Meeting the Renewable Fuel Standard (RFS) Mandate for Cellulosic Biofuels: Questions and Answers

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Summary

The Renewable Fuel Standard (RFS) was expanded under the Energy Independence and Security Act of 2007 (EISA; P.L. 110-140) in an effort to reduce dependence on foreign oil, promote biofuel use, and stabilize transportation fuel prices, among other goals. Over a 15-year period, the RFS seeks to establish a market for biofuels in the transportation sector by requiring that increasing amounts of biofuels—36 billion gallons by 2022—be blended into transportation fuel. The mandate is to be accomplished with an assortment of advanced biofuels, including cellulosic biofuels—fuels produced from cellulosic materials including grasses, trees, and agricultural and municipal wastes—which will ramp up over time to comprise some 44% of the RFS in 2022.

The U.S. Environmental Protection Agency (EPA) is required to lower the cellulosic biofuel standard if the projected volume of cellulosic biofuel production is less than the volume specified in the statute. The cellulosic biofuel allotment in the mandate, as established by Congress in EISA, was 100 million gallons due in 2010, 250 million gallons in 2011, and 500 million gallons in 2012, increasing to 16 billion gallons by 2022. However, analysis suggested the United States did not have sufficient cellulosic biofuel production capacity to meet the RFS mandate for 2010, 2011, and 2012. As a result, EPA lowered the RFS cellulosic biofuel mandate (actual volume) to 5 million gallons in 2010, 6.6 million gallons in 2011, and 8.65 million gallons in 2012. The cellulosic biofuel community may fare better at achieving the lower mandates set and proposed by EPA if certain obstacles are overcome. Roadblocks include unknown levels of feedstock supply, expensive conversion technology that has not yet been applied commercially, and insufficient financial support from private investors.

EPA reports that very few, if any, facilities are consistently producing cellulosic biofuel for commercial sale. Some financial support from the Departments of Energy and Agriculture is available to expedite cellulosic biofuel production. For example, the Biomass Crop Assistance Program (BCAP), created under the Food, Conservation, and Energy Act of 2008 (2008 farm bill; P.L. 110-246), is designed to support establishment and production of 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 material for use in a biomass conversion facility. Also, the Department of Energy's Loan Guarantee Program, created under the Energy Policy Act of 2005 (EPAct05, P.L. 109-58), distributes loan guarantees to eligible commercial-scale renewable energy systems, including cellulosic biofuel plants, although criticisms have been raised that the program has been slow to get started.

Many questions regarding cellulosic biofuels and the RFS may arise as the 112th Congress engages in energy legislation debates. EPA compliance data indicate that there was no commercial production of cellulosic biofuel under the RFS for 2010. Results for 2011 are still unclear. Can and will the 2012 and future RFS mandates for cellulosic biofuels be met? What impact will the continued lowering of the cellulosic ethanol mandate have on investment in cellulosic ethanol production? Should the 112th Congress continue to provide support for U.S. cellulosic biofuel production, and if so, how? This report, in a question and answer format, discusses some of the concerns facing the cellulosic biofuel community, including feedstock supply estimates, and potential legislative options to address cellulosic biofuel production uncertainty for the RFS.

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Introduction

The Renewable Fuel Standard (RFS) mandates that domestic transportation fuel contain a specified volume of biofuels, including advanced biofuel, cellulosic biofuel, and biomass-based diesel.[1] The RFS requires that increasing amounts of biofuels be included in transportation fuel over a 15-year period, with the goal of using 36 billion gallons of biofuels annually by 2022. The mandate is to be accomplished in large part with cellulosic biofuels. Congress in the Energy Independence and Security Act of 2007 (EISA; P.L. 110-140) mandated cellulosic biofuel standards that began with 100 million gallons in 2010, 250 million gallons in 2011, and 500 million gallons in 2012, and increased to 16 billion gallons by 2022. The scheduled 2012 cellulosic biofuels mandate would have constituted 3% of the RFS, gradually ramping up to constitute 44% of the RFS in 2022. Because of a lack of U.S. production capacity, the U.S. Environmental Protection Agency (EPA), in successive years, issued final rules under its waiver authority for the RFS established in EISA, which lowered the 2010 cellulosic biofuel mandate (actual volume) to 5 million gallons,[2] the 2011 mandate to 6.6 million gallons,[3] and the 2012 mandate to 8.65 million gallons.[4]

A concern for the 112th Congress may be whether enough cellulosic biofuel can be produced to satisfy the RFS mandate in future years. A lack of cellulosic feedstock supply, financial assistance, and technology advancement are considered among the most pressing issues that could inhibit cellulosic biofuel production. More than four years after EISA was enacted, progress toward meeting the cellulosic biofuels mandate has been delayed on multiple fronts (e.g., financial, administrative, and technical). With the reduction in the RFS cellulosic biofuel mandate levels in each of the first three years, Congress may reconsider the configuration of the RFS, determine whether additional resources are necessary for cellulosic biofuel production, and assess the success rate of this effort compared to other renewable energy efforts.

What Are Cellulosic Biofuels?

Cellulosic biofuels are liquid, solid, or gaseous fuels made from cellulose material. 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), energy crops (e.g., switchgrass), tree crops (e.g., hybrid poplar), and urban sources of waste (e.g., municipal solid waste).

[1] The RFS was expanded under the Energy Independence and Security Act of 2007 (EISA; P.L. 110-140). For more information on the expanded RFS, see CRS Report R40155, *Renewable Fuel Standard (RFS): Overview and Issues*, by Randy Schnepf and Brent D. Yacobucci.

[2] U.S. Environmental Protection Agency, "Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule," 75 *Federal Register*, March 26, 2010.

[3] U.S. Environmental Protection Agency, "Regulation of Fuels and Fuel Additives: 2011 Renewable Fuel Standards; Final Rule," *Federal Register*, December 9, 2010.

[4] U.S. Environmental Protection Agency, *EPA Finalizes 2012 Renewable Fuel Standards*, EPA-420-F-11-044, December 2011, EPA-420-F-11-044.

The most widely discussed cellulosic biofuel is cellulosic ethanol for transportation.[5] Cellulosic ethanol differs from the corn ethanol currently blended into transportation fuel; it is made from feedstock with no food value, potentially results in fewer greenhouse gas emissions, and has a higher energy balance.[6] Converting cellulosic feedstock to ethanol, however, is more expensive and difficult than converting corn 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).[7]

Analysis suggests that increased use of cellulosic biofuels for transportation could potentially help to reduce U.S. dependence on foreign oil, stabilize energy prices, strengthen rural infrastructure, and improve the environment. In addition, cellulosic feedstocks may fare better in the food-energy debate, since crop residue, and not the crop itself, is used for cellulosic biofuel production. Some contend, however, that cellulosic biofuels require a substantial feedstock supply that has yet to be verified, may be in competition for use as a biopower feedstock, may cause environmental degradation (e.g., by removing residues that furnish nutrients and stability to the soil),[8] and may hinder efforts to promote energy efficiency.

What Is the Relationship Between Cellulosic Biofuels and the Renewable Fuel Standard?

The RFS established in Section 202 of EISA called for 100 million gallons of cellulosic biofuels to be included in the national transportation fuel supply in 2010, and the mandate increases to 16 billion gallons by 2022.[9] Data and analysis presented during the RFS debate and ultimate passage of EISA in 2007 supported the idea that these levels of cellulosic biofuel production capacity would be achievable. Some reasoned that plentiful feedstock was available[10] and that the conversion technology was on the brink of being certified 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.[11] Others were

[5] For more information on cellulosic biofuels, see CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*, by Kelsi Bracmort et al.

[6] For more information on ethanol, see CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*, by Brent D. Yacobucci.

[7] Cellulose feedstocks can also be used to provide heat or generate electricity via gasification, combustion, anaerobic digestion, and other conversion processes. For more information on anaerobic digestion, see CRS Report R40667, *Anaerobic Digestion: Greenhouse Gas Emission Reduction and Energy Generation*, by Kelsi Bracmort.

[8] R. M. Cruse and C .G. Herndl, "Balancing Corn Stover Harvest for Biofuels with Soil and Water Conservation," *Journal of Soil and Water Conservation*, vol. 64, no. 4 (July/August 2009), pp. 286-291.

[9] For more information on the RFS, see CRS Report R40155, *Renewable Fuel Standard (RFS): Overview and Issues*, by Randy Schnepf and Brent D. Yacobucci.

[10] 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.

[11] 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, (continued...)

leery about the time frame provided to meet the RFS cellulosic biofuel mandate given capacity restrictions, weather impacts, and uncertainty about technology advancements.[12]

EPA has the authority to waive completely or in part the cellulosic biofuel consumption mandates established in EISA, given certain circumstances.[13] For instance, the Administrator may waive the cellulosic biofuel requirement if the Administrator determines, after public notice and opportunity for comment, that there is an inadequate domestic supply.[14] EPA generally conducts its cellulosic biofuel volume assessment by using publicly available information and information provided by the Departments of Energy and Agriculture, and by monitoring the funding, production, and construction status of select companies with planned and existing cellulosic biofuel facilities,[15] among other methods.

The 2010 renewable fuel standard for cellulosic biofuels was originally 100 million gallons. In March 2010, EPA lowered the 2010 cellulosic biofuel mandate to 5 million gallons (actual volume) with the issuance of a waiver that expired after one year.[16] The 2011 renewable fuel standard for cellulosic biofuels was originally 250 millions gallons. However, in November 2010, EPA lowered the mandate to 6.6 million gallons (actual volume).[17] The 2012 renewable fuel standard for cellulosic biofuels was originally 500 million gallons. In December 2011, EPA announced it will lower the mandate to 8.65 million gallons (actual volume). EPA estimates that six facilities can make volumes of cellulosic biofuels available for transportation use in 2012.

What Challenges Are Associated with Cellulosic Biofuels Production?

Since the RFS was expanded under EISA to include 250 million gallons of cellulosic biofuel starting in 2011,[18] U.S. cellulosic biofuel production has had a slow start. Impediments to increasing capacity to meet the cellulosic biofuel mandate include technology setbacks, escalating prices for certain feedstocks, lack of feedstock availability, and delayed financial support. Limited access to capital has been indicated as one of the primary reasons that timely completion of many cellulosic biofuel plants has stalled. Commercial cellulosic biofuel facilities are estimated to cost

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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.

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

[13] For more information on EPA's waiver authority, see CRS Report RS22870, *Waiver Authority Under the Renewable Fuel Standard (RFS)*, by Brent D. Yacobucci.

[14] 42 U.S.C. 7545(o)(7).

[15] EPA reports that it is tracking the progress of more than 100 biofuel production facilities.

[16] U.S. Environmental Protection Agency, "Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule," 75 *Federal Register*, March 26, 2010.

[17] U.S. Environmental Protection Agency, "Regulation of Fuels and Fuel Additives: 2011 Renewable Fuel Standards; Final Rule," *Federal Register*, December 9, 2010.

[18] The original RFS established by § 1501 of EPAct05 required 4.0 billion gallons of renewable fuel for 2006, ascending to 7.5 billion gallons by 2012. The original RFS would have required that 250 million gallons of the renewable fuel be derived from cellulosic biomass starting in 2013.

hundreds of millions of dollars (see **Table 1**), roughly three times as much as a corn ethanol plant. 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 large scale.[19]

Table 1. Selected Examples of Cellulosic Ethanol Plant Cost Estimates, 2010

Company	Production Capacity (mgy)	Feedstock Required	Capital (millions)
BlueFire (California Plant)[a]	3.9	190 wet tons/day of post-sorted municipal solid waste	$120
BlueFire (Mississippi Plant)[a]	19	550 tons/day of wood waste (mostly forest residues)	$250
Enerkem (Mississippi Plant)[b]	10	300 dry tons/day of post-sorted municipal solid waste	$118
POET (Iowa Plant)[c]	25	770 dry tons/day (mostly corncobs with some corn residue)	$200
ZeaChem Inc. (Oregon Plant)[d]	0.25	10 dry tons/day of hybrid polar trees	$73

Source: Compiled by CRS.

Notes: In comparison, a 40 mgy corn ethanol plant costs approximately $80 million to construct in 2006.[20]

a. Conversation with Arnold Klann from BlueFire Ethanol Inc., February 2, 2010.

b. E-mail from Marie-Helene Labrie of Enerkem, February 3, 2010.

c. Conversation with Jim Sturdevant from POET, February 2, 2010.

d. Conversation with Carrie Atiyeh from ZeaChem Inc., February 2, 2010.

The federal government provides financial assistance primarily through two programs. To help increase investment in cellulosic biofuel production technologies, the government established the Department of Energy (DOE) Loan Guarantee Program (LGP).[21] Loans may not exceed 80% of total project costs. Over 90% of the projects that have received funding to date are pilot- or demonstration-scale projects that are seen as likely to become a commercial technology.[22] Some are concerned that the LGP is not being carried out at a pace responsive to market momentum for

[19] For more information on federal spending for cellulosic biofuels, see CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*, by Kelsi Bracmort et al.

[20] 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.

[21] 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 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. Funding information for the loan guarantee program is provided in CRS Report R41150, *Energy and Water Development: FY2011 Appropriations*, coordinated by Carl E. Behrens.

[22] DOE considers a bioenergy project commercial-scale if it converts, at a minimum, 700 tons of biomass per day to energy. Dan Tobin, "Biomass Summit," *The DOE Loan Guarantee Program: A Status Report*, Washington, DC, October 20, 2009.

cellulosic biofuels.[23] The Government Accountability Office (GAO) reviewed DOE's execution of the Loan Guarantee Program and recommended that DOE develop performance goals reflecting the LGP's policy goals and activities; revise the loan guarantee process to treat applicants consistently unless there are clear, compelling grounds not to do so; and develop mechanisms for administrative appeals and for systematically obtaining and addressing applicant feedback.[24]

The second federal government program, focused on feedstock development, is the U.S. Department of Agriculture's (USDA's) Biomass Crop Assistance Program (BCAP).[25] The two main program components 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 material for use in a biomass conversion facility. USDA issued the BCAP final rule on October 27, 2010, implementing both program components. Some have concerns regarding the program's eligibility requirements, sustainability, and funding.

Additionally, the government provides a tax credit to support cellulosic ethanol production. The 2008 farm bill offers a production credit of $1.01 per gallon of ethanol produced from qualifying cellulosic feedstocks.[26] The credit is set to expire at the end of 2012. Previously, the value of the credit was reduced by the amount of the volumetric ethanol excise tax credit (VEETC) and the small ethanol producer credit, both of which expired December 31, 2011.[27] The cellulosic ethanol producers should be able to claim the full credit of $1.01 per gallon.

In addition to financing issues, other challenges to cellulosic biofuel production include multiple definitions of biomass in various laws. The renewable biomass definition for the RFS under EISA does not allow biomass removal from federal lands, and excludes crops from forested lands.[28] Some argue that opening up federal lands for biomass removal 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. The definition of biomass under EISA also excludes most municipal solid waste (MSW), which some view as a potential source for conversion to biofuels.

[23] 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.

[24] U.S. Government Accountability Office, *Further Actions Are Needed to Improve DOE's Ability to Evaluate and Implement the Loan Guarantee Program*, GAO-10-627, July 2010, http://www.gao.gov/new.items/d10627.pdf.

[25] 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*, by Randy Schnepf, or visit http://www.fsa.usda.gov/FSA/webapp?area=home&subject=ener&topic=bcap.

[26] For more information on the blender tax credit, see CRS Report RL34130, *Renewable Energy Programs in the 2008 Farm Bill*, by Randy Schnepf.

[27] For more information, see CRS Report R40110, *Biofuels Incentives: A Summary of Federal Programs*, by Brent D. Yacobucci.

[28] For more information on biomass definitions, see CRS Report R40529, *Biomass: Comparison of Definitions in Legislation Through the 111th Congress*, by Kelsi Bracmort and Ross W. Gorte.

Also challenging for cellulosic biofuel production are the time periods of feedstock contracts. Agricultural and forestry producers may not agree to a contract that requires a lengthy time commitment. For example, it generally takes three years for switchgrass crops to reach maturity.[29] A producer may have to commit his land to one particular cellulosic feedstock crop for a number of years, thus limiting the producer's choice to grow certain crops on an annual basis depending upon market demand.

Were the Revised 2010 and 2011 RFS Mandates for Cellulosic Biofuels Met? Will the 2012 Cellulosic Biofuel Mandate Be Met?

Even before enactment of EISA, reported production data indicated that overcoming any or all of the hurdles to increase cellulosic biofuel production to meet the original 2010 RFS mandate of 100 million gallons set by Congress was unlikely. Compliance for the 2010 cellulosic biofuels mandate is difficult to ascertain as the year 2010 was a transition year for the RFS, going from the RFS first established under EPAct05, RFS1, to the RFS established under EISA, RFS2.[30] RFS1 had different cellulosic biofuels production requirements[31] than RFS2 and had a 2.5-to-1 ratio where each gallon of cellulosic ethanol counted as 2.5 gallons toward the EPAct05 mandate. Based on EPA Moderated Transaction System (EMTS) data (reported only July 1 to December 31) on RFS2 renewable identification numbers (RINS), zero RINs or production volume were registered for the 2010 RFS2 cellulosic biofuel mandate of 6.5 million gallons ethanol equivalent volume (5 million gallons actual volume).[32] However, the design of the RFS2 transition program allowed for RFS1 cellulosic RINs to be used towards compliance under the RFS2 program. Therefore, it is possible that compliance with the 2010 standards could have been satisfied in whole or in part with the RFS1 cellulosic RINs. [33] Also, the statute allows companies to purchase cellulosic biofuel waiver credits[34] in lieu of submitting RINs in years when EPA lowers the mandate. Compliance with 2010 standards could have been met with the purchase of cellulosic biofuel waiver credits. For 2010, EMTS records indicate that 12,186 cellulosic biofuel waiver

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

[30] Congress first established an RFS with the enactment of the Energy Policy Act of 2005 (EPAct, P.L. 109-58). This initial RFS is referred to as RFS1. Two years later, the Energy Independence and Security Act of 2007 (EISA, P.L. 110-140) expanded the biofuels mandate. This expanded RFS is referred to as RFS2.

[31] The original RFS (RFS1) did not require a cellulosic biofuel production volume until 2013, when 250 million gallons were mandated.

[32] EMTS is a system that manages renewable identification number (RIN) transactions under the RFS. As of July 1, 2010, the RFS2 regulations require renewable fuel producers and importers, gasoline and diesel refiners, renewable fuel exporters, RIN owners, and any other RFS2 regulated party to submit all RIN generation information and other RIN transactions to EMTS. Using data generated from EMTS, EPA provides aggregated monthly data on RIN generation and renewable fuel volume production for specific fuel categories, such as cellulosic biofuel. 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. See http://www.epa.gov/oms/fuels/renewablefuels/compliancehelp/rfsdata.htm#2010.

[33] CRS could find no record of RFS1 cellulosic RINs being used to meet compliance for the 2010 cellulosic biofuels mandate.

[34] 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.

credits were purchased.[35] Total cellulosic biofuel waiver credits available for purchase are to be equal to the reduced cellulosic biofuel volume established by EPA for the compliance year.[36] Therefore, the 2010 waiver credits purchased are significantly below the volume established by EPA for the 2010 cellulosic biofuel mandate.

Currently, EMTS is not depicting any cellulosic biofuel registered thus far toward the 2011 mandate of 6.6 million gallons (for the time period January through October 2011).[37] Compliance for 2011 may come through use of waiver credits instead of through the use of cellulosic biofuel RINs. The 2010, 2011, and 2012 price for a cellulosic biofuel waiver credit is $1.56, $1.13, and $0.78 per credit, respectively.

In its 2012 RFS final rule, EPA projected that the 2012 cellulosic biofuel production mandate will be met primarily by six companies: American Process Inc., Fiberight, INEOS Bio, KiOR, KL Energy, and ZeaChem.[38] Anticipated fuel production to meet the 2012 mandate is provided in **Table 2**. According to EPA, roughly 8.65 million gallons of cellulosic biofuel could be available in 2012, assuming there are no further construction or financing delays, and if pathways for certain cellulosic fuels to register under the RFS2 are approved by EPA.EPA acknowledges that the "task of projecting the volume of cellulosic biofuel production for 2012 remains a difficult one."[39] Cellulosic biofuel producers "face not only the challenge of the scale up of innovative, first-of-a-kind technology, but also the challenge of securing funding in a difficult economy."[40] Further, these companies will need to be able to sell the fuel at $0.78 per gallon wholesale to compete with the waiver credits. Thus delivered cost for the producer should be less than $1.79, which equals the $1.01 tax credit plus the $0.78 waiver credit. Thus, some argue, it is difficult to state with certainty how much cellulosic biofuel will be produced and over what time frame.

Table 2. Projected 2012 RFS Cellulosic Biofuel Available Volume

Company Name	Fuel	Capacity (million gallons/year)	Earliest Production	2012 Projected Available Volume (million gallons)	Ethanol Equivalent (million gallons)
American Process Inc.	Ethanol	0.9	Early 2012	0.5	0.5
Fiberight	Ethanol	6.0	Early 2012	2.0	2.0
INEOS Bio	Ethanol	8.0	May 2012	3.0	3.0
KiOR	Gasoline, Diesel	10.0	Mid 2012	3.0	4.8
KL Energy	Ethanol	1.5	Online	0.1	0.1
ZeaChem	Ethanol	0.25	Early 2012	0.05	0.05

Source: EPA, *Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, Final Rule*, December 22, 2011, http://www.epa.gov/otaq/fuels/renewablefuels/documents/rfs-2012-standards-final-rule.pdf.

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

[36] 40 CFR 80.1456.

[37] EPA EMTS data for cellulosic biofuel available at http://www.epa.gov/otaq/fuels/rfsdata/2011emts.htm.

[38] U.S. Environmental Protection Agency, *EPA Finalizes 2012 Renewable Fuel Standards*, EPA-420-F-11-044, December 2011.

[39] U.S. Environmental Protection Agency, "Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards; Proposed Rule," 76 *Federal Register* 38844-38890, July 1, 2011.

[40] Ibid.

What Impact Will Significantly Lowering the 2010, 2011, and 2012 RFS Mandates Have on Investment in Cellulosic Biofuel Production?

As noted above, EPA has the authority to waive the cellulosic biofuel mandate on a yearly basis. Indeed, EPA issued a waiver to substantially lower the 2010, 2011, and 2012 cellulosic biofuel mandates. Further, in any year that EPA grants a waiver, the agency must also make waiver credits available at a set price. EPA's waiver authority creates uncertainty for investors in cellulosic biofuel ventures. Investors may fear that the full cellulosic biofuel mandate will never be required by EPA. If investors are reluctant to invest in cellulosic biofuels, mandates may not be met. And policymakers may regard this investment factor, among others, as a reason to question the need for an RFS. Furthermore, the waivers and subsequent cellulosic biofuel waiver credits may also be undercutting the market.

Some lenders may deny financing due to lack of confidence in federal support for cellulosic biofuels.[41] If the cellulosic biofuel community was unable to produce 5% of the cellulosic biofuel mandate, as established in EISA, for its first year of inclusion in the RFS (in 2010), some may wonder about the viability of this advanced biofuel type over the long term.[42] Others contend that the cellulosic biofuel community hit a stumbling block mainly due to a bad economy, and that production will dramatically increase over the coming years.[43]

How Much Cellulosic Feedstock Exists for Conversion to Biofuels?

A significant criterion in evaluating whether a commercial cellulosic biofuel production plant will be a favorable investment is whether a steady feedstock supply exists at a location suitable to the biorefinery.[44] However, determining actual availability of feedstock is difficult. Quantifying feedstock available for conversion to biofuels requires information about feedstock sources, production rates, accessibility, and location restrictions (e.g., public versus private lands if the feedstock is to be used for certain energy purposes). Investors must make feedstock predictions based on data from weather patterns and land use change, as well as handling, storage, and transportation costs, among other things. This is a particularly important problem where a growth season of four to five months must provide biomass feedstock for 12 months of plant operation.[45]

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[41] Dan Chapman, "Bio Energy Backers Stay Upbeat Despite Setbacks," *Atlanta Journal-Constitution* , January 13, 2010.

[42] Russel Gold and Siobhan Hughes, "Biofuel Production Fall Far Short of Targets," *Wall Street Journal*, February 4, 2010.

[43] Renewable Fuels Association, "Obama Administration on Right Track with Biofuels," press release, February 3, 2010, http://renewablefuelsassociation.cmail1.com/T/ViewEmail/y/9C2814171DC11FF6/F83B91963160BD91C5EC08CADFFC107B.

[44] A biorefinery is a facility that processes biomass into biofuels.

[45] One company, POET, has devised a feedstock supply plan whereby the feedstock will be stored by the producer, under a four-year contract, and delivered to the biorefinery as needed. Jim Lane, "Should the Renewable Fuel Standard be Scrapped, or Revised?" *Biofuels Digest*, November 2, 2011, http://biofuelsdigest.com/bdigest/2011/11/01/are-you-

(continued...)

To make the supply available throughout the year, special equipment may be required for feedstock harvest, handling, collection, storage, or transport, as cellulosic feedstock is often too bulky for average farming equipment to handle.

The amount of cellulosic feedstock necessary for conversion to a biofuel depends on the feedstock type, the conversion process, and the desired biofuel (see **Table 3**). Biofuel conversion yield is measured in gallons per ton. Feedstock, or crop, yield is measured in tons per acre. Total yield, measured in gallons per acre, depends on both the feedstock yield and the conversion yield. Yields are much higher on prime cropland than on marginal lands. However, if cellulosic feedstocks are produced on prime cropland, then they become vulnerable to the food-versus-fuel debate because they could crowd out food crops.

Table 3. Theoretical Ethanol Production Yields for Selected Feedstocks

Feedstock	Ethanol (gallons per dry ton of feedstock)
Corn Grain	124.4
Corn Stover	113.0
Rice Straw	109.9
Cotton Gin Trash	56.8
Forest Thinnings	81.5
Hardwood Sawdust	100.8
Bagasse	111.5
Mixed Paper	116.2
Switchgrass	96.7

Source: U.S. Dept. of Energy, Biomass Program, http://www1.eere.energy.gov/biomass/ethanol_yield_calculator.html and U.S. Dept. of Energy, National Ethanol Feedstock Resources, http://www.afdc.energy.gov/afdc/ethanol/feedstocks_resources_national.html.

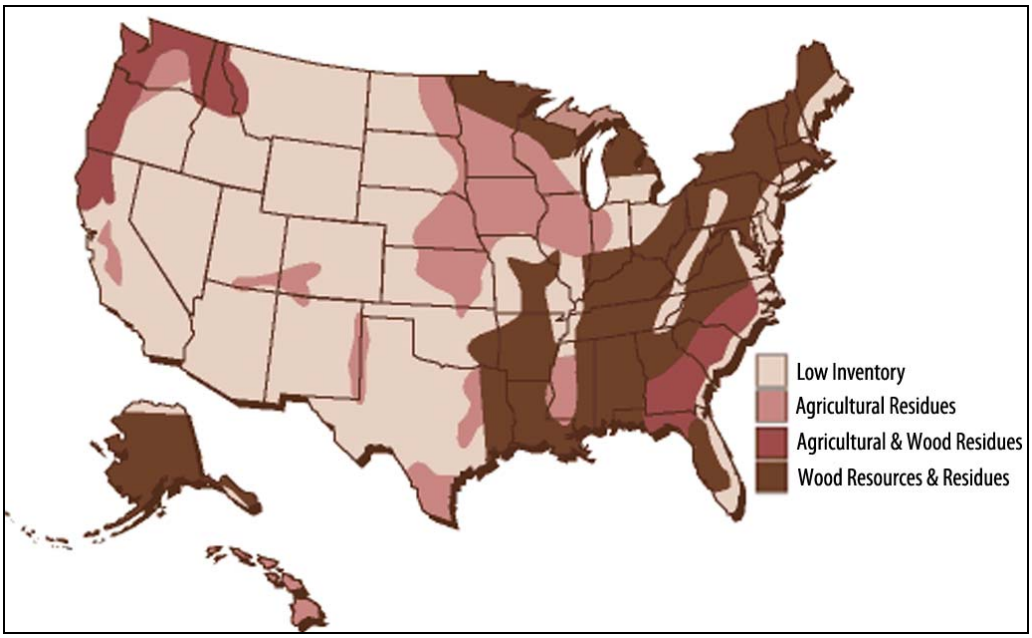
Note: Actual yield commonly ranges from 60% to 90% of theoretical yields.

Some argue that current estimated cellulosic feedstock yields will need to increase markedly over the next decade to meet the RFS mandate of 16 billion gallons of cellulosic biofuel production per year by 2022. Others contend that a significant growth of cellulosic feedstock is not essential, as advances in conversion technologies will afford the opportunity to produce more cellulosic biofuel with less feedstock. If cellulosic feedstock yields do increase, the traditional geographic areas for feedstock cultivation may be subject to additional energy, environmental, and agricultural policy scrutiny (see **Figure 1**).

(...continued)

any-less-worried-about-energy-security-today-than-you-were-4-years-ago-asks-bp/.

Figure 1. Geographical Areas with Biomass Resources



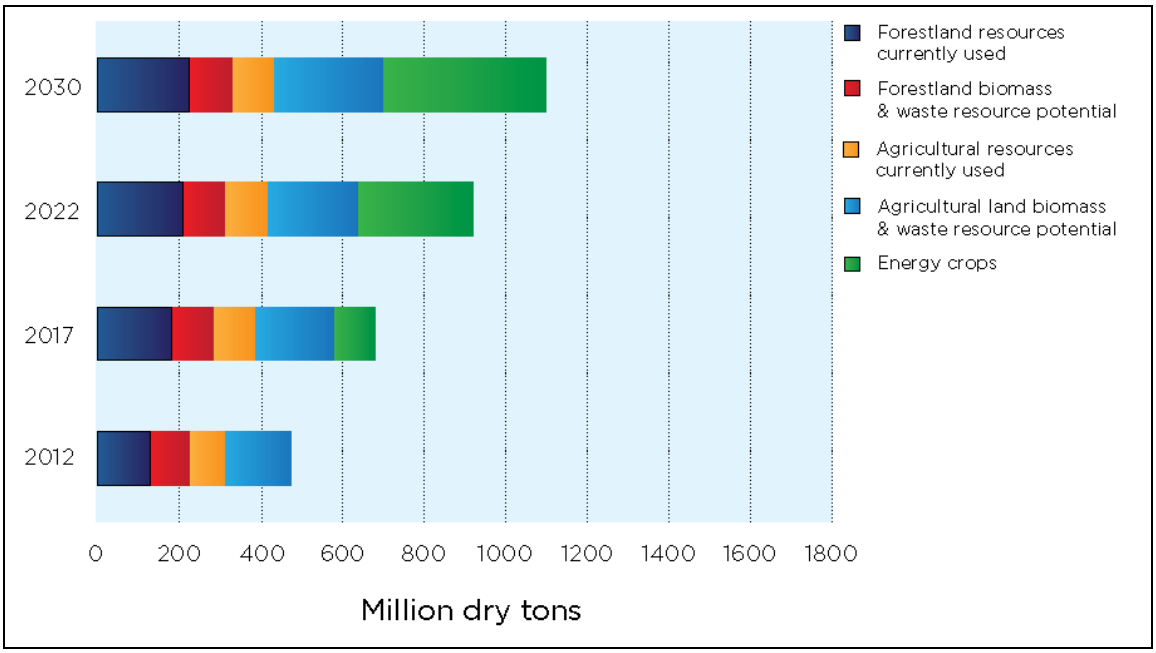
Source: U.S. Department of Energy, http://www.energysavers.gov/images/biomass_map.gif.

Few studies have estimated the current or long-term cellulosic feedstock supply available for conversion to biofuels on a national basis.46 DOE reports 473 to 555 million dry tons (at $60 per dry ton or less) of used and potential forest and agricultural biomass available in 2012 (see Figure 2 and Figure 3).47 Moreover, DOE reports that 1.1 to 1.6 billion dry tons of used and potential forest and agricultural biomass could be available in 2030 (at $60 per dry ton or less).

[46] The estimates provided in each study are based on numerous assumptions and modeling techniques unique to each study. Some of the commonly cited studies include U.S. Department of Energy, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, ORNL/TM-2011/224, August 2011, http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf; National Academy of Sciences, *Renewable Fuel Stadard: Potential Economic and Environmental Effects of U.S. Biofuel Policy*, 2011, http://www.nap.edu/catalog.php?record_id=13105; DOE, USDA, *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; National Academy of Sciences, National Academy of Engineering, National Research Council, *Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs, and Environmental Impacts*, Washington, DC, 2009, http://www.nap.edu/catalog.php?record_id=12620; Sandia National Laboratories, *90-Billion Gallon Biofuel Deployment Study*, February 2009, http://hitectransportation.org/news/2009/Exec_Summary02-2009.pdf; and Biomass Research and Development Initiative, *Increasing Feedstock Production for Biofuels Economic Drivers, Environmental Implications, and the Role of Research*, December 2008, http://www.brdisolutions.com.

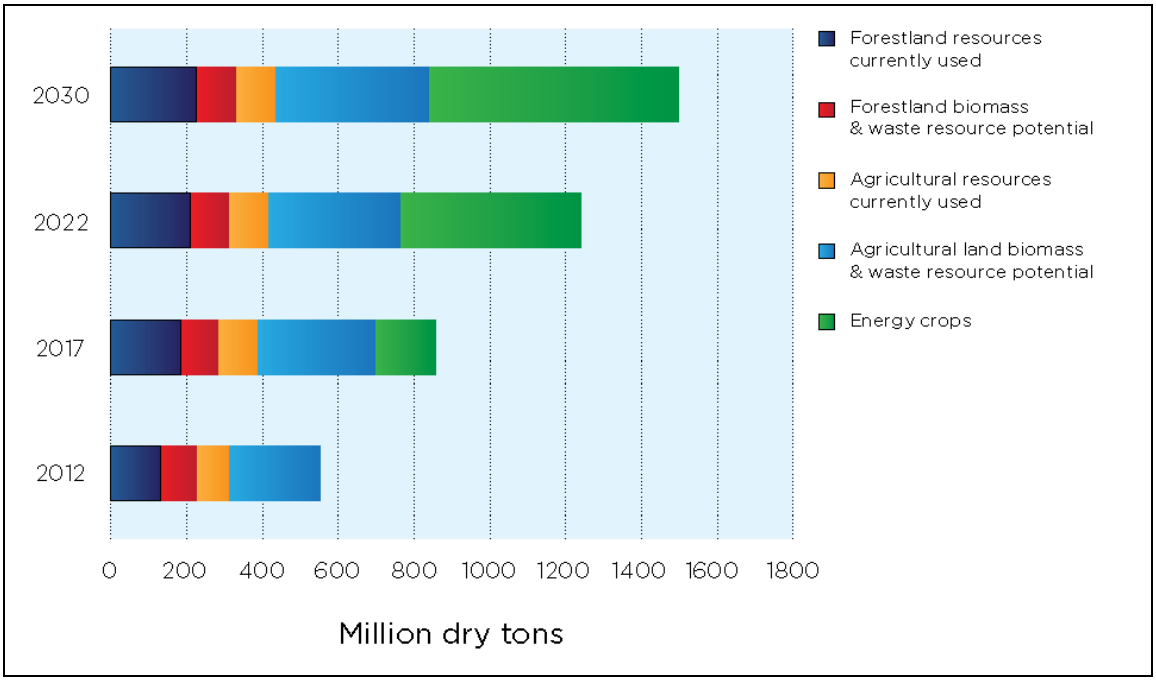
[47] U.S. Department of Energy, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, ORNL/TM-2011/224, August 2011, http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf

Figure 2. Summary of Currently Used and Potential Biomass Resources at $60 per Dry Ton or Less Identified Under Baseline Assumptions



Source: U.S. Department of Energy, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, ORNL/TM-2011/224, August 2011, http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf

Figure 3. Summary of Currently Used and Potential Biomass Resources at $60 per Dry Ton or Less Identified Under High-Yield Assumptions



Source: U.S. Department of Energy, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, ORNL/TM-2011/224, August 2011, http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf

How Many Commercial Cellulosic Biofuel Plants Exist?

EPA reports that very few, if any, facilities are consistently producing cellulosic biofuel for commercial sale.[48] There are a few operational plants.[49] In its final rule, EPA provides information on potential 2012 cellulosic biofuel plants including biofuel production estimates, technology process, and anticipated start dates.[50] As observed over the last few years, due to unforeseen financial and technical issues, it can be difficult to gauge when or if cellulosic biofuel companies will actually come online and how much cellulosic biofuel will be produced. Approximately two dozen demonstration- or pilot-scale cellulosic ethanol plants are reported to exist currently in the United States.[51]

What Policy Options Are Available to Meet the Congressionally Mandated RFS for Cellulosic Biofuels?

Some legislative options were introduced in the 111th Congress to address the limited cellulosic biofuel production capacity for the RFS.[52] Other possible options available to Congress include lowering the cellulosic biofuel mandate, modifying the definition of cellulosic biofuel (S. 1185), terminating the RFS (e.g., H.R. 424), modifying 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 (e.g., H.R. 230), implementing new financial support mechanisms, extending relevant tax provisions (e.g., H.R. 851, H.R. 2231, S. 884, S. 1294), or making federal lands available for biomass removal. Cellulosic biofuel advocates may find it beneficial for Congress to make the cellulosic biofuel mandate more

[48] U.S. Environmental Protection Agency, "Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards; Proposed Rule," 76 *Federal Register* 38844-38890, July 1, 2011.

[49] KL Energy and Range Fuels have both both registered cellulosic biofuel production facilities under the RFS program and are eligble to generate cellulosic biofuel RINS. EPA reports that Range Fuels recently shut down to work through technical difficulties.

[50] Environmental Protection Agency, *Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, Final Rule*, December 22, 2011, http://www.epa.gov/otaq/fuels/renewablefuels/documents/rfs-2012-standards-final-rule.pdf..

[51] 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; 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.

[52] The 111th Congress considered legislation that would have affected cellulosic biofuel production if enacted. Section 129 of the American Clean Energy and Security Act of 2009 (H.R. 2454, also known as Waxman-Markey) would have amended the Loan Guarantee Program to incorporate renewable fuel pipeline construction.52 Title I of the American Clean Energy Leadership Act of 2009 (ACELA, S. 1462) would have amended the Loan Guarantee Program and created a Clean Energy Deployment Administration, under DOE, to advance lending and implementation of commercial clean energy technologies. H.R. 2283 and S. 943 would have waived the lifecycle greenhouse gas emission reduction requirements for renewable fuel production.

attainable in the near term (e.g., two to five years). Opponents may view any additional congressional action to assist the cellulosic biofuel community as harmful to the entire renewable energy market in the long run.

EPA is responsible for implementing the RFS and revising the RFS when necessary. Congress monitors EPA's implementation of the RFS. EPA's initial waiver was issued for the first year that cellulosic biofuel was to contribute to the advanced biofuels portion of the RFS, and subsequent waivers were issued for the following two years. Whether the cellulosic biofuel industry can scale up production to meet the RFS targets in coming years is unclear.

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