-in fuels) or blending biofuels with lower greenhouse gas emissions directly into gasoline and diesel fuel. The second involves switching from petroleum-based fuels to other alternatives, such as natural gas, hydrogen, or electricity, because an LCFS would allow a wider array of fuel pathways than the RFS. Under

[19]GAO-17-94

[20]For example, the California Low Carbon Fuel Standard requires a 10-percent reduction in the carbon intensity of fuels in the State of California by 2020. It requires fuel suppliers to reduce the expected lifecycle greenhouse gas emissions from motor fuels on the basis of the fuels' energy content. In this way, the greenhouse gas intensity of transportation fuels decreases, regardless of the growth in transportation or fuel demand.

the first scenario, an LCFS would promote biofuel usage, rather than incentivizing electrification of the light-duty vehicle fleet. As a result, according to some experts, an LCFS is preferable to a carbon tax because it more efficiently reduces greenhouse gas emissions and promotes the expansion of the biofuel sector. However, other experts we spoke with critiqued an LCFS as being uneconomical. Specifically, one expert stated that, while an LCFS such as the one in California could force technology and create greenhouse gas reductions in the fuel market, the costs of implementing an LCFS are much higher than its benefits.

Chairman Lankford, Ranking Member Heitkamp, and Members of the Subcommittee, this concludes my prepared statement. I would be pleased to answer any questions that you may have at this time.

GAO Contact and Staff Acknowledgments

If you or your staff members have any questions concerning this testimony, please contact Frank Rusco, Director, Natural Resources and Environment, 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 statement. Other individuals who made key contributions to this testimony include Karla Springer, Assistant Director; Jesse Lamarre-Vincent; Marietta Revesz; and Jarrod West.