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The Renewable Fuel Standard (RFS): Cellulosic Biofuels

(name redacted)
Specialist in Agricultural Conservation and Natural Resources Policy

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Summary

The Renewable Fuel Standard (RFS) was established under the Energy Policy Act of 2005 (EPAct05, P.L. 109-58), and was later expanded under the Energy Independence and Security Act of 2007 (EISA; P.L. 110-140), in accordance with efforts at that time to reduce dependence on foreign oil, promote biofuel use, and stabilize transportation fuel prices, among other goals. Over 15 years, the RFS requires that increasing amounts of biofuels—36 billion gallons by 2022—be used in transportation fuel. The mandate is to be accomplished in part with advanced biofuels, including cellulosic biofuels—fuels produced from cellulosic materials, including grasses, trees, and agricultural and municipal wastes—which would increase over time to comprise some 44% of the RFS in 2022.

The U.S. Environmental Protection Agency (EPA) is required to set the annual standard (i.e., usage requirement) for cellulosic biofuels under the RFS if the projected volume of cellulosic biofuel production is less than the volume specified in the statute (i.e., the mandate). Under this circumstance, EPA can lower the annual cellulosic biofuels standard to the volume expected to be available for that year. If EPA lowers the standard for a given year, it is required to do so by November 30 of the preceding year, and it must issue cellulosic biofuel waiver credits that obligated parties may purchase for that compliance year in lieu of actual fuel requirements. EPA concluded that the nation lacked sufficient production capacity to meet the RFS cellulosic biofuels mandate each year from 2010 to 2016. In 2010, EPA reduced the mandate from the statutory volume of 100 million gallons to 6.5 million (ethanol-equivalent) gallons, in 2011 from 250 million gallons to 6.0 million gallons, in 2012 from 500 million gallons to 10.45 million gallons, and in 2013 from 1 billion gallons to 810,185 gallons. In May 2015, EPA announced its proposal to lower the 2014 mandate from 1.75 billion gallons to 33 million gallons, the 2015 standard from 3 billion gallons to 106 million gallons, and the 2016 standard from 4.25 billion gallons to 206 million gallons and to rescind the 2011 cellulosic biofuel standard. EPA intends to finalize the RFS volume requirements for 2014, 2015, and 2016 by November 30, 2015. This delay in issuing the annual standards—EPA is currently one year and eight months past the statutory deadline for 2014 and eight months past the deadline for 2015—raises significant uncertainty for biofuel producers, feedstock growers, and refiners.

The 2010-2012 reduced cellulosic biofuel mandates were not met by actual cellulosic biofuel production, which EPA reports was limited. Instead, these mandates were largely met with waiver credits. Official compliance data for 2013 and 2014 is unavailable at this time as the compliance deadline for these years has not been finalized.

Actual cellulosic biofuel production has fallen significantly short of the RFS mandates. However, in 2014, the industry opened three commercial-scale cellulosic ethanol plants in Iowa and Kansas with a combined production capacity of up to 52 million gallons per year. In addition, a large portion of cellulosic biofuel production for 2014 and 2015 is being met with two newly approved cellulosic biofuel pathways—renewable compressed natural gas and renewable liquefied natural gas. There was also the November 2014 bankruptcy filing by the company KiOR, which had commenced operations of the first commercial-scale cellulosic fuel facility in 2012 in Mississippi. While these milestones are significant for a nascent cellulosic biofuel industry, given the many challenges the industry has faced on multiple fronts, and given past performance, it may be likely that the cellulosic biofuel volumes set in statute will not be met in the near term.

Evaluating the viability of the cellulosic biofuel component of the RFS is difficult. Many factors have impacted and may continue to impact what can be accomplished. Factors to consider include the uncertainty stemming from EPA's implementation of the RFS, Congress's action on biofuel

programs and tax incentives, industry's difficulty in producing cellulosic biofuel, and the unknown impact of current oil and gasoline prices.

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Introduction

The Renewable Fuel Standard (RFS), created by the Energy Policy Act of 2005 (EPAct05, P.L. 109-58) and expanded under the Energy Independence and Security Act of 2007 (EISA, P.L. 110-140), mandates that domestic transportation fuel contain specified volumes of biofuels—including conventional biofuels (e.g., cornstarch ethanol) and advanced biofuels (e.g., cellulosic biofuel, biomass-based diesel). Given the economic and policy environments at the time the RFS was enacted, there was discussion that the RFS could help to reduce dependence on foreign oil, promote biofuel use, and stabilize transportation fuel prices, among other goals.[1] The revised RFS under EISA requires that increasing amounts of biofuels be included in transportation fuel, with volume requirements identified in statute over a 15-year period. These requirements start with 9 billion gallons of total renewable fuel in 2008 and build up to 36 billion gallons annually by 2022.[2] The mandate is to be accomplished in large part with increasing volumes of cellulosic biofuels, with 16 billion gallons required by 2022. Thus far, the yearly cellulosic biofuels volume requirements identified in the statute have not been met.

The RFS contains annual volume standards (i.e., usage requirements) for each of its biofuel categories, including for cellulosic biofuels. Recognizing that the cellulosic biofuel industry was in its infancy at the time of the RFS's passage, Congress gave the U.S. Environmental Protection Agency (EPA) waiver authority to adjust the annual cellulosic biofuel standard under certain conditions. For instance, if the projected volume of cellulosic biofuel production is less than the volume specified in the statute (i.e., the mandate) for a given year, EPA is required to lower the cellulosic biofuel standard by November 30 of the preceding year and to issue cellulosic biofuel waiver credits to be used in lieu of actual cellulosic fuel for obligated parties to purchase for that compliance year. Due to a lack of U.S. cellulosic biofuel production capacity, the EPA, in successive years from 2010 to 2013, issued final rules under its waiver authority that lowered the cellulosic biofuel standard.[3] EPA also proposes to lower the 2014, 2015, and 2016 cellulosic biofuel standards.[4]

In the years since the inception of the cellulosic biofuels mandate for the RFS, there have continued to be questions about whether cellulosic biofuels can be produced in sufficient quantities to satisfy the RFS mandate in the near term and in future years. Progress toward meeting the cellulosic biofuels mandate has been delayed due to several issues; specifically, feedstock supply, financial viability and financing, and technology advancement are considered among the most significant limiting factors for cellulosic biofuel production. Given that the EPA has lowered the RFS cellulosic biofuel standard for four consecutive years and proposes to do so again for 2014, 2015, and 2016, and for various other reasons, some contend that Congress

[1] For more information on the expanded RFS, see CRS Report R43325, *The Renewable Fuel Standard (RFS): In Brief*, by (name redacted)

[2] Volume requirements for years following 2022 are to be determined by the U.S. Environmental Protection Agency (EPA) in future rulemaking.

[3] Additional information about the volume adjustments, including the federal court order to vacate the 2012 requirement and an EPA proposal to rescind the 2011 requirement, is provided in the cellulosic biofuel compliance section of this report. EPA, "Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule," 75 *Federal Register*, March 26, 2010; EPA, "Regulation of Fuels and Fuel Additives: 2011 Renewable Fuel Standards; Final Rule," *Federal Register*, December 9, 2010; EPA, "Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards; Final Rule," *Federal Register*, January 9, 2012; EPA, "Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Cellulosic Biofuel Standards; Direct Final Rule," 79 *Federal Register*, May 2, 2014.

[4] EPA, "Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017; Proposed Rule," 80 *Federal Register* 33099, June 10, 2015.

should repeal the RFS. Others want to reconsider its configuration, determine whether additional resources are necessary for cellulosic biofuel production, and/or assess the success of this effort compared to other renewable energy efforts. Still others assert that the current structure provides adequate incentives and measures to address any cellulosic biofuel production shortfalls.

The EISA RFS Cellulosic Biofuel Standard

The expanded RFS established in Section 202 of EISA requires that a certain volume of cellulosic biofuels be included in the national transportation fuel supply.[5] The required volume increases incrementally each year. The RFS calls for 100 million gallons of cellulosic biofuels in 2010, 3 billion gallons in 2015, 10.5 billion gallons in 2020, and 16 billion gallons by 2022 (see **Table 1**). Cellulosic biofuels would comprise some 44% of the mandate if 16 billion gallons of cellulosic biofuels were actually produced in 2022.

Cellulosic Biofuel Requirement Differences Between the RFS1 and the RFS2

Cellulosic biofuel requirements under the expanded RFS established by EISA, sometimes referred to as RFS2, are more substantial than the requirements under the original RFS (or RFS1) established by §1501 of EPAct05. There are three points in particular where differences exist between the expanded RFS and the original RFS: cellulosic biofuel type, cellulosic biofuel volume, and the production time frame. First, the original RFS had a narrower definition of what constituted a cellulosic biofuel, limiting the mandate to only cellulosic biomass ethanol. The original RFS did have a broader definition as to what counted as cellulosic material. The expanded RFS has a broader definition for cellulosic biofuels, accepting a variety of biofuel types from cellulosic material. Second, under the expanded RFS, the cellulosic biofuel volumes required are much larger. Third, the time frame to produce the biofuels is expedited under EISA. The original RFS was much smaller in scope, requiring 4.0 billion gallons of total renewable fuel for 2006, ascending to 7.5 billion gallons by 2012. Further, the original RFS would have required that 250 million gallons of the renewable fuel be derived from cellulosic biomass starting in 2013, whereas the expanded RFS required 250 million gallons of cellulosic biofuel in 2011.

Limited analyses exist that provide information on how the EISA RFS annual cellulosic biofuel volume requirements were determined.[6] Data and analysis presented during the RFS debate and ultimate passage of EISA in 2007 supported the idea that the required levels of cellulosic biofuel production capacity could be achieved. Some argued that plentiful feedstock would be available[7] and that the conversion technology was close to being proven as commercially viable. Moreover, some presumed that the federal government would provide substantial financial support and enhance the infrastructure needed to spur a commercial cellulosic biofuels market.[8] Others were

[5] The EISA statute defines 'cellulosic biofuel' as renewable fuel derived from any cellulose, hemi-cellulose, or lignin that is derived from renewable biomass and that has lifecycle greenhouse gas emissions, as determined by the EPA administrator, that are at least 60% less than the baseline lifecycle greenhouse gas emissions of conventional fuel. More information is provided in the cellulosic biofuels section of this report.

[6] One case study suggests that the expanded RFS volume requirements, overall and for individual biofuel categories, had "no reference within the energy policy subsystem." For more information, see H. L. Breetz, "Fueled by Crisis: U.S. Alternative Fuel Policy, 1975-2007" (Doctoral dissertation, Dartmouth College, 2012).

[7] U.S. Dept. of Energy, U.S. Dept. of Agriculture, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, April 2005, http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf.

[8] Diane Greer, "Creating Cellulosic Ethanol: Spinning Straw into Fuel," *BioCycle*, April 2005; Biotechnology Industry Organization, *Achieving Sustainable Production of Agricultural Biomass for Biorefinery Feedstock*, Washington, DC, 2006, http://www.bio.org/ind/biofuel/SustainableBiomassReport.pdf; and Biotechnology Industry Organization, "Energy Bill Biofuels Mandates Will Be Achievable with Biotechnology Advances," press release, November 18, 2007, http://bio.org/news/pressreleases/newsitem.asp?id=2007_1218_01&p=yes.

leery about the time frame provided to meet the RFS cellulosic biofuels mandate, given the as-yet-undeveloped production capacity.[9]

Waiver Authority

Congress gave the EPA administrator waiver authority to adjust the renewable fuel volume amounts identified in statute under certain circumstances.[10] More specifically, Congress provided EPA with three waivers it may use to adjust the volume requirements—a general waiver, a cellulosic biofuel waiver, and a biomass-based diesel waiver. The cellulosic biofuel waiver may be used by the administrator to reduce the cellulosic biofuel mandate when the projected volume amount for a given year is less than what is identified in statute.[11] Should EPA decide to lower the cellulosic biofuel mandate in a given year, it is required to set the volume by November 30 of the preceding year and must issue waiver credits for obligated parties to purchase for that compliance year.[12] Additionally, EPA may use the general waiver authority to waive the RFS, or any specific category of the RFS, if there is evidence that full implementation may cause severe economic or environmental harm.[13]

RFS Compliance

EPA monitors RFS compliance by fuel blenders and other obligated parties according to their reported accumulation of renewable identification numbers (RINs) for each biofuel's yearly volumetric standard. A RIN is a unique 38-character number that is issued (in accordance with EPA guidelines) by the biofuel producer or importer at the point of biofuel production or the port of importation. Each qualifying gallon of renewable fuel has its own unique RIN. The EPA uses its Moderated Transaction System (EMTS) to manage RIN transactions.[14] Using data generated from the EMTS, EPA provides aggregated monthly data on RIN generation and renewable fuel volume production for specific fuel categories, such as cellulosic biofuel.[15] In general, compliance is achieved by an obligated party when the number of RINs submitted to EPA each year for cellulosic biofuels equates to the volume requirement for that year. Previous-year RINs may be used to meet current-year compliance, although there are some stipulations.

As noted above, EPA has the authority to waive the cellulosic biofuel mandate on a yearly basis. In any year that EPA grants a waiver, the agency must also make per-gallon waiver credits

[9] Ian Talley, "Renewed Energy: US Biofuel Mandate Calls for Big Production Boost," *Dow Jones International News*, December 18, 2007, at http://www.factiva.com/.

[10] For more information on EPA's waiver authority, see CRS Report RS22870, *Waiver Authority Under the Renewable Fuel Standard (RFS)*; CRS Report R44045, *The Renewable Fuel Standard (RFS): Waiver Authority and Modification of Volumes*, by (name redacted).

[11] 42 U.S.C. 7545(o)(7)(D).

[12] Waiver credits are discussed in the "RFS Compliance" section of this report.

[13] 42 U.S.C. 7545(o)(7)(A).

[14] For more information on EPA's Moderated Transaction System (EMTS), see http://www.epa.gov/oms/fuels/renewablefuels/epamts.htm.

[15] Concerns have been raised about fraudulent renewable identification numbers (RINs), especially due to recent biodiesel fraudulent RIN activity. While RIN fraud is possible as discussed in CRS Report R42824, *Analysis of Renewable Identification Numbers (RINs) in the Renewable Fuel Standard (RFS)*, by (name redacted) , there has been no reported fraudulent cellulosic biofuel RIN activity. In July 2014, EPA issued a final rule that establishes a voluntary quality assurance program for verifying the validity of RINs. For more information, see EPA, "RFS Renewable Identification Number (RIN) Quality Assurance Program; Final Rule," 79 *Federal Register*, July 18, 2014.

available at a set price, the formula for which is set in statute.[16] Waiver credits may be used by obligated parties to comply with the cellulosic biofuel volume obligation in lieu of RINs generated with the production of the cellulosic biofuel.[17] The 2010, 2011, 2012, and 2013 prices for cellulosic biofuel waiver credits were $1.56, $1.13, $0.78, and $0.42, respectively. The 2014 and 2015 cellulosic biofuel waiver credit prices are $0.49 and $0.64, respectively. If waiver credits[18] are issued (when the mandate is reduced), compliance is to be met when the combination of waiver credits and RINs equates to the volume requirement for that year.

Table 1. RFS Biofuels Mandate in EPAct05 and EISA: Total Renewable Fuels and Cellulosic Biofuels

(in billions of gallons)

	EPAct05		EISA		
				Cellulosic biofuels	
Year	Total renewable fuels	Cellulosic biomass ethanol	Total renewable fuels	Statute	EPA revised (ethanol-equivalent volume)
2006	4.0	—	—	—	—
2007	4.7	—	—	—	—
2008	5.4	—	9.00	0.00	—
2009	6.1	—	11.10	0.00	—
2010	6.8	—	12.95	0.100	0.0065[a]
2011	7.4	—	13.95	0.250	0.0060[b]
2012	7.5	—	15.20	0.500	0.0105[c]
2013	†	0.250	16.55	1.00	0.0008[d]
2014	†	◊	18.15 (15.93 EPA revised)[e]	1.75	0.033[e]
2015	†	◊	20.5 (16.3 EPA revised)[e]	3.00	0.106[e]
2020	†	◊	30.0	10.5	—
2022	†	◊	36.0	16.0	—

Sources: EPAct05 (P.L. 109-58) Section 1501, and EISA (P.L. 110-140), Section 202.

Notes: Ethanol-equivalent volume is the volume used for RFS compliance purposes, which takes into account the energy content of the fuel. † = according to EPAct05 statute, the total renewable fuel amount for 2013 and thereafter shall be determined by the EPA administrator. ◊ = according to EPAct05 statute, a minimum of 250 million gallons of cellulosic biomass ethanol is required for 2013 and thereafter.

[16] 42 U.S.C. 7545 (o)(7)(D)(ii). In April 2015, EPA published a final rule stating that it will announce the cellulosic biofuel waiver credit price on the agency's "Renewable Fuels: Regulations & Standards" website to allow for more expeditious publication of the credit prices. Previously, the prices were published as a part of the rulemaking process in the *Code of Federal Regulations*. EPA, "Regulation of Fuels and Fuel Additives: Cellulosic Waiver Credit Price and Minor Amendments to Renewable Fuel Standard Regulations," 80 *Federal Register*, April 3, 2015.

[17] EPA, *Questions and Answers on Changes to the Renewable Fuel Standard Program (RFS2)*, February 2013.

[18] Waiver credits are not allowed to be traded or banked for future use, and are only allowed to be used to meet the cellulosic biofuel standard for the year that they are offered.

a. U.S. Environmental Protection Agency (EPA), "Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule," 75 *Federal Register*, March 26, 2010.
b. EPA, "Regulation of Fuels and Fuel Additives: 2011 Renewable Fuel Standards; Final Rule," *Federal Register*, December 9, 2010.
c. Vacated under *API vs. EPA.* Level originally set by EPA at 0.00865 billion gallons. EPA, "Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards; Final Rule," *Federal Register*, January 9, 2012.
d. EPA, "Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards; Final Rule," 79 *Federal Register*, May 2, 2014.
e. EPA, "Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017; Proposed Rule," 80 Federal Register 33099, June 10, 2015.

EPA Annual Cellulosic Biofuel Projections, 2010-2016

EPA generally conducts its cellulosic biofuels volume projection analysis based on an evaluation of individual producers' production plans and progress to date, discussions with cellulosic biofuel producers, the Energy Information Administration (EIA), the Department of Agriculture (USDA), and the Department of Energy (DOE), and an assessment of the probabilities associated with production schedules from each of the producers.[19] EPA's analyses concluded that the United States did not have sufficient cellulosic biofuel production capacity to meet the scheduled RFS mandates for 2010 to 2016. Therefore, for 2010 EPA reduced the mandate from the statutory volume[20] of 100 million gallons to 6.5 million ethanol-equivalent gallons;[21] for 2011 from 250 million gallons to 6.0 million ethanol-equivalent gallons;[22] for 2012 from 500 million gallons to 10.45 million ethanol-equivalent gallons;[23] and for 2013 from 1 billion gallons to 810,185 ethanol-equivalent gallons.[24]

The rulemaking process to determine the 2014, 2015, and 2016 RFS annual standards is still in progress. The delay in issuing the 2014 and 2015 standards raises significant uncertainty for biofuel producers, feedstock growers, and obligated parties.[25] EPA proposes to lower the 2014

[19] In its proposed rule, EPA reported it tracked the progress of several dozen potential cellulosic biofuel production facilities. EPA, "Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017; Proposed Rule," 80 Federal Register 33099, June 10, 2015.

[20] A distinction between which type of gallon is being referred to—straight or ethanol-equivalent—must be made. The ethanol-equivalent value takes into account the difference in energy content between renewable fuels, and therefore allows for direct comparisons. An ethanol-equivalence value for a renewable fuel with a higher energy content than cornstarch ethanol, such as biodiesel, may allow for that fuel to count more per gallon toward a mandate than other biofuels.

[21] EPA, "Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule," 75 *Federal Register*, March 26, 2010.

[22] EPA, "Regulation of Fuels and Fuel Additives: 2011 Renewable Fuel Standards; Final Rule," *Federal Register*, December 9, 2010.

[23] EPA, *Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, Final Rule*, January 9, 2012. This rule was vacated by the U.S. Court of Appeals for the D.C. Circuit in API v. EPA. EPA revised the 2012 rule and set the final required level at zero.

[24] EPA, "Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards; Final Rule," 79 *Federal Register*, May 2, 2014; EPA had previously issued a final rule on August 15, 2013, reducing the 2013 cellulosic biofuel standard to 6.0 million ethanol-equivalent gallons.

[25] When questioned about its rulemaking timeline for the RFS at a congressional hearing, the EPA responded that it was committed to getting the rules out in 2015 and meeting deadlines for 2016, although no timeline was provided. U.S. Congress, House Committee on Oversight and Government Reform, Subcommittee on Energy Policy, Health Care and Entitlements, *Examining EPA's Management of the Renewable Fuel Standard Program*, 113th Cong., December (continued...)

cellulosic biofuel mandate from 1.75 billion gallons to 33 million ethanol-equivalent gallons, the 2015 standard from 3 billion gallons to 106 million ethanol-equivalent gallons, and the 2016 standard from 4.25 billion gallons to 206 million ethanol-equivalent gallons.[26] According to EPA,

- The 2014 proposed volumes reflect what was actually produced (i.e., EMTS 2014 RIN data).
- The 2015 proposed volume reflects what was actually produced for those months where data are available and estimates for what might be produced in those months where data are not available.
- For the 2016 projection, EPA proposes to use a similar methodology to the 2015 methodology for estimating what might be produced.
- There are approximately eight facilities—all with various start dates and production ranges over the next two years—along with the renewable compressed natural gas and renewable liquefied natural gas industry that may produce commercial-scale volumes of cellulosic biofuel by 2016.[27] EPA does not believe that cellulosic biofuel will be imported into the United States, except from one facility in Canada.
- As of May 29, 2015, EPA had not received any projections of cellulosic biofuel production for 2015 or 2016 from the Energy Information Administration (EIA), but the agency anticipates that EIA will provide such projections for the final rule. EPA will take these projections into consideration.

In response to legal challenges of its cellulosic biofuel projection methodology for a specific year, EPA has in certain years revised the annual cellulosic biofuel standard to zero or proposed to voluntarily rescind an annual cellulosic biofuel standard.[28] This has occurred when the standard as originally reduced by EPA has not been met. For instance, EPA's 2012 standard was vacated by a court decision. As a follow-up to the same court decision, EPA proposes to rescind the 2011 cellulosic biofuel standard.

EPA Reported Cellulosic Biofuel Compliance

2010-2012

In a straightforward scenario, cellulosic biofuel compliance with the RFS requires actual cellulosic biofuel production, waiver credits, or a combination of both. However, the situation becomes complicated when cellulosic biofuels are not produced on schedule. Despite the RFS mandate for cellulosic biofuels starting in 2010, the first registered production of cellulosic biofuels in the United States was not achieved until 2012.[29]

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10, 2014.

[26] EPA, "Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017; Proposed Rule," 80 *Federal Register* 33099, June 10, 2015.

[27] For more information, see "Cellulosic Biofuel Producer Company Descriptions," memorandum from Dallas Burkholder to EPA Air Docket EPA–HQ–OAR–2015–0111.

[28] Additional information about these volume adjustments is provided in the "Legal Challenges" section of this report.

[29] EPA reports that the first cellulosic biofuel RINs were registered in 2012 for cellulosic biofuel produced at demonstration-scale facilities. EMTS records for 2012 show that RINs were generated for cellulosic ethanol and (continued...)

RFS cellulosic biofuel compliance can be separated into two phases: pre-EISA and post-EISA. There were different stipulations about how compliance was met prior to EISA (under RFS1) and after EISA (under RFS2). The transition from RFS1 (EPAct05) to RFS2 (EISA) occurred in 2010. RFS1 had different production requirements than RFS2 for cellulosic biofuels,[30] including an ethanol-equivalency ratio of 2.5-to-1, where each gallon of cellulosic ethanol counted as 2.5 gallons toward the EPAct05 mandate.[31] The EPA reports that zero cellulosic biofuel RINs were produced in 2010 under the RFS2 rules.[32] The EPA reports that the majority of compliance for 2010 was met with RINs generated (i.e., production) under RFS1.[33] EMTS records show that 12,186 cellulosic biofuel waiver credits were purchased in 2010, which likely made up for the remainder of 2010 compliance.[34]

Compliance data following the RFS1-to-RFS2 transition year of 2010 is more straightforward than other years. EPA reports that zero cellulosic biofuel RINS were produced in 2011.[35] Compliance for 2011 was met with excess cellulosic biofuel RINs generated in 2010 under RFS1 and cellulosic biofuel waiver credits.[36] EMTS records report that 4,248,388 RFS2 cellulosic biofuel waiver credits were purchased in 2011.[37] EPA reports that there is no "need to address compliance with the 2012 cellulosic biofuel standard" since there was a federal court decision that vacated the 2012 standard.[38] EMTS reports that 20,069 RINS were generated for cellulosic ethanol and 1,741 RINS were generated for cellulosic diesel in 2012.[39]

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cellulosic diesel in 2012.

[30] The original RFS (RFS1) did not require a cellulosic biofuel production volume until 2013, when 250 million gallons were mandated. Further, the definition of cellulosic biofuel was amended by EISA. Under RFS1, cellulosic biofuel could either be fuel produced from cellulosic feedstocks or fuel from conventional feedstocks using biomass for process energy. EISA eliminated the latter option of this definition for RFS2.

[31] EISA did not stipulate a 2.5-1 ratio for cellulosic biofuel for the RFS2. Instead, the ethanol-equivalence value depends on the type of biofuel being produced.

[32] EMTS reports zero RINs available for 2010 cellulosic biofuel and cellulosic diesel. For more information, see http://www.epa.gov/otaq/fuels/rfsdata/2010emts.htm.

[33] EPA "Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards; Proposed Rule," 78 *Federal Register*, February 7, 2013. The design of the RFS2 transition program allowed for RFS1 cellulosic RINs to be used towards compliance under the RFS2 program. The RFS1 cellulosic RINs likely came from non-cellulosic feedstocks that qualified under the then-effective definition of cellulosic biomass. EPA reports the 2010 cellulosic biofuel standard could have been met with cellulosic biofuel RINs generated under RFS2 regulations after July 1, 2010, cellulosic biomass ethanol RINs generated under RFS1 regulations between January 1, 2010, and July 1, 2010, and cellulosic biomass ethanol RINs generated under RFS1 regulations in 2009. EPA, *Questions and Answers on Changes to the Renewable Fuel Standard Program (RFS2)*, http://www.epa.gov/otaq/fuels/renewablefuels/compliancehelp/rfs2-aq.htm.

[34] See http://www.epa.gov/otaq/fuels/rfsdata/rfs2cellulosicwaivercredits.htm.

[35] EMTS reports zero RINs available for 2011 cellulosic biofuel and cellulosic diesel. For more information, see http://www.epa.gov/otaq/fuels/rfsdata/2011emts.htm.

[36] The statute allows companies to purchase cellulosic biofuel waiver credits in lieu of submitting RINs in years when EPA lowers the mandate. EPA, "Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards; Final Rule," 78 *Federal Register*, August 15, 2013.

[37] See http://www.epa.gov/otaq/fuels/rfsdata/rfs2cellulosicwaivercredits.htm. If the 2011 cellulosic biofuel standard is rescinded, EPA reports that it would refund the money paid by obligated parties to purchase cellulosic waiver credits to comply with the 2011 cellulosic biofuel standard.

[38] EPA, Enviroflash, *Update - 2012 Cellulosic Biofuel Standard Mandate Issued*, February 27, 2013.

[39] Blue Sugar Corporation is the first company to be issued cellulosic biofuel RINs. EPA reports these RINs were "retired" because the cellulosic ethanol produced was exported to Brazil. For more information, see http://www.epa.gov/otaq/fuels/rfsdata/2012emts.htm. EPA, "Regulation of Fuels and Fuel Additives: 2013 Renewable (continued...)

2013-2014

Evaluation of RFS compliance for a given calendar year is best determined once a rulemaking is complete that announces the annual standards (the statutory deadline for the rulemaking is November 30 of the preceding year) and once obligated parties have submitted the required information by the compliance deadline (typically March 31 of the following year). EPA completed the rulemaking process for the RFS annual standard for 2010-2013. However, the rulemaking process for 2014-2016 is ongoing. Compliance deadlines for 2010 through 2012 were met. Although it is eight months past the end of calendar year 2014, EPA has not yet finalized the compliance deadline for 2013 or 2014. EPA reports that "it is important for obligated parties preparing a compliance demonstration report for a given calendar year to have an understanding of their RFS obligations for the next compliance year."[40] Thus, due partly to the lack of a final rulemaking for the 2014 RFS annual standards, EPA proposes that the 2013 compliance deadline be January 31, 2016, and that the 2014 compliance deadline be June 1, 2016.[41] These proposed compliance deadlines follow EPA's anticipated deadline of November 30, 2015, for issuing the 2014, 2015, and 2016 RFS annual standards.

EMTS data for 2013 and 2014 cellulosic biofuel production and RIN generation are available. EMTS reports that 422,740 RINs were generated for cellulosic renewable gasoline blendstock and 395,777 RINS were generated for cellulosic diesel for the 2013 standard.[42] EMTS reports that 728,509 RINs were generated for cellulosic ethanol; 8,859 RINs for cellulosic diesel; 44,168 RINs for cellulosic renewable gasoline blendstock; 15,208,068 RINs for renewable compressed natural gas; 17,379,815 RINS for renewable liquefied natural gas; and 50,446 RINs for cellulosic heating oil.[43] The majority of the 2014 cellulosic biofuel mandate is being met with new fuel pathways approved by EPA in July 2014.[44] This trend appears to continue for the first seven months of 2015, where EMTS records show 49,429,794 cellulosic biofuel RINs (mostly renewable compressed natural gas and renewable liquefied natural gas) and 173,731 RINs for cellulosic diesel were generated as of July 29, 2015.

Legislative Context

The shift toward large-scale, economically feasible production of cellulosic biofuels has thus far proven elusive. Advancements have been made, but not in step with the pace set by Congress for the RFS. Multiple factors have contributed to the cellulosic biofuels market being at the stage it is today, with the two major factors being technological issues and a recession that slowed the

(...continued)

Fuel Standards; Final Rule," 78 *Federal Register*, August 15, 2013.

[40] EPA, "Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017; Proposed Rule," 80 *Federal Register* 33099, June 10, 2015.

[41] Ibid.

[42] For more information, see http://www.epa.gov/otaq/fuels/rfsdata/2013emts.htm.

[43] For more information, see http://www.epa.gov/otaq/fuels/rfsdata/2014emts.htm.

[44] These pathways include compressed natural gas and liquefied natural gas produced from biogas from landfills, municipal wastewater treatment facility digesters, agricultural digesters, and separated municipal solid waste digesters, as well as electricity produced from biogas from landfills used to power electric vehicles, municipal wastewater treatment facility digesters, agricultural digesters, and separated municipal solid waste digesters. EPA, "Regulation of Fuels and Fuel Additives: RFS Pathways II, and Technical Amendments to the RFS Standards and E15 Misfueling Mitigation Requirements; Final Rule," 79 *Federal Register* 138, July 18, 2014. EPA continues to work on approving new cellulosic biofuel pathways for the RFS and lists the approved pathways on the RFS new pathways website.

economy, including energy demand.[45] Due to production shortfalls, EPA has significantly reduced the cellulosic biofuels mandate each year from 2010 through 2013 and proposes to do so again for 2014, 2015, and 2016. Based on actual cellulosic biofuel production volumes for the 2010 to 2014 time frame, in crafting the legislation, Congress overestimated how much cellulosic biofuel production would occur on an annual basis. Further, although Congress provided EPA with waiver authority to align the cellulosic biofuel standard closer to actual production, projecting the production amount continues to be a challenge for both EPA and the EIA.[46] If mandate reductions and continual production shortfalls signify that the cellulosic biofuels mandate is not working as intended, Congress could decide that modifications are necessary.

The Role of Congress

Congress continues to have the authority to maintain or amend the RFS statutory mandates. Should the RFS be continued in its present form, amended, or eliminated completely? What additional public costs would each of these options engender? When expanding the RFS in EISA, Congress in effect made a technology choice by selecting a preferred technology (i.e., cellulosic biofuel) among many unknown technologies. Undoing that commitment by modifying or repealing the RFS could involve substantial costs to both public and private investors. The discussion about whether the cellulosic biofuels industry requires additional federal support to meet the RFS mandate has continued since the establishment of RFS1; however, the discussion became more pronounced when the RFS was expanded in 2007 to call for a much larger volume of cellulosic biofuel to be produced in a shorter timeframe. In response, Members of the 112th, 113th, and 114th Congresses proposed a variety of bills that would have affected the cellulosic biofuels industry (see **Table 2**).

Table 2. Selected Legislation from the 114th, 113th and 112th Congresses Pertaining to Cellulosic Biofuels

Congress	Legislation
114th	• S. 934 would require the cellulosic biofuel standard to be based on actual production and would modify the definition of cellulosic biofuel to exclude compressed natural gas, liquefied natural gas, or electricity used from biogas. • H.R. 3228 would require EPA to limit the volume of cellulosic biofuel to be blended into the nation's fuel supply to what is commercially available.
113th	• H.R. 550 and S. 251 would have modified the way EPA projects yearly cellulosic biofuel mandates. • H.R. 796 would have required a reduction in the advanced biofuel mandate if the cellulosic mandate is lowered in any given year. • H.R. 1461 would have repealed the RFS. • H.R. 1462 would have eliminated the non-advanced biofuel portion of the RFS and modified the way EPA projects yearly cellulosic biofuel mandates.

[45] These and other cellulosic biofuel production challenges are further explained in the cellulosic biofuels section.

[46] EIA reports that "its forecasts and projections to date have proven to be too optimistic, as volumes have been below expectations." U.S. Energy Information Administration, *Cellulosic biofuels begin to flow but in lower volumes than foreseen by statutory targets*, February 26, 2013.

Congress	Legislation
112th	• H.R. 230 would have modified the DOE Loan Guarantee Program, appropriating funds for EPAct05 Section 1512 Conversion Assistance for Cellulosic Biomass Waste-Derived Ethanol Approved Renewable Fuels, establishing a loan guarantee program for cellulosic ethanol production technology development. • H.R. 424 would have amended the RFS to revert back to RFS1 targets and eliminated all advanced biofuel mandates. • H.R. 851, H.R. 2231, H.R. 884, H.R. 1294 would have implemented new financial support mechanisms, extending relevant tax provisions. • H.R. 6047 would have modified the way EPA projects yearly cellulosic biofuel volume mandates.

Source: CRS.

Notes: Legislation is presented in order of introduction for a given Congress. None of these bills became law.

Congress could decide to modify the cellulosic biofuels mandate, and thus the RFS. This option could require an analysis of the cellulosic biofuels market and, perhaps more importantly, consideration of circumstances that were not as prevalent when the RFS was expanded in 2007. Some of these circumstances include budget concerns, the blend wall,[47] military interest in renewable fuels,[48] the slow development of the cellulosic biofuels production sector, and relatively low gasoline prices. Such an analysis might quantify the amount of federal support already granted to the cellulosic biofuels industry. One analysis of federal and public funding data for advanced biofuel projects provided by Environmental Entrepreneurs—an organization of business leaders—suggested that, since 2007, USDA, DOE, and the Department of Defense (DOD) have provided $928.4 million in grants and loan guarantees to eight companies that Environmental Entrepreneurs expects to bring commercial cellulosic biofuel facilities online by 2017.[49]

Alternatively, Congress could take a wait-and-see approach to address concerns with the cellulosic biofuels mandate. Given EPA's consecutive lowering of the mandate by approximately 95% to 99% for 2010 to 2013 and a proposal to do so for 2014, 2015, and 2016, some questions exists as to whether the cellulosic biofuels industry can ramp up production in the coming years to meet the scheduled RFS mandates. There may be an upcoming shift where some corn ethanol facilities plan to transition to cellulosic biofuel production, and it is not known what effect this might have on cellulosic biofuel production estimates.[50] Further, it is not yet known what impact the additional feedstocks and production pathways (e.g., renewable compressed natural gas) approved by EPA may have on meeting the RFS cellulosic biofuel mandate, although for 2014 and thus far in 2015 the new renewable natural gas fuel pathways are responsible for the majority

[47] The blend wall is the upper limit to the total amount of ethanol that can be blended into U.S. gasoline without exceeding the currently utilized 10% level. For more information, see CRS Report R40445, *Intermediate-Level Blends of Ethanol in Gasoline, and the Ethanol "Blend Wall"*, by (name redacted)

[48] U.S. Government Accountability Office, *Defense Energy: Observations on DOD's Investments in Alternative Fuels*, GAO-15-674, July 2015.

[49] Environmental Entrepreneurs, *E2 Advanced Biofuel Market Report 2014*. CRS tallied USDA, DOE, and DOD funding from Appendix H of the report for those companies with commercial facilities expected to come online in the United States before 2017 that were identified as producing cellulosic biofuel in Appendix B of the report.

[50] POET LLC, "POET and Agrivida sign technology collaboration joint development agreement," press release, August 21, 2012. Additionally, it is not known what impact the bolt-on technology employed by Quad County Corn Processors, which produces cellulosic ethanol from corn kernel fiber, will have on cellulosic biofuel production.

of cellulosic biofuel RIN generation.[51] Last, Congress may leave it to EPA, as required by the statute, to modify the applicable volumes of the RFS in its entirety starting in 2016 if certain conditions are met.[52]

It is possible that a substantial portion of the cellulosic biofuels volume mandate may be unattainable for years to come. EIA reports that while "cellulosic biofuels volumes are expected to grow significantly relative to current levels, they will likely remain well below the targets envisioned in the Energy Independence and Security Act of 2007."[53] Congress has multiple options to address the lack of cellulosic biofuels production if it chooses to do so. Congress could make a statutory change to the definition of cellulosic biofuels for the RFS to open it up to additional feedstocks that can assist with meeting the annual production targets. Or Congress may continue to require that the EPA set the cellulosic biofuels mandate based on the best available evidence—the status quo option.[54] In the 114th Congress, some Members have proposed legislation (e.g., S. 934, H.R. 3328) that would require EPA to base the cellulosic mandate on actual production or what is currently available. Congress could also eliminate the cellulosic biofuels portion of the mandate or the RFS entirely.

The Role of EPA

Congress directed EPA to implement the RFS. One of EPA's roles in implementing the RFS is to reduce the annual standard for cellulosic biofuels if—after assessing the cellulosic biofuels market, consulting with EIA, and taking other measures—the volume amount identified in statute cannot be met. This new reduced standard for a given calendar year is to be determined through the rulemaking process.

EPA's administration of the cellulosic biofuel feature of the RFS has its proponents and opponents. At times the support and opposition for the cellulosic biofuel feature are mingled with support and opposition for the overall RFS. Some Members of Congress and stakeholders are dissatisfied with EPA's implementation of the RFS and with the challenges to comply with the mandate, among other things.[55] Some contend that EPA has not carried out its responsibilities regarding the RFS as expeditiously as desired.[56] Some are not satisfied with the accuracy of EPA's annual cellulosic biofuel standard.[57] Some Members of Congress support a strong RFS that will

[51] EPA, "Regulation of Fuels and Fuel Additives: RFS Pathways II, and Technical Amendments to the RFS Standards and E15 Misfueling Mitigation Requirements; Final Rule," 79 *Federal Register* 138, July 18, 2014.

[52] More information is provided in the "Uncertainty" section of this report, below.

[53] U.S. Energy Information Administration, *Cellulosic biofuels begin to flow but in lower volumes than foreseen by statutory targets*, February 26, 2013.

[54] Although some stakeholders have questioned whether EPA does, in fact, use the best available evidence. American Petroleum Institute v. EPA, 706 F.3d 474 (D.C. Cir. 2013).

[55] U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Energy, *The EPA Renewable Fuel Standard Mandate*, 114th Cong., July 23, 2015.

[56] U.S. Congress, Senate Committee on Homeland Security and Governmental Affairs, Subcommittee on Regulatory Affairs and Federal Management, *Re-examining EPA's Management of the Renewable Fuel Standard Program*, 114th Cong., June 18, 2015; U.S. Congress, House Committee on Oversight and Government Reform, Subcommittee on Energy Policy, Health Care and Entitlements, *Examining EPA's Management of the Renewable Fuel Standard Program*, 113th Cong., 2nd sess., December 10, 2014; American Petroleum Institute, "EPA incapable of implementing the RFS, time for repeal," press release, November 21, 2014.

[57] American Petroleum Institute (API) and the American Fuel and Petrochemical Manufacturers Association (AFPM), *Comment on EPA's Proposed Rule: Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-based Diesel Volume for 2017*, July 27, 2015; Institute for Energy Research, *Comment on the Environmental Protection Agency (EPA) Proposed Rule: Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards*, (continued...)

"provide the certainty needed to unlock future investments in renewable fuels and necessary infrastructure, reduce our nation's dependence on foreign sources of energy, and drive innovation and progress toward cellulosic, biodiesel, recycled-waste, algal, and other advanced biofuels."[58] Some contend that EPA should raise the cellulosic biofuel requirements for 2015 and 2016 to amounts greater than what is in the proposed rule, among other things, to "help drive the growth of the advanced and cellulosic biofuels industry in the manner that Congress intended.... "[59] Some in the cellulosic biofuel community assert that EPA should better manage its administration of cellulosic waiver credits so that the number of credits issued by the agency improves the market conditions for obligated parties to purchase actual cellulosic biofuel, among other things.[60] Lastly, one cellulosic producer reports that it expects to "stop all future U.S. cellulosic investments if EPA's proposed base renewable fuel requirements are not strengthened."[61]

One could argue that EPA has a difficult job trying to follow through on Congress's directions, given the challenges faced by the cellulosic biofuels industry. Further, it could be argued that any federal agency would likely find it difficult to accurately project when a new technology selected by Congress, not yet proven at commercial scale, would come online and at what pace. EPA can modify its projection procedure for cellulosic biofuels, and it can take into account the 2013 federal court decision about how EPA estimates cellulosic biofuel production, but any major changes to its procedure would likely require additional instruction from Congress.

EPA has not been given much guidance by the courts, or Congress, on how to calculate a cellulosic biofuels projection, although the methodology the agency used previously was under scrutiny from the oil industry, among others, as evidenced by the court case concerning the 2012 cellulosic biofuels standard. It is not clear if the current methodology being used for the 2014-2016 standards will face the same scrutiny. Arguably, setting a standard too low could impact federal support (e.g., grants, tax incentives) and private investment for the technology. This could hinder the overall goals of the RFS, such as economic development in rural areas. Prospects for the cellulosic biofuels industry could be affected if EPA continues to incorrectly project annual amounts of cellulosic biofuel production.

Legal Challenges

Mainly due to implementation issues, some aspects of the RFS have been challenged in the courts. Since 2010, seven cases involving the EPA and its administration of the RFS have been brought before a federal court.[62] One case in particular is germane to the cellulosic biofuel mandate: *American Petroleum Institute v. EPA* (hereinafter *API v. EPA*).

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March 25, 2013.

[58] Sen. Amy Klobuchar, "As EPA Finalizes Rule, Klobuchar, Grassley, Durbin, Thune, Franken, and Kirk Lead Bipartisan Group of 37 Senators in Calling for a Strong Renewable Fuel Standard," press release, April 23, 2015.

[59] Biotechnology Industry Organization (Bio), *Comment on EPA's Proposed Rule: Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-based Diesel Volume for 2017*, July 27, 2015.

[60] Quad County Corn Processors, *Comment on EPA's Proposed Rule: Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-based Diesel Volume for 2017*, July 24, 2015.

[61] POET, "POET submits comments to EPA on RFS proposal," press release, July 27, 2015.

[62] Wyoming Refinery Company v. EPA, 787 F.3d 568 (D.C. Cir. 2015); Lion Oil Company v. EPA, 14-3405 (8th Cir. 2015); Monroe Energy, LLC v. EPA, 750 F.3d 909 (D.C. Cir. 2014); American Petroleum Institute v. EPA, 706 F.3d 474 (D.C. Cir. 2013); Vinmar Overseas, Ltd. v. OceanConnect, LLC, 2012 Westlaw 3599486 (S.D. Tex. Aug. 20, 2012), 2012 Westlaw 5989206 (S.D. Tex. Nov 29, 2012); Grocery Manufacturers Association v. EPA, 693 F.3d 169 (D.C. Cir. 2012); National Petrochemical & Refiners Association v. EPA, 630 F.3d 145 (D.C. Cir. 2010).

API challenged the EPA about two aspects of the RFS, and subsequently the challenge was referred to the U.S. Court of Appeals. The first aspect, which is directly related to cellulosic biofuels, was an objection to EPA's 2012 cellulosic biofuels projection (i.e., whether EPA used an appropriate methodology to estimate the amount of cellulosic biofuels that can be produced). The court agreed with API and found that EPA's methodology for making its cellulosic biofuel projection did not take neutral aim at accuracy, and therefore it was an unreasonable exercise of agency discretion.[63] The court went on to explain that the Clean Air Act tasked EPA with establishing a projection that aims at accuracy, not at deliberately indulging a greater risk of overshooting than undershooting.[64] The 2012 rule was vacated and remanded to EPA, which set the final 2012 level at zero. EPA accepted the federal court's decision to vacate the 2012 cellulosic biofuel standard, and in its 2014 proposed rule proposed to rescind the 2011 standard as well.[65] The second aspect of the petition was an objection to EPA not providing a reasoned explanation for its refusal to reduce the 2012 advanced biofuels volume standard. The court rejected this part of the petition. In subsequent rules issued by EPA, the agency appears to address principles contained in the court ruling, such as, in its 2013 final rule, its responsibility to accurately project how much cellulosic biofuel will be produced, not to "individually advance a technology-forcing [cellulosic biofuels] agenda."[66]

Uncertainty

One overwhelming theme is associated with the RFS cellulosic biofuel mandate: uncertainty. It comes from all stakeholders—government and non-government. What will be the revised annual cellulosic biofuel standard? When will the standard be announced? What federal funding sources (e.g., tax incentives, farm bill energy provisions) exist for cellulosic biofuel facilities? How many cellulosic biofuel plants exist? How many are operating? How much cellulosic biofuel will be produced? Many times, the only known constant seems to be the statute itself. According to many, such uncertainty can potentially wreak havoc on an emerging industry. This section discusses some of the uncertainties.

One source of uncertainty, particularly for investors in cellulosic biofuel ventures, concerns EPA's waiver authority. Investors may fear that the full cellulosic biofuels mandate will continually be waived to lower amounts by EPA, thus depriving them of the government-mandated market on which they had originally based their investment. From this viewpoint, EPA's proposal to lower the 2014, 2015, and 2016 overall RFS may further hamper investment.

Another form of uncertainty for all involved parties is the delayed announcement of the proposed annual renewable fuel standards. Under the Clean Air Act, each year's standards are required to be finalized by November 30 of the previous year, although the statute does not stipulate any penalty or other action if this deadline is missed. The delay may lead to uncertainty in investments and planning for the biofuel and petroleum industries, among others. EPA issued a proposed rule for the 2014, 2015, and 2016 RFS annual standards in May 2015 and anticipates issuing a final rule by November 30, 2015.

[63] 706 F.3d 474, *476.

[64] 706 F.3d 474, *479.

[65] EPA, Enviroflash, *Update - 2012 Cellulosic Biofuel Standard Mandate Issued*, February 27, 2013; EPA, "2014 Standards for the Renewable Fuel Standard Program; Proposed Rule," 78 *Federal Register*, November 29, 2013.

[66] American Petroleum Institute v. EPA, 706 F.3d 474 (D.C. Cir. 2013).

Those in favor of continuing an RFS with a cellulosic biofuels component argue that adequate production and consumption of cellulosic biofuels can be achieved in a cost-effective manner if there is consistent federal policy, possibly allaying the concerns of some investors.[67] However, minimal actual production has led some to question the viability of cellulosic biofuels over the long term.[68] Furthermore, a cellulosic biofuels industry that has regularly not produced enough biofuel to meet the annual standard has drawn criticism from groups—especially the petroleum industry—that contend they are being unfairly targeted to purchase credits for a fuel that is unlikely to be produced at the required levels.[69] Last, investors and the cellulosic biofuels community alike may be more apprehensive about the federal policy for advanced biofuels as 2016 draws nearer. This apprehension may be due to a provision in the RFS statute that requires the EPA administrator, starting in 2016, to modify the applicable volumes of the RFS in their entirety for subsequent years if the administrator waives the renewable fuel mandate, the advanced biofuel mandate, the cellulosic biofuels mandate, or the biomass-based diesel mandate by at least 20% for two consecutive years or by at least 50% for a single year.[70]

Background on Cellulosic Biofuels

As an important component of the RFS, production of cellulosic biofuels faces significant technical and economic issues. Further, there are multiple cellulosic feedstocks and conversion technologies that can be used to produce cellulosic biofuels. Cellulosic biofuels—which can be liquid, solid, or gaseous—are fuels made from materials containing cellulose. Cellulose, a complex carbohydrate, is the organic matter found in plant walls that, along with hemicellulose and lignin, helps to give a plant its rigid structure. Cellulose feedstock includes agricultural residues (e.g., corn stover), forestry residues (e.g., wood chips), dedicated energy crops (e.g., switchgrass, hybrid poplar), and urban sources of waste (e.g., municipal solid waste).

The most widely discussed cellulosic biofuel is cellulosic ethanol for transportation.[71] Cellulosic ethanol differs from the cornstarch ethanol that dominates transportation biofuels in the United States; it is made from feedstock with no or only limited food value, potentially results in lower greenhouse gas emissions, and has a higher lifecycle energy balance.[72] Converting cellulosic feedstock to ethanol, however, is more expensive and difficult than converting cornstarch to ethanol. The conversion of cellulose to ethanol generally happens in three phases—pretreatment, hydrolysis, and fermentation to ethanol. Pretreatment weakens the plant wall structure so that the cellulose is easier to obtain during hydrolysis. Hydrolysis—acid or enzymatic—separates the cellulose into sugars. Fermentation converts the sugars into ethanol. Cellulose can also be converted to liquid fuels through processes other than fermentation (e.g., thermochemical processes).[73]

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[67] John M. Biers, "Non-Food Ethanol Projects Coming to Life," Dow Jones Newswires, November 20, 2012.

[68] "Zero Dark Ethanol," *The Wall Street Journal*, January 30, 2013.

[69] "Oil Industry Sues EPA a Second Time Over RFS Mandate," *The Energy Daily*, July 26, 2012.

[70] 42 U.S.C. 7545 (o)(7)(F). For more information, see CRS Report R44045, *The Renewable Fuel Standard (RFS): Waiver Authority and Modification of Volumes*, by (name redacted)

[71] For more information on cellulosic biofuels, see CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*, by (name redacted) et al.

[72] For more information on ethanol, see CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*, by (name redacted) .

[73] Cellulose feedstocks can also be used to provide heat or generate electricity via gasification, combustion, anaerobic digestion, and other conversion processes. For more information, see CRS Report R40667, *Anaerobic Digestion:* (continued...)

Potential Benefits of Cellulosic Biofuels

It has been anticipated that cellulosic biofuel production would assist various energy, environment, and economic efforts. Cellulosic biofuel production has not yet reached full scale, making its impact difficult to quantify. However, some general potential benefits can be explored.

Energy Security

Cellulosic biofuel production—at full capacity and with the proper infrastructure—may expand the fuel types available to the average consumer. This could help to strengthen energy security, and galvanize a market for services, technologies, and products that are associated with its production and use. Any such developments are likely to be contingent, at a minimum, on a cellulosic biofuel that is sustainable and has an energy density suitable to what the energy industry has come to expect from fossil fuels.

Environment

Cellulosic biofuels, if they can be produced at scale, may result in some environmental benefits, including greenhouse gas emission reduction, air quality improvement, and the use of more water-efficient strategies, among other things. EISA requires any cellulosic biofuel registered with the RFS to have lifecycle greenhouse gas emissions that are at least 60% less than the baseline lifecycle greenhouse gas emissions (i.e., of the gasoline or diesel it is to replace).[74] One lifecycle greenhouse gas emission analysis of petroleum gasoline, corn ethanol, and cellulosic ethanol reported that cellulosic ethanol offered the largest reductions in greenhouse gas emissions.[75] Further, within the cellulosic biofuel feedstock arena, it may be that greater greenhouse gas emissions reductions are possible by using forest-based feedstocks as opposed to agricultural-based feedstocks.[76] Actual greenhouse gas (GHG) emission results for cellulosic biofuel production will vary based on a number of factors, including the time frame of the assessment, the feedstock used, the cellulosic biofuel production technology type, and more. Robust analyses of the GHG emission reduction possible from cellulosic biofuel production will require more data from biofuel facilities and feedstock suppliers as facilities come online. While more operational plants are needed to gauge the air quality impact and the water use from cellulosic biofuel production, it may be that technological advances over time will lead to adoption of more efficient water use and better air pollution control, based partially on lessons learned from conventional corn ethanol facilities.[77]

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Greenhouse Gas Emission Reduction and Energy Generation, by (name redacted) and CRS Report R41440, *Biopower: Background and Federal Support*, by (name redacted)

[74] 42 U.S.C. 7545 (o)(1)(E).

[75] Michael Wang, Jeongwoo Han, and Zia Haq, et al., "Energy and greenhouse gas emission effects of corn and cellulosic ethanol with technology improvements and land use changes," *Biomass and Bioenergy*, vol. 35 (2011).

[76] Jesse Daystar, Ronalds Gonzalez, and Carter Reeb, et al., "Economics, Environmental Impacts, and Supply Chain Analysis of Cellulosic Biomass for Biofuels in the Southern US: Pine, Eucalyptus, Unmanaged Hardwoods, Forest Residues, Switchgrass, and Sweet Sorghum," *Bioresources*, vol. 9, no. 1 (2014). The study considered pine, eucalyptus, unmanaged hardwood, and forest residuals to be forest-based feedstock, and switchgrass and sweet sorghum to be agriculture-based feedstock.

[77] National Research Council, "Water Implications of Biofuels Production in the United States," 2008; Donna Jones, "Potential air emission impacts of cellulosic ethanol production at seven demonstration refineries in the United States," *Journal of the Air and Waste Management Association*, vol. 60 (September 2010).

Rural Economic Development

Thus far, cellulosic biofuel production facilities have been constructed in close proximity to the feedstock to be utilized (e.g., crop residue, forestry residue). With the exception of some eligible feedstocks (e.g., yard waste, food waste), this would place cellulosic biofuel production facilities in rural areas, which could enhance some rural economies. A transportation conundrum may result from cellulosic biofuel production facilities being located in rural areas, specifically the transfer of fuel to where it is needed most, which is areas with high demand for transportation fuel (e.g., large cities). Currently, availability of rail capacity and tank cars for conventional ethanol is limited—a situation that could be exacerbated if demand grows with additional cellulosic biofuel production.

Potential Challenges for Cellulosic Biofuels

U.S. production of cellulosic biofuels has had a slow start. Impediments to increasing capacity involve a variety of factors, including financing, feedstock eligibility, and feedstock supply, among others.

Financing

The production of cellulosic biofuels has been reported to be "complex, capital-intensive, and costly."[78] Commercial cellulosic biofuel facilities are estimated to cost hundreds of millions of dollars, significantly more than a traditional corn ethanol plant, especially when measured in terms of the amount of biofuel produced (measured in million gallons per year, or mgy). For example, the company INEOS Bio reports that its Indian River 8 mgy production capacity plant cost approximately $130 million.[79] American Process, Inc., reports that its Alpena 0.8 mgy pilot plant cost approximately $36 million.[80] POET-DSM reports that its 25 mgy commercial cellulosic ethanol plant, which opened in September 2014, cost approximately $250 million.[81] DuPont reports that its 30 mgy cellulosic ethanol plant cost approximately $225 million.[82] In comparison, a 40 mgy corn ethanol plant cost approximately $80 million to construct in 2006.[83] Some lenders find it extremely risky, perhaps even cost-prohibitive, to provide financial backing to cellulosic biofuel plants, mainly because the conversion technology has not been applied or proven on a commercial scale.[84] These costs, and the perceived financial risk, are likely to decrease if a significant number of commercial-scale plants come online and prove to be economically viable.

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[78] U.S. Congressional Budget Office, *The Renewable Fuel Standard: Issues for 2014 and Beyond*, June 2014.

[79] Email from Bryan Stockton of ML Strategies, December 13, 2012.

[80] Email from Kim Nelson of American Process, Inc., December 11, 2012.

[81] POET-DSM, *Testimony of Kevin Potas, Business Development Manager at POET-DSM Advanced Biofuels*, EPA Public Hearing for the 2014 Standards for the Renewable Fuel Standard Program, December 5, 2013, http://www.poetdsm.com/testimony. POET-DSM, "First commercial-scale cellulosic ethanol plant in the U.S. opens for business," press release, September 3, 2014, http://poetdsm.com/pr/first-commercial-scale-cellulosic-plant.

[82] *DuPont Cellulosic Ethanol: Commercializing Advanced Renewable Fuel in Iowa*, 2013, http://biofuels.dupont.com/fileadmin/user_upload/live/biofuels/DuPont_Nevada_CE_final.pdf.

[83] Clean Fuels Development Corporation, Nebraska Ethanol Board, and U.S. Dept. of Agriculture, *A Guide for Evaluating the Requirements of Ethanol Plants*, 2006, http://www.ethanol.org/pdf/contentmgmt/guide_for_evaluating_the_requirements_of_ethanol_plants.pdf.

[84] For more information on federal spending for cellulosic biofuels, see CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*, by (name redacted) et al.

Feedstock Eligibility

When determining feedstock eligibility for the RFS, definitions matter. Due to the many biofuel programs at various federal agencies and tax incentives, there is a plethora of biomass definitions and other terminology that describe biomass feedstock for cellulosic biofuel production. However, only the definitions contained in EISA Section 201 may deem a feedstock or fuel eligible for the RFS.[85]

Feedstock Supply

Another cellulosic biofuel production challenge is feedstock contracts, which will likely cover multiple years. Cellulosic biofuel production companies generally want to "lock in" their feedstock supply, preferably at a set price for a predetermined time in order to have better projections of operational costs. Agricultural and forestry producers may not agree to a contract for a cellulosic feedstock that requires a lengthy time commitment. For example, it generally takes three years for switchgrass crops to reach maturity.[86] As a result, a producer would have to commit its land to one particular cellulosic feedstock crop for a number of years, thus limiting the producer's choice to grow other, potentially more remunerative crops during that period. Some are concerned about collecting cellulosic feedstocks in a way that could possibly harm the landscape (e.g., soil carbon, water quality). One potential strategy is the use of conservation planning for any land involved in cellulosic feedstock collection.[87] Conservation planning allows a producer to maintain, protect, and improve the natural resources of the land, helping to ensuring that those resources remain in the best possible condition and exist in the future. For instance, a producer who implements soil and water conservation techniques, and other non-conservation planning measures, should be able to annually provide feedstock to a biofuel producer with minimal natural resource disturbance. Additionally, there are concerns about the equipment and time needed to harvest, transport, and store the cellulosic feedstock. Some could contend that these concerns are perfectly normal for an emerging business model, and that the feedstock supply challenges will be overcome as more cellulosic biofuel production plants come into operation. In early 2013, EPA reported that the industry had made significant progress regarding

[85] There are some important distinctions about the renewable biomass definition for the RFS contained in EISA as compared to other laws. For example, the renewable biomass definition for the RFS under EISA does not allow for biomass removed from federal lands, and excludes crops from forested lands. There have been ongoing discussions to modify both the cellulosic biofuel definition and the renewable biomass definition for the RFS under EISA. Some suggest that broadening the cellulosic biofuel definition to include more feedstocks and fuel pathways could help industry to meet the annual RFS mandates. It is not clear that EPA has the capacity to address such additions. Moreover, some argue that a renewable biomass definition that allows biomass removal from federal lands could provide an inexpensive supply of cellulosic feedstock that would be immediately available to biorefineries for cellulosic biofuel production. Others contend that biomass removal from federal lands is a short-term response to the cellulosic feedstock source problem and might not be carried out in a sustainable manner, leading to deterioration of the nation's parks and recreation areas. Further, the definition of biomass under EISA also excludes most municipal solid waste (MSW), which some view as a potential source for conversion to biofuels. For more information on biomass definitions, see CRS Report R40529, *Biomass: Comparison of Definitions in Legislation*, by (name redacted).

[86] University of Tennessee, *Growing and Harvesting Switchgrass for Ethanol Production in Tennessee*, SP701-A, http://www.utextension.utk.edu/publications/spfiles/SP701-A.pdf.

[87] For example, the USDA Natural Resources Conservation Service and DuPont signed a memorandum of understanding with the goal "to safeguard natural resources on private lands used to supply bio-based feedstocks for cellulosic ethanol production." U.S. Department of Agriculture, "USDA Announces New Conservation Collaboration with DuPont to Promote Sustainable Harvesting of Bio-based Feedstocks for Cellulosic Ethanol," press release, March 29, 2013.

feedstock supply, citing companies that have secured feedstock contracts with local agricultural producers.[88]

Existing Plant Capacity

In terms of starting commercial-scale cellulosic biofuel production, 2014 could be deemed as having been a banner year for the cellulosic biofuels industry, with the opening of three commercial-scale cellulosic ethanol facilities. Quad County Corn Processors in Iowa started producing cellulosic ethanol from corn kernel fiber in July 2014. The "bolt-on" project, which has a production capacity of up to 2 million gallons of cellulosic ethanol per year, is an add-on to the existing 35 mgy cornstarch ethanol facility.[89] September 2014 brought the commencement of the POET-DSM Project Liberty plant in Iowa, a commercial-scale facility producing cellulosic ethanol from corn stover with a production capacity of up to 25 mgy.[90] And in October 2014, Abengoa opened a commercial-scale cellulosic ethanol plant in Kansas.[91] The plant produces cellulosic ethanol from crop residues and has a production capacity of up to 25 mgy.

In its proposed rule, EPA provides information on eight companies and one additional industry (compressed and liquefied natural gas) with the potential to produce cellulosic biofuels by 2016.[92] EPA's assessment includes their biofuel production estimates, technology process, and anticipated start dates. Four of the companies identified in the 2014 proposed rule were also identified in the 2013 final rule.

As observed over the last few years, due to unforeseen financial and technical issues, it can be difficult to determine when or if cellulosic biofuel companies will actually come online and how much cellulosic biofuel will be produced. In 2010, it was reported that approximately two dozen demonstration- or pilot-scale cellulosic ethanol plants existed in the United States.[93] The Advanced Ethanol Council reported in 2012 that there were nine cellulosic biofuel pilot/demonstration facilities, eight commercial facilities under construction or commissioning, and seven commercial facilities at the engineering stage.[94] Environmental Entrepreneurs projects

[88] EPA, "Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards; Final Rule," 78 *Federal Register,* August 15, 2013. In its 2014 proposed rule, EPA briefly mentions a feedstock contract for one of the facilities projected to produce cellulosic biofuel in 2015. This may lead some to believe that feedstock supply is of minor concern. However, feedstock supply and any challenges it may cause will be more fully understood once multiple commercial-scale facilities are actively operating.

[89] Iowa Renewable Fuels Association, "Quad County Corn Processors Produces First Gallons of Cellulosic Ethanol in Iowa," press release, July 1, 2014.

[90] POET-DSM, "First commercial-scale cellulosic ethanol plant in the U.S. opens for business," press release, September 3, 2014, http://poetdsm.com/pr/first-commercial-scale-cellulosic-plant.

[91] Abengoa, "Abengoa celebrates grand opening of its first commercial-scale next generation biofuels plant," press release, October 17, 2014.

[92] EPA, "Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017; Proposed Rule," 80 *Federal Register* 33099, June 10, 2015.

[93] Wallace E. Tyner and Sarah Brechbill, "Cellulosic Biofuels: Feedstocks, Conversion Technologies, Economics, and Policy Issues," CRS Workshop on the Development of the U.S. Cellulosic Biofuels Industry, Washington, DC, October 6, 2009; and conversation with Wallace Tyner from Purdue University, February 2, 2010;CRS Report R41460, *Cellulosic Ethanol: Feedstocks, Conversion Technologies, Economics, and Policy Options*, by (name redacted); EPA, *Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis*, EPA-420-R-10-006, Washington, DC, February 2010, pp. 171 and 186, http://www.epa.gov/oms/renewablefuels/420r10006.pdf.

[94] Advanced Ethanol Council (AEC), *Cellulosic Biofuels Industry Progress Report 2012-2013*, December 2012, http://ethanolrfa.org/page/-/PDFs/AEC%20Cellulosic%20Biofuels%20Industry%20Progress%20Report%202012-2013.pdf?nocdn=1. AEC acknowledges the report does not profile all cellulosic biofuel projects under development in the United States.

that 17 commercial cellulosic biofuel facilities will come online in the United States by 2017, with at least 12 of the facilities producing cellulosic ethanol.[95]

Financial Assistance

Several forms of federal financial support are available for cellulosic biofuel production, including the Department of Energy (DOE) Loan Guarantee Program (LGP), the USDA Biorefinery Renewable Chemical, and Biobased Manufacturing Assistance Program (BAP), the Biomass Crop Assistance Program (BCAP), and tax incentives. For example, since at least 2008, the government has provided tax incentives to support cellulosic biofuel production.[96] Other sources of financial assistance include smaller grants awarded by federal agencies for unique initiatives.[97]

To help promote cleaner energy technologies, including cellulosic biofuel production technologies, Congress established the DOE LGP.[98] Loans may not exceed 80% of total project costs. The DOE Section 1703 loan program supports clean energy technologies that are high technology risks (e.g., biomass, solar, alternative fuel vehicle technologies). In addition, the DOE Section 1705 loan program, which expired in 2011, supported renewable energy systems, electric power transmission systems, and leading-edge biofuels.[99] Some in the industry are concerned that the LGP is not being carried out at a pace responsive to market momentum for cellulosic biofuels.[100]

The USDA BAP assists in the development of new and emerging technologies for advanced biofuels.[101] BAP provides competitive grants and loan guarantees for construction and/or retrofitting of demonstration-scale biorefineries to demonstrate the commercial viability of one or more processes for converting renewable biomass to advanced biofuels. Because BAP has not received any discretionary funding needed to implement the grant portion of the program, USDA has only implemented the loan guarantee portion of the program using mandatory funding. USDA reports that seven biorefineries were granted a BAP conditional commitment for a loan guarantee

[95] Environmental Entrepreneurs, *E2 Advanced Biofuel Market Report 2014*, 2014. CRS tallied commercial facilities listed in Appendix B that are to be located in the United States and projected to produce cellulosic biofuel by 2017.

[96] For more information, see CRS Report R42566, *Alternative Fuel and Advanced Vehicle Technology Incentives: A Summary of Federal Programs*, by (name redacted) et al. ; P.L. 113-295.

[97] For example, USDA and DOE have both provided grants to support advanced biofuels.

[98] A loan guarantee is defined as a "pledge with respect to the payment of all or a part of the principal or interest on any debt obligation of a non-federal borrower to a non-federal lender." The LGP was first authorized under Title XVII of EPAct05 and then amended under the American Recovery and Reinvestment Act of 2009 (P.L. 111-5). DOE may issue Section 1703 loan guarantees to eligible projects that "avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases" and "employ new or significantly improved technologies as compared to technologies in service in the United States at the time the guarantee is issued." Eligible projects include commercial-scale renewable energy systems. EISA authorized the DOE to issue loan guarantees in part to support renewable energy projects. For more information on loan guarantees, see CRS Report R42152, *Loan Guarantees for Clean Energy Technologies: Goals, Concerns, and Policy Options*, by (name redacted)

[99] In 2011, a Section 1705 loan for $132.4 million was awarded to Abengoa Bioenergy Biomass of Kansas, LLC for a commercial-scale cellulosic ethanol project. U.S. Department of Energy, "Energy Department Finalizes $132 Million Loan Guarantee to Support the Abengoa Bioenergy Project," press release, September 29, 2011, http://energy.gov/articles/energy-department-finalizes-132-million-loan-guarantee-support-abengoa-bioenergy-project.

[100] Renewable Fuels Association, "2010 State of the Industry Address," 2010 National Ethanol Conference, Orlando, FL, February 16, 2010, http://ethanolrfa.3cdn.net/b76292e4bf133edd34_e1m6bhh33.pdf.

[101] For more information, see P.L. 111-5 and CRS Report R43416, *Energy Provisions in the 2014 Farm Bill (P.L. 113-79)*, by (name redacted) .

at a total of approximately $704 million from FY2009 through FY2012.[102] Under the 2014 farm bill (P.L. 113-79), BAP received mandatory funding of $100 million in FY2014 for loan guarantees and $50 million for FY2015 and FY2016. Subsequently, for FY2015, Congress limited BAP mandatory funding to $30 million (P.L. 113-235).

Another federal government program, focused on feedstock development, is the BCAP.[103] The two main program objectives of BCAP are to support the establishment and production of eligible crops for conversion to bioenergy in selected areas, and to assist agricultural and forest land owners and operators with collection, harvest, storage, and transportation of eligible materials for use in a biomass conversion facility. USDA issued the BCAP final rule on October 27, 2010, implementing both program components. Since the program's inception, 11 BCAP project areas have been established.[104] Outlays under BCAP reached $248 million in FY2010 but have since declined to an estimated $13.6 million in FY2014. The 2014 farm bill authorized mandatory funding of $25 million annually for FY2014 through FY2018. Subsequently, for FY2015, Congress limited mandatory funds for BCAP to $23 million (P.L. 113-235).

Conclusion

Cellulosic biofuel has supporters and detractors. Proponents suggest that increased use of cellulosic biofuels for transportation could potentially help to reduce U.S. dependence on foreign oil, strengthen rural economies, and improve the environment. In contrast, others argue that cellulosic biofuels at RFS volumes may never materialize, and would require a substantial feedstock supply that has yet to be verified and may never be cost-competitive without government support.

Cellulosic biofuel production is not at the stage many had predicted when EISA was enacted. The lower production levels make it nearly impossible to meet the RFS annual cellulosic biofuel volume obligations in the near future. According to many, the crux of the matter could be that a lack of cellulosic biofuel production may eventually jeopardize the entire advanced biofuel component of the RFS. Year after year, the same reasons are given as to why production has stagnated—technological setbacks, lack of financing, etc. Additionally, uncertainty is a recurring theme both for cellulosic biofuel production and RFS implementation. Some observers maintain that it is questionable whether the industry will make substantial progress toward the goals that Congress established, unless consistent steps are taken by all stakeholders, including clear direction from Congress; prompt program implementation by the EPA; assured financial and technical support from USDA and DOE; and investment from the private sector.

[102] Email from Ashley Martin, USDA, March 1, 2013.

[103] BCAP receives its authorization from Title IX of the Farm Security and Rural Investment Act of 2002 (P.L. 107-171) and was amended by Title IX of the Food, Conservation, and Energy Act of 2008 (P.L. 110-246). For more information on BCAP, see CRS Report R41296, *Biomass Crop Assistance Program (BCAP): Status and Issues*.

[104] BCAP project areas are specific geographic areas where producers may enroll land to grow specified biomass crops. Participants may be eligible to receive financial and technical assistance as well as annual payments to establish these crops.

Author Contact Information

(name redacted)
Specialist in Agricultural Conservation and Natural Resources Policy
[redacted]@crs.loc.gov , 7-....