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Created by the Energy Policy Act of 2005 and substantially amended by the Energy Independence and Security Act of 2007, the Renewable Fuel Standard (RFS) mandates an increasing amount of fuel from renewable sources that must be blended into the transportation fuel supply of the United States. Starting in 2008, RFS began with a mandated volume of nine billion gallons. By 2022, RFS requires blending 36 billion gallons of renewable fuel. Thus, in a little over a decade, RFS requires the amount of renewable fuel to quadruple.

Meeting the targets of RFS would make substantial strides in energy security and independence, and provide the expected environmental and economic benefits. However, biofuels are not free from controversy. Most notably, opponents of biofuels criticize diverting crops from human consumption to fuel production, the food versus fuel debate. The issue has been frequently studied (with opposing results) and fervently debated, while the implementation of RFS and the recent summer drought increased the interest and controversy surrounding this issue.

This Essay does not seek to definitively resolve the food versus fuel debate. Focusing specifically on RFS, the Essay highlights and examines many non-food crops and feedstock considered by RFS. In fact, many non-food crops and feedstock have already been approved: crop residue, municipal solid waste, camelina, wood waste, waste oils, algae, switchgrass, and biogas from landfills and digesters. By exploring these options, this Essay will show that RFS does not require sound food and energy policy to conflict.

Part I of this Essay introduces the food versus fuel controversy. As an introduction to the Renewable Fuel Standard, Part II explores RFS goals, explains key terms, identifies qualifying fuels, and describes the overall regulatory structure. Expanding upon the basics of RFS, Part III examines the current mandate, current production, future mandates, and expected future production projections. By carefully weighing RFS structure, current production, and future projections, Part III demonstrates the extent that non-food fuels can be utilized to meet the goals of RFS. Therefore, Part IV concludes that non-food crops hold enormous potential and can play a major and non-controversial role in the energy policy of the United States, minimizing the impact on food policy. With carefully crafted biofuel policy, like RFS, the United States can meet its energy needs without jeopardizing its food supply.

I. FOOD VERSUS FUEL

While RFS sets forth ambitious goals to develop the U.S. biofuel industry, biofuels are not without controversy. Arising during the food crisis in 2007 and 2008, one primary concern with the production of biofuels is competition between

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crops for energy production and crops for human consumption, more commonly referred to as "food versus fuel."[1] This issue, "food versus fuel," is perhaps the most widely known controversy facing the biofuel industry.[2] Government studies, including the *Billion Ton Update*, which aimed to quantify the amount of available biomass in the U.S., note the potential effect that the increased demand for biomass can have on food supply and food prices.[3] However, the degree of the effect and even the existence of the effect have been challenged.[4]

The most recent studies have reached varying conclusions. Of note, one study found that the "food versus fuel" impact is clear in the case of ethanol, but not in the case of biodiesel.[5] In both cases, the short-term effects were determined to be minimal.[6] Another recent study noted that short-term effects are possible but long-term effects are unlikely due to market adjustments.[7] Others conclude that biofuels do increase food prices, but that they are not the main driver; instead, economic

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1. *See* Cheng Qiu et al., *Considering Macroeconomics Indicators in the Food Before Fuel Nexus*, 34 Energy Economics 2021, 2021 (Nov. 2012), *available at* http://www.sciencedirect.com/science/article/pii/S0140988312001880. More recently, the increased demand for meat has been credited for the price spikes in 2007 and 2008. Gal Hochman et al., *The Role of Inventory Adjustments in Quantifying Factors Causing Food Price Inflation* (The World Bank Dev. Research Grp. Env't & Energy Team, Working Paper No. WPS5744, 2011), *available at* http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-5744.

2. *See generally* Peter R. Hartley & Kenneth B. Medlock III, Climate Policy and Energy Security: Two Sides of the Same Coin? (May 2008) (working paper) (on file with The James A. Baker III Institute of Public Policy at Rice University), *available at* http://www.bakerinstitute.org/publications/IEEJClimatePolicy.pdf; *see Malthusiasm Returns: Is it "Food vs. Fuel," or "Progress vs. Same as it Ever Was,"* BIOFUELS DIGEST (Feb. 14, 2011), http://www.biofuelsdigest.com/bdigest/2011/02/14/malthusiasm-returns-is-it-food-vs-fuel-or-progress-vs-same-as-it-ever-was/ ("With the return of scarcity—whatever is driving it, weather or growing market demand or a combination thereof—the usual suspects have found their way back to the op-ed pages . . . .").

3. U.S. DEP'T OF ENERGY, DE-AC05-00OR22725, U.S. BILLION-TON UPDATE 25-26 (2011), *available at* http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf.

4. *See* Philip C. Abbott et al., *What's Driving Food Prices?*, FARM FOUNDATION (July 2008), http://www.farmfoundation.org/news/articlefiles/404-ExecSum8.5x11.pdf(identifying biofuel production as a force driving food price); Philip C. Abbott et al., *What's Driving Food Prices in 2011?*, FARM FOUNDATION (July 2011), http://www.farmfoundation.org/news/articlefiles/1742-FoodPrices_web.pdf(identifying the same) ; John Baffes & Tassos Haniotis, *Placing the 2006/08 Commodity Price Boom in Perspective* 2 (The World Bank Dev. Prospects Grp., Policy Research Working Paper No. 5371, 2010), *available at* http://wwwwds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2010/07/21/000158349_20100721110120/Rendered/PDF/WPS5371.pdf (concluding that there is a strong link between energy prices and non-energy commodity prices, *i.e.,* food, and that the effect of biofuels on food prices is less than previously thought) ; Zibin Zhang et al., *Food vs. Fuel: What Do Prices Tell Us?*, 38 ENERGY POLICY 445, 445-51 (2010) (determining that there are limited short-term correlations between biofuels and agricultural commodity prices and no direct long-term relations).

5. Ladislav Kristoufek et al., Relationship Between Prices of Food, Fuel, and Biofuel 15 (Sept. 182012) (paper prepared for presentation), http://ageconsearch.umn.edu/bitstream/135793/2/Kristoufek.pdf. However, another study came to the opposite conclusion that soybean price was more affected by biofuel than corn price, when factoring in cross price elasticity of soybeans and corn. *See* Gal Hochman et al., *Biofuel and Food-Commodity Prices,* 2 AGRICULTURE 272, 278 (2012), *available at* http://www.mdpi.com/2077-0472/2/3/272.

6. Kristoufek et al., *supra* note 5, at 16.

7. *See* Qiu et al., *supra* note 1.

growth was determined to be the primary driver of increased food prices.[8] Others continue to caution that biofuels could drive food prices higher, even if they are not the single cause of increased food prices.[9] Regardless of the existence or degree of the impact that biofuels have on food supply and food prices, the concern is prevalent and is not likely to vanish from the public consciousness in the near future. Thus, biofuel proponents have to learn to coexist with the "food versus fuel" controversy.[10] The Renewable Fuel Standard is not unaware of the controversy, accounting for factors relevant to those concerned about the RFS impact on food.[11]

Related to the "food versus fuel" controversy is the issue of land use change. This issue has two components: direct change and indirect change. Direct land use change is quite simple; it is the change of land from production of one crop to another, sometimes a switch from a food crop to a bioenergy crop.[12] More difficult to measure and quantify, indirect land use change is the conversion of non-agricultural land, grasslands and forests, to agricultural land to meet growing demand for agricultural products, whether for food or bioenergy.[13]

Like "food versus fuel," there is significant debate surrounding the indirect land use change (ILUC) issue; however, the concern is related to greenhouse gas emissions, not the food supply.[14] Direct land use change, though, can impact food production.

RFS directly accounts for land use change. The Environmental Protection Agency (EPA) determined that there were 402 million acres of agricultural land available in 2007.[15] The EPA will not require individual recordkeeping regarding land use unless this number is exceeded.[16] However, the EPA will conduct additional analysis if total agricultural land exceeds 397 million acres.[17] This threshold has not yet been exceeded, reaching 392 million acres in 2011.[18] In 2012, total agricultural land used in the United States decreased slightly to 384

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8. Hochman et al., *supra* note 5, at 278.

9. Mark W. Rosegrant et al., *The New Normal? A Tighter Global Agricultural Supply and Demand Relation and its Implications for Food Security*, *AM. J. AGR. ECON (2012), available at http://ajae.oxfordjournals.org/content/early/2012/05/24/ajae.aas041.full?keytype=ref&ijkey=K7CClHuXcwVYNq9*.

10. This is not to say that biofuel proponents should not continue to research the effect and continue to educate the public if the evidence does indicate that the impacts are minimal or even non-existent.

11. See discussion *infra* Section II.

12. Richard J. Plevin, et al., *Greenhouse Gas Emissions from Biofuels' Indirect Land Use Change are Uncertain but May Be Much Greater Than Previously Estimated*, 44 ENVTL. SCI. & TECH. 8015(2010), *available at* http://pubs.acs.org/doi/pdfplus/10.1021/es101946t.

13. *Id.*

14. Seungdo Kim & Bruce E. Dale, *Indirect Land Use Change for Biofuels: Testing Predictions and Improving Analytical Methodologies*, 35 BIOMASS & BIOENERGY at 1 (2011), *available at* http://www.worldofcorn.com/uploads/useruploads/kim-dale.pdf. The issue is particularly prominent as some studies have shown indirect land use change to be a primary impact on lifecycle greenhouse gas emissions of biofuels. *See id.* (citing five other studies). The Kim-Dale study found that U.S. biofuel production through 2007 did not produce indirect land use change. *Id.* at 5.

15. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. 1,320, 1,324 (Jan. 9, 2012) (to be codified at 40 C.F.R. pt. 80).

16. *Id.*

17. *Id.*

18. *Id.*

million acres.[19] Likewise, Canada's baseline for total agricultural land in 2007 is 124 million acres.[20] In 2011 and 2012, total acreage in Canada reached 121 million acres.[21] Biofuel produced in Canada and other countries can qualify for RFS. However, international land directly converted to new agricultural land cannot be used to produce feedstock for fuels that qualify for RFS.[22]

While the examination of land use change primarily reflects concerns surrounding greenhouse gas emissions, it also has bearing on "food versus fuel." If the total amount of agricultural land does exceed the 397 million acre threshold, the EPA will conduct additional analyses regarding environmental impact. These analyses provide an opportunity for biofuel opponents to reintroduce "food versus fuel" concerns into the EPA's rulemaking.

With a serious drought during the summer of 2012, biofuels took center stage. A number of parties, including many state governors, petitioned the EPA to waive the volume requirements for portions of 2012 and 2013, citing food price concerns.[23] The EPA examined the request to determine if RFS would severely harm the economy of the States. The EPA denied the waiver petition, finding that the most likely outcome is no change to food prices.[24] In fact, the EPA estimate of total impact of a waiver would be a reduction of approximately seven cents per bushel.[25]

As noted above, this Essay does not seek to resolve the controversy, but it is important to understand the controversy prior to examining the Renewable Fuel Standard. It is also important to consider the fact that biofuels provide environmental and energy security benefits that must be weighed alongside any effect on food prices.[26] The EPA estimated that RFS will cost each individual an additional $10 annually for food.[27] A study by the Oak Ridge National Laboratory estimates that the energy security benefits of biofuels are approximately fifteen cents per gallon.[28] Thus, with enough trips to the gas station, individuals can provide an important national benefit of greater value than the increased cost of food.

With a general understanding of the "food versus fuel" controversy, this Essay will introduce the Renewable Fuel Standard and then examine the potential of non-

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19. Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards, 78 Fed. Reg. 9282, 9287 (Feb. 7, 2013) (proposed rule).

20. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. at 1,324

21. *Id.*; Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards, 78 Fed. Reg. at 9287.

22. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Pathways Under the Renewable Fuel Standard Program, 77 Fed. Reg. 700, 706 (January 5, 2012) (withdrawn on March 5, 2012 by 77 Fed. Reg. 13,009, pending further comment).

23. Notice of Decision Regarding Requests for a Waiver of the Renewable Fuel Standard, 77 Fed. Reg. 70,752(Nov. 27, 2012).

24. *Id. at* 70,753.

25. *Id. at* 70,753 n.2.

26. As discussed in Part II, the greenhouse gas benefits of RFS are quite clear. Oak Ridge National Laboratory estimates that the energy security benefits of biofuels are approximately fifteen cents per gallon. Regulation of Fuels and Fuel Additives: 2013 Biomass-Based Diesel Renewable Fuel Volume, 77 Fed. Reg. 59,458, 59,471 (Sept. 27, 2012) (to be codified at 40 C.F.R. pt. 80).

27. *Id. at* 59,472.

28. *Id. at* 59,471.

food crops that can be utilized to meet the goals of RFS.

II. AN INTRODUCTION TO RFS

The Renewable Fuel Standard was initially created by the Energy Policy Act of 2005 and substantially amended by the Energy Independence and Security Act of 2007. Starting conservatively, RFS only required nine billion gallons of renewable fuel in 2008. However, RFS contained lofty goals for 2022: 36 billion gallons of renewable fuel. To meet this goal, the renewable fuel industry would have to rapidly increase capacity and utilize various sources of biomass as feedstock for the fuel.

The basic structure of RFS is quite simple. Obligated parties, defined as refiners and importers of fuel, must meet renewable volume obligations (RVOs) set annually by the Environmental Protection Agency (EPA). RVOs are based on congressional mandate but may be adjusted by the EPA based on actual production levels. Obligated parties are then assigned an RVO for each fuel category based on the total amount of non-renewable fuel produced multiplied by the percentages developed annually by the EPA for each fuel category.[29]

There are four fuel categories contained within RFS: renewable fuel, biomass-based diesel, cellulosic biofuel, and advanced biofuel. These categories are not exclusive; the EPA refers to the categories as "nested." To qualify as renewable fuel, the fuel must be produced from renewable biomass, replace transportation fuel or heating oil, and reduce greenhouse gas emissions by 20% compared to a 2005 baseline. These requirements serve as a threshold requirement for each of the other fuel types.

Fuel qualifying as advanced biofuel must reduce greenhouse gas emissions by 50% and use any renewable biomass feedstock, with the exception of cornstarch. The category is very broad as it is essentially a catch-all category for biofuels other than cornstarch ethanol, the most prevalent biofuel. The advanced biofuel category includes cellulosic biofuel and biomass-based diesel. But these two categories have additional qualifying requirements.

Biomass-based diesel must reduce greenhouse gas emissions by 50%, be used as a transportation fuel, heating oil, or fuel additive, and qualify as biodiesel or non-ester renewable diesel.

Cellulosic biofuel must reduce greenhouse gas emissions by 60% and derive from cellulose, hemi-cellulose, or lignin. As Congress hoped RFS would create and mature a cellulosic biofuel industry, RFS requires cellulosic biofuel to be the largest source of renewable fuel in 2022—16 billion gallons.

As noted, the qualifying fuel types overlap, meaning a fuel may qualify in multiple categories. For example, biomass-based diesel, cellulosic biofuel, and advanced biofuel qualify as renewable fuel; biomass-based diesel and cellulosic biofuel qualify as advanced biofuel. Thus, in a sense there are really two qualifying fuel types, renewable fuel and advanced biofuel, but these categories contain subcategories. Nevertheless, the EPA must set an RVO for each category each year, and obligated parties must meet the requirements of four different fuel

29. *See* 40 C.F.R. §80.1407 (2012).

categories.

Each obligated party demonstrates compliance with annual RVOs by using renewable identification numbers (RINs).[30] Each RIN is a unique, 38-digit numeric code representing a volume of renewable fuel.[31] RINs are generated if the produced or imported fuel qualifies for a D-code and the fuel is demonstrated to be renewable biomass through reporting and recordkeeping.[32] Once registered, the assigned RIN corresponds to the volume of renewable fuel. The RIN does not become a marketable credit until the RIN is separated from the volume of fuel, ending the association between the RIN and the specific volume of fuel.[33] An obligated party, renewable fuel owner, or exporter may separate the RIN from the batch of renewable fuel.[34] Once separated, the RIN becomes marketable, and freely transferable by any registered party.[35] Separated RINs are the currency of RFS.

In meeting these standards, not all renewable fuels are necessarily equal. Due to assigned equivalence values, a RIN-gallon may be greater than a standard gallon.[36] After much consideration, the EPA adopted an energy-based equivalent value system to create a "level playing field."[37] In essence, the equivalence value is determined by the fuel's energy output in comparison with ethanol, assigned an equivalence value of 1.0.[38] For example, one standard gallon of biodiesel (mono-alkyl ester) equals 1.5 RIN-gallons, or ethanol-equivalent gallons.[39] The EPA has developed a formula based on energy content to determine the equivalence value for all types of renewable fuels that are not assigned an equivalence value in the regulations.[40] Equivalence values will play a key role in ensuring that the goals of RFS are met. Parties petitioning the EPA for a new fuel pathway may also have to petition for an equivalence value.[41]

The EPA's focus on greenhouse gas emissions for RFS is quite apparent. But what about the "food versus fuel" concern? In the initial RFS rulemaking, the EPA measured the impact of RFS on agricultural commodities and food prices.[42] The EPA utilized two models: FASOM and FAPRI-CARD.[43] The FASOM model showed a potential 10% increase in the price of soybeans and a 38% increase in the

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30. 40 C.F.R. § 80.1406(b) (2010). A party with multiple facilities may aggregate the facilities to meet the RVO. *Id.* § 80.1406(c). The formulas to determine compliance are available at 40 C.F.R. § 80.1427(a). The regulations also allow facilities to carry a deficit into the subsequent year, but facilities may not carry deficits in consecutive years. *Id.* § 80.1427(b).

31. 40 C.F.R. § 80.1401; *Id.* § 80.1425.

32. 40 C.F.R. § 80.1426(a)(1) (2010). Aggregate compliance may exempt obligated parties from reporting and recordkeeping related to renewable biomass. *Id.*

33. *See* 40 C.F.R. § 80.1429 (2010).

34. *See id.*

35. *See* 40 C.F.R. §§ 80.1428(b), 80.1429 (2010).

36. *See* 40 C.F.R. § 80.1415 (2010).

37. *RFS Final Rule*, 77 Fed. Reg. 14,709-10 (Mar. 26, 2010).

38. *See id.*; 40 C.F.R. § 80.1415(b)(1).

39. *See* 40 C.F.R. § 80.1415(b)(2).

40. *See id.* § 80.1415(c)(1).

41. *See id.* § 80.1415(c).

42. Regulation of Fuels and Fuel Additives: 2013 Biomass-Based Diesel Renewable Fuel Volume, 77 Fed. Reg. 59,458, 59,471 (Sept. 27, 2012) (to be codified at 40 C.F.R. pt. 80).

43. *Id.*

price of soybean oil.[44] The increase use of soybean oil for biodiesel will result in fewer U.S. exports.[45] Some recent reports, however, indicate that technology may increase soybean yields domestically and internationally by up to 10%.[46]

In recent RFS rulemaking procedures, the EPA has not provided much consideration related to "food versus fuel." For example, the EPA did not probe too deeply into food impacts for the biomass-based diesel (BBD) requirement because the renewable volume obligation (RVO) did not exceed what was modeled in the analysis of the initial RFS final rule.[47]

When approving new feedstock and pathways, the EPA does consider factors such as competing uses (i.e., "food versus fuel") when running scenarios of RFS impact.[48] Clearly, RFS does not ignore the potential impacts that biofuels can have on food prices.

III. MEETING THE CURRENT MANDATE AND PROJECTING THE FUTURE

With a general understanding of RFS and the "food versus fuel" controversy, this section discusses the current status of RFS and explores the future of RFS. The potential of non-food feedstock is of particular focus in the exploration of the future. But this section begins by demonstrating that RFS is working, even if not exactly as Congress intended.

A. Current Mandate

While the cellulosic biofuel category has yet to produce significant volumes, falling short of Congressional goals, the overall mandated amount of biofuels has been met each year. Although the "food versus fuel" controversy questions the impact and not the actual use of food crops for fuel, there is no doubt that food crops have been used to meet the mandate.

The two largest food crop contributors are corn and soybeans. Corn ethanol, already more than 13 billion gallons of RFS, will reach 15 billion gallons in 2015 and then remain at that amount for the remainder of the program. Additionally, the EPA expects that inedible corn oil from the ethanol process will be used to generate approximately one quarter of the biomass-based diesel requirement in 2013. Thus, although corn ethanol and inedible corn oil already play a significant role in meeting the goals of RFS, greater increases will be required in other fuel categories after 2015.

Soybeans are another typical food crop used for fuel. The EPA estimates that approximately half of the biomass-based diesel requirement in 2013 will come from soybean derived fuel.[49] Six hundred million gallons of biomass-based diesel

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44. *Id.*

45. *Id.*

46. *Id.*

47. *Id.* at 59,472.

48. *See, e.g.,* Supplemental Determination for Renewable Fuels Produced Under the Final RFS2 Program From Grain Sorghum, 77 Fed. Reg. 74,592, 74,593 (Dec. 17, 2012) (to be codified at 40 C.F.R. pt. 80).

49. Regulation of Fuels and Fuel Additives*,* 77 Fed. Reg. at 59,463 (estimating 600 million gallons from soybean oil of the 1.28 billion gallons total).

(BBD) requires 4.53 billion pounds of soybeans.[50] While this amount equals approximately one-quarter of the total U.S. soybean oil supply, the EPA estimates that nearly one-third of the total U.S supply of soybean oil will be available after traditional, non-biodiesel domestic use.[51] However, the use for BBD may reduce soybean oil exports.[52] But the EPA and other academic studies indicate that non-soybean feedstocks will see high growth in the future.[53]

Another significant food-based contributor is sugarcane-based ethanol. Imports of Brazilian sugarcane ethanol will play a role in meeting the other advanced biofuel requirement.[54] Ethanol imports from Brazil have averaged nearly 400 million gallons over the past few years, with a high of 730 million gallons in 2006.[55] Sugar prices and demand in Brazil have limited exports in recent years.[56] The amount of Brazilian exports in the future will depend on advanced biofuel RIN prices.[57] While sugarcane ethanol imports have varied drastically in recent years, 2013 could be a historical maximum in ethanol importation.[58]

Since the introduction of RFS, additional oilseeds have entered the market for BBD.[59] Although the EPA assumes the 2013 BBD standard will be met with soybeans, it notes the ability of other oilseeds to penetrate the market, even in 2013.[60] The EPA recently approved a pathway for canola,[61] and a camelina pathway was proposed in early 2012.[62] Additional pathways are currently under consideration.[63] Algae-based pathways may also provide significant quantities as the technology continues to rapidly advance in this area.[64]

Because the EPA set a minimum amount of BBD to be produced annually after

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50. *Id.* at 59,464.

51. *Id.* at 59,465.

52. *See id.* at 59465. EPA estimates 6.875 billion pounds of soybean oil for biofuel use or export in 2012-13; 2010-11 exports reached 3.233 billion pounds. *Id.* Based on these estimates, 2010-11 export levels could not be maintained in 2012-13. *Id.* Although, soybean oil exports have been as low as 2.193 billion pounds in recent years, 2008-09. *Id.*

53. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. 1320, 1335 (Jan. 9, 2012) (to be codified at 40 C.F.R. pt. 80).

54. *Id. at 1332.*

55. *Id.*

56. *Id.*

57. *Id.*

58. Regulation of Fuels and Fuel Additives: 2013 Biomass-Based Diesel Renewable Fuel Volume, 77 Fed. Reg. 59458, 59461 (Sept. 27, 2012) (to be codified at 40 C.F.R. pt. 80).

59. *Id.* at 59464.

60. *Id.*

61. Supplemental Determination for Renewable Fuels Produced Under the Final RFS2 Program From Canola Oil, 75 Fed Reg. 59622 (Sept. 28, 2010) (to be codified at 40 C.F.R. pt. 80).

62. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 77 Fed Reg. 462 (Jan. 5, 2012) (to be codified at 40 C.F.R. pt. 80).

63. *See generally Guidance on New Fuel Pathway Approval Process*, U.S. ENVTL. PROTECTION AGENCY, http://www.epa.gov/otaq/fuels/renewablefuels/compliancehelp/rfs2-lca-pathways.htm (listing pending pathway assessments, including various non-food feedstocks: algae, cover crops, biogenic waste oils, grease, giant cane, napier grass, biogas from landfills and anaerobic digesters, jatropha, municipal sewage sludge, cellulosic biomass, and non-cellulosic separated food waste) (last updated Jan. 23, 2013).

64. Regulation of Fuels and Fuel Additives: 2013 Biomass-Based Diesel Renewable Fuel Volume, 77 Fed. Reg. 59458, 59465 (Sept. 27, 2012). (to be codified at 40 C.F.R. pt. 80)

2012, with the potential to increase, the EPA must determine the new mandated amount annually. To do so, the EPA must consider multiple factors when determining biodiesel RVOs: environmental impact, impact on energy security, expected rate of production, infrastructure compatibility, cost to consumer, and other economic impacts such as food prices and job creation.[65] Food prices are considered part of the "other economic impacts" but it is not the only factor even in that category. However, one might also consider that expected rate of production has some bearing on "food versus fuel" as the EPA has looked at the impact of production from non-food crops in recent RVO determinations.

Because the cellulosic biofuel category volumetric requirements are set by the Energy Independence and Security Act of 2007 (EISA), the EPA does not necessarily readjust the standard annually. However, the EPA does examine whether or not the mandate for the category can be met, potentially requiring a reduction to the volume requirements. For reductions to the cellulosic biofuel, the EPA considers all relevant factors: producer production plans and progress, the EPA assessment, public comments, volume estimates from EISA, and other information as available.[66] Competition from food production is not of particular concern, most likely due to the fact that cellulosic biofuels by their nature tend not to compete with food crops.

The EPA is not mandated to reach a certain degree of certainty in its projections. However, the EPA understands its duty to "promote predictability and reduce uncertainty."[67] The EPA has rejected concurrent reductions of the other advanced biofuel category when reducing the mandated cellulosic biofuel category.[68] If volumes of other advanced biofuels are available, the EPA believes that utilizing these fuels aligns with the goals of the EISA.[69] The EPA wants to create a viable market for cellulosic biofuel and not depress the market with a low volume requirement and RVO.[70] One of the primary purposes of RFS is to grow the cellulosic biofuel industry.[71] While industry growth is certainly slower than expected, the biomass-based diesel industry has proven to grow, even with the lapse of the biodiesel production tax credit. With RFS in place, the biofuel industry will continue to grow, especially those produced with non-food crops.

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65. Clean Air Act of 1963, 42 U.S.C. §7545(o)(2)(B) (Supp. II 2008).

66. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. 1320, 1321, 1324 (Jan. 9, 2012) (to be codified at 40 C.F.R. pt. 80).

67. *Id.* at 1325.

68. *Id.* at 1331.

69. *Id.*

70. *Id.* at 1330. A recent decision by the United States Court of Appeals for the District of Columbia vacated and remanded the 2012 cellulosic biofuel volume requirement, limiting the ability of EPA to use RFS as a technology forcing mechanism. *See* Am. Petroleum Inst. v. E.P.A., 706 F.3d 474 (D.C. Cir. 2013). At least one commentator noted that EPA can easily limit the impact of the ruling through careful phrasing of the basis of its requirements. Rhead Enion, *D.C. Circuit's biofuels mandate ruling*, THE LEGAL PLANET (Jan. 29, 2013), http://legalplanet.wordpress.com/2013/01/29/d-c-circuits-biofuels-mandate-ruling/.

71. *Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards*, 77 Fed. Reg. at 1329-30.

B. The Future of RFS

Although a considerable amount of the current RFS mandate is met with food crops, the future of non-food-based fuels is bright. This section highlights a number of promising opportunities. First, most broadly, this section looks at the future of the cellulosic biofuel industry. Second, this section highlights emerging RFS pathways. As noted above, there are three components of an RFS-eligible pathway: the feedstock, the production process, and the fuel type. There are multiple new pathway components, creating a multitude of new pathways.[72] Although all components can have an effect on increasing opportunities for the use of non-crop feedstock, this section primarily highlights the opportunities of various non-food feedstock and the impact of food crops. This section concludes with an estimate of the total impact that non-food crops can have on RFS.

1. The Cellulosic Biofuel Industry

Largely indigestible by humans, cellulose is a common organic compound found in plant life. A major goal of RFS is to substantially grow the cellulosic biofuel industry in the United States. In 2022, RFS requires that 16 billion of the 36 billion gallons of fuel come from biofuel, the largest share for a single fuel category. Thus far, however, the industry has been slow to produce significant volumes, only 20,000 RINs generated in 2012.[73] Not included in this number, the Dupont Danisco Cellulosic Ethanol facility, operating at half capacity, is producing approximately 125,000 gallons per year, but the company has chosen not to generate RINs.[74] In fact, the cellulosic biofuel targets have been substantially reduced by the EPA in the initial years of RFS. Due to the significant cuts to the volume requirements (approximately 97-98%), the trend will likely continue because significant volumes are already required. However, there is great potential for a thriving cellulosic biofuel industry in the United States.

A projection by Sandia National Laboratory stated that even without the displacement of food crops, the U.S. could produce 75 billion gallons of cellulosic biofuel.[75] Even without utilizing equivalence values, 75 billion gallons is more than double of what is required by RFS in 2022 . The cellulosic biofuel industry is slowly working its way to this total.

The EPA is tracking the progress of more than 100 cellulosic biofuel facilities.[76] Currently the nameplate capacity of biofuel facilities in the U.S. is 26.6 million gallons,[77] with an EPA estimated 49 million gallon design capacity for

72. *See* Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 77 Fed. Reg. 700 (January 5, 2012), *withdrawn*, 77 Fed. Reg. 13009 (Mar. 5, 2012) (withdrawn pending further comment).

73. 2012 RFS2 Data, U.S. ENVTL. PROTECTION AGENCY, (Jan. 7, 2013), http://www.epa.gov/otaq/fuels/rfsdata/2012emts.htm (data from Jan. to Oct. 2012).

74. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. at 1326.

75. ADVANCED ETHANOL COUNCIL, CELLULOSIC BIOFUELS: INDUSTRY PROGRESS REPORT 2012-2013 (2012) *available at* http://ethanolrfa.3cdn.net/d9d44cd750f32071c6_h2m6vaik3.pdf.

76. *Id.* at 1325.

77. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. at 1329.

facilities in 2013.[78] By 2015, nameplate capacity is expected to reach 250 million gallons.[79] To put these numbers in perspective, the congressionally mandated amount of cellulosic biofuel in 2012 was 500 million gallons, and 1 billion gallons in 2013.

Although the cellulosic biofuel industry has been slow to grow, it has to be noted that the industry continues to emerge, even if slower than anticipated. Because cellulose can be derived from a multitude of plants and the limited dietary value of cellulose, the industry will play a key role in providing RFS fuels that do not compete with food.

2. Production Process

Pathways are key to RFS because they allow biofuel producers to generate RINs for their biofuel; RINs play a key role in providing the economics of biofuel facilities. A pathway includes the feedstock, fuel type, and production process. Although all three elements are required for a pathway, once the EPA has examined a specific element, analyses for other pathways using the same elements can be conducted more expediently by the EPA.

In a recent direct rule, the EPA approved the use of esterification for the production of biodiesel for approved feedstock.[80] By examining the esterification process and combining the results with previous analyses, the EPA was able to approve multiple pathways.[81] Now various feedstocks, such as soybeans, cover crops, algae, canola, waste oil, and corn oil, used to produce biodiesel through esterification will generate RINs. The direct final rule was withdrawn on March 5, 2012 due to adverse comments, which had to do with approved feedstocks, not the esterification process.[82] However, in a subsequent final rule on March 5, 2013, the EPA once again delayed the approval of esterification, with virtually no analysis.[83]

3. Fuel Type

The EPA also added renewable gasoline as a fuel type for eligible pathways.[84] Feedstocks considered for the eligible pathways were non-food feedstock such as crop residue, yard waste, food waste, and municipal solid waste.[85] All three technological pathways analyzed for corn stover met the GHG reductions required

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78. Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards, 78 Fed. Reg. 9282, 9294 (Feb. 7, 2013) (proposed rule).

79. *Cellulosic biofuels begin to flow but in lower volumes than foreseen by statutory targets*, U.S. ENERGY INFO. ADMIN. (Feb. 26, 2013), http://www.eia.gov/todayinenergy/detail.cfm?id=10131

80. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 77 Fed. Reg. 700, 721 (Jan. 5, 2012), *withdrawn*, 77 Fed. Reg. 13009 (Mar. 5, 2012) (withdrawn pending further comment).

81. 77 Fed. Reg. at 721-24, *withdrawn*, 77 Fed. Reg. at 13009.

82. 77 Fed. Reg. at. 13009.

83. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 78 Fed. Reg. 14190, 14213 (Mar. 5, 2013).

84. 77 Fed. Reg. at, 714, *withdrawn*, 77 Fed. Reg. at 13009.

85. 77 Fed. Reg. at 714-15, *withdrawn*, 77 Fed. Reg. at 13009.

for qualifying fuels.[86] Additional conversion methods were also approved.[87] However, the direct final rule was withdrawn on March 5, 2012 due to adverse comments, primarily directed at potential feedstocks, not renewable gasoline as a fuel type.[88] One year later, the EPA approved certain renewable gasoline pathways.[89]

The EPA has also noted significant potential for bioelectricity-based RINs.[90] However, there is not yet an approved pathway and the EPA anticipates that it may be difficult to demonstrate use of the electricity for transportation.[91] The transportation sector currently uses the equivalent of 300 million gallons of ethanol.[92] To qualify for RFS, the electricity has to be derived from renewable biomass, not just any renewable source like solar and wind.

4. Feedstocks

These new processes and fuel types are important to meeting the goals of RFS. As noted above, a qualifying pathway consists of three elements: a fuel type, a production process, and a feedstock. When considering food policy, the feedstock is the most important element. The sections that follow explore various feedstock options. While a few food feedstocks are explored, many of these feedstocks are non-food crops.

a. Algae

Algae thrive in virtually every environment on the planet, capable of living in virtually any type of water—fresh, salt, and brackish.[93] Additionally, algae can be grown in waste water and can recycle carbon dioxide emissions.[94] Among all potential biomass feedstocks, algae have the greatest yield, producing 1,000 to 6,500 gallons of oil per acre per year.[95] For comparison purposes, soybeans, currently the largest source of renewable oil, produce approximately 50 gallons of oil per acre per year.[96] The EPA has interpreted the term algae broadly, specifically to include cyanobacteria.[97] Algae are also expected to meet the GHG

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86. 77 Fed. Reg. at 719, *withdrawn*, 77 Fed. Reg. at 13009.

87. 77 Fed. Reg. at 719, *withdrawn*, 77 Fed. Reg. at 13009.

88. 77 Fed. Reg. at 13009.

89. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 78 Fed. Reg. 14190, 14205 (Mar. 5, 2013).

90. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. 1320, 1333 (Jan. 9, 2012) (to be codified at 40 C.F.R. pt. 80).

91. *Id.*

92. *Id.*

93. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg 14670, 14697 (Mar. 26, 2010) (to be codified at 40 C.F.R. pt. 80).

94. U.S. DEP'T OF ENERGY, NATIONAL ALGAL BIOFUELS TECHNOLOGY ROADMAP 3 (May 2010) *available at* http://www1.eere.energy.gov/biomass/pdfs/algal_biofuels_roadmap.pdf.

95. *Id.*

96. *Id.*

97. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. at 14697.

requirements of RFS.[98] Additionally, algae are largely grown on non-arable land, limiting land use impact and food competition.[99] Furthermore, many RFS pathways for algae have already been approved by the EPA.

By 2022, production of biofuel from algae is expected to reach 100 million gallons.[100] Yet, the potential of algae is enormous. Even in the early years of the Department of Energy's Aquatic Species Program, researchers acknowledged that the impact of algae-based biofuel would be in the billions of gallons.[101] One recent study found that utilizing all suitable land for algae, including land that is nonagricultural, noncompetitive, and non-sensitive, resulted in 58 billion gallons per year; this is equivalent to nearly 48% of petroleum imports to meet the 2008 demand for transportation fuels.[102] While technologically feasible to displace a large amount of petroleum imports and use, the economics of algae biofuel production must advance significantly to meet these goals.

b. Biogas (Landfills, Sewage Treatment, and Digesters)

Biogas can be harvested from multiple sources, such as landfills, sewage treatment facilities, and anaerobic digesters (primarily on farms). In all three instances, there is no competition with food crops. The resulting biogas can be used as fuel itself or used to create electricity for electric vehicles.

Biogas from landfills qualify for RFS.[103] The EPA recognizes that landfills are designed to be permanent and the feedstocks are not accessible to separate the renewable biomass.[104] The process of generating biogas virtually serves a separate function; only the biogenic material will create the gas.[105]

Capturing biogas from landfills is already a common occurrence. According to the EPA, 590 operational projects already produce 14.8 billion kilowatt-hours of electricity.[106] If all kilowatt-hours were used to generate electricity to power vehicles, over 650 million ethanol-equivalent gallons of fuel would be generated.[107] For future production, the EPA recognizes more than 500 candidate landfills, creating a potential for an additional 10 billion kilowatt-hours of electricity, the equivalent of another 443 million RINs.[108] In addition to utilizing the electricity

98. *Id.*
99. *Id.*
100. *Id.*
101. U.S. DEP'T OF ENERGY, *supra* note 94, at 4. Perhaps lacking foresight, the DOE Aquatic Species Program was scrapped in 1996, citing expected algae costs of $59 to $186 per barrel. *Id.* at 4-5.
102. Mark S. Wigmosta et al., *National Microalgae Biofuel Production Potential and Resource Demand*, WATER RES. RESEARCH (Mar. 2011), *available at* http://www.agu.org/journals/wr/wr1104/2010WR009966/. 220 GL roughly equals 58 billion gallons. Note that these are not ethanol-equivalent gallons. Because algae are an oil crop, the potential RFS impact is at least 50% greater when accounting for equivalence values.
103. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. at 14670.
104. *Id.*
105. *Id.*
106. U.S. Envtl. Prot. Agency, *An Overview of Landfill Gas in the United States* 8, http://www.epa.gov/lmop/documents/pdfs/overview.pdf (last updated June, 2012).
107. *See* 40 C.F.R. § 80.1415(b)(6).
108. U.S. Envtl. Prot. Agency, *supra* note 106, at 19; 40 C.F.R. § 80.1415(b)(6).

from biogas to power vehicles, technology is being developed to convert the biogas into alternative fuels.[109]

There is significant potential for energy generation from anaerobic digesters, some of which can be utilized for transportation. At swine and dairy animal feeding operations alone, the EPA estimates that nearly 45 MMBtu can be generated each year.[110] Using the EPA's equivalence value (77,000 Btu equals one gallon of renewable fuel), 584 million RINs could be generated if all of the energy was used for transportation fuel.[111] While all of the 45 MMBtu will likely not be utilized for transportation, a portion of it could be used in compressed natural gas vehicles or used to generate electricity to power electric vehicles. Additionally, it should be noted that the EPA's figures do not include poultry farms.[112] Other bio-based materials can also be anaerobically digested, such as crop residue and residual algal biomass. Thus, anaerobic digesters have great potential to play an important role in meeting RFS requirements.

Just as animal waste can be utilized, sewage sludge is also a potential feedstock. In the United States, the amount of sewage sludge is estimated at approximately 6.2 million dry metric tons per year.[113] This is enough to generate 1.8 billion gallons of biodiesel.[114] Not only is this greater than the total amount of biodiesel currently produced in the United States, this represents 2.7 billion ethanol-equivalent gallons for RFS. Additionally, once the oil and fatty acid content of the sludge has been removed, the remainder can be anaerobically digested to create biogas. There are technological and economic barriers to overcome, but sewage sludge could be utilized to meet a significant portion of the RFS requirements.

Electricity from biogas is also an important element in ensuring that certain production processes qualify for RIN generation.[115] In cases where biogas makes sense as a transportation fuel, it will likely be used for fleet vehicles and therefore such use would have to be documented.[116] Yet, even in cases where biogas is not used to generate transportation fuel directly, biogas may be utilized by biofuel processing plants to limit GHG emissions, helping the fuel qualify in one of the advanced biofuel categories.[117]

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109. U.S. Envtl. Prot. Agency, *Landfill Methane Outreach Program : Basic Information*, http://www.epa.gov/lmop/basic-info/index.html (last updated Sept. 28, 2012).

110. U.S. Envtl. Prot. Agency, *U.S. Anaerobic Digester Status Report* 2 (Oct.2010), http://www.epa.gov/agstar/documents/digester_status_report2010.pdf.

111. *See* 40 C.F.R. § 80.1415(b)(5).

112. U.S. Envtl. Prot. Agency, *supra* note 110, at 1.

113. David M. Kargbo, *Biodiesel Production from Municipal Solid Sludges*, 24 ENERGY FUELS 2791 (2010), *available at* http://www.epa.gov/cleanenergy/documents/biodiesel_from_sewage_sludges.pdf.

114. *Id.* at 2792. By utilizing microorganisms, the amount of fuel could increase to more than 10 billion gallons. *Id.* at 2794.

115. *See* 40 C.F.R. § 80.1426 tbl. 1 (2012).

116. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. 14,670, 14,686 (Mar. 26, 2010).

117. *See* Supplemental Determination for Renewable Fuels Produced Under the Final RFS2 Program From Grain Sorghum, 77 Fed. Reg. 74,592, 74,593 (Dec. 17, 2012) (to be codified at 40 C.F.R. pt. 80).

c. Camelina

Camelina, a flowering plant from the mustard family, is an oilseed crop. Camelina oil has been largely used to produce jet fuel for testing.[118] There are at least 50,000 acres of camelina planted across at least twelve states in the United States.[119] Limiting competition with food crops, it is expected that camelina will be grown in fields that would otherwise be fallow, as the crop has little impact on moisture and nutrient content of the soil.[120] Camelina is a particularly strong candidate for rotation with wheat; it even requires the same equipment for harvest.[121] Thus, the EPA does not believe camelina will impact the total amount of acreage for agricultural use.[122]

Based on the total acreage of wheat grown and the areas currently suitable for camelina production via rotation with wheat, the EPA estimates the availability of at least 9 million acres for camelina production.[123] This is the equivalent of approximately 100 million gallons of renewable fuel per year, assuming only one third of the land is in rotation each year.[124] Camelina yields, however, are expected to significantly increase in the next few years, potentially quadrupling.[125] Additionally, if production can be achieved in additional climates, the amount of available acreage could easily increase two to two-and-a-half times.[126] With increases in yield and climate tolerance, camelina production could approach one billion gallons in the coming years. It should also be noted that camelina contains twice the oil content of soybeans, 36% to 18%.[127]

This significant amount of biofuel would not come at the expense of food crops . Although the EPA did not address camelina crops grown without wheat rotation,[128] if camelina proves to be economically beneficial, it could be expected that the crop may appear on other marginal lands not suitable for food crop production. Camelina may also be grown internationally and converted to fuel to meet RFS. In Canada, more than 20 million acres of wheat was harvested in 2010.[129] Wheat production in Europe is more than twice the amount in the United

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118. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Pathways Under the Renewable Fuel Standard Program, 77 Fed. Reg. 700, 702 (Jan. 5, 2012) (withdrawn on Mar. 5, 2012 by 77 Fed. Reg. 13,009, pending further comment).

119. *Id*.

120. *Id*.

121. *Id*. at 703.

122. *Id*. at 702.

123. *Id*. at 705.

124. *Id*.

125. *Id*. The increases will result from seed technology, and improvements in planting and harvest techniques. *Id.*

126. *Id*. EPA noted 22 million acres potentially suitable for camelina production via wheat rotation. *Id.* The total number of U.S. land in wheat production is approximately 60 million acres. *Id.*

127. *Id*. at 707.

128. *Id*. at 706.

129. Food & Agric. Org. of the United Nations, FAOSTAT.ORG, http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor (select "Canada" in "Country" field; "2010" in "Year" field; "Wheat" in "Item" field; "Area Harvested" in "Element" field; follow "Show Data" hyperlink). 8,268,700 hectares equals 20,432,402.68 acres.

States.[130] Camelina production in these situations may also qualify for RINs under RFS.[131]

The EPA assumed no land use change for camelina.[132] Camelina production will largely be distributed in the northwest portion of the United States.[133] In the southwest U.S., there is a different feedstock opportunity—perennial grass.[134]

d. Perennial Grasses (Switchgrass, Miscanthus, Energy Cane, Giant Reed, and Napiergrass)

In its initial rulemaking, the EPA approved switchgrass, which the EPA considers to include miscanthus due to similarities between the two crops.[135] The EPA recently issued a direct final rule to qualify additional renewable fuel pathways by adding eligible feedstocks, fuel types, and production processes.[136] The additional feedstocks included the addition of biofuels from camelina, energy cane, giant reed, and napiergrass.[137] However, the direct final rule was withdrawn on March 5, 2012 due to adverse comments, primarily due to the addition of these feedstocks.[138] The primary concern was that napiergrass and giant reed are considered invasive in certain parts of the country.[139] In March 2013, the EPA approved the use of camelina and energy cane, but further delayed action on napiergrass and giant reed.[140]

Energy cane is still in the very early stages of research and development.[141] Giant reed already grows in the U.S. and is used for limited commercial purposes, but not yet significantly for energy purposes.[142] Napiergrass is perhaps the most developed feedstock of the three; it is currently grown as a forage crop.[143] All three crops out-perform switchgrass in regards to biomass yield, but the ethanol yield for

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130. *Id.* (select "United States of America" in "Country" field; "2010" in "Year" field; "Wheat" in "Item" field; "Production Quantity" in "Element" field; follow "Show Data" hyperlink; select "Europe + (Total)" in "Country" field; "2010" in "Year" field; "Wheat" in "Item" field; "Production Quantity" in "Element" field; follow "Show Data" hyperlink).

131. Regulation of Fuels and Fuel Additives, 77 Fed. Reg. at 706 (final rule is pending). Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 78 Fed. Reg. 14190 (Mar. 5, 2013).

132. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Pathways Under the Renewable Fuel Standard Program, 77 Fed. Reg. at 710.

133. *Id.* at 713.

134. *Id.*

135. *Id.* at 711.

136. *Id.* at 700.

137. *Id.*

138. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Pathways Under the Renewable Fuel Standard Program, 77 Fed. Reg. 13009, 13009 (Mar. 5, 2012) (to be codified at 40 C.F.R. pt. 80)

139. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 78 Fed. Reg. 14190, 14191 (Mar. 5, 2013).

140. *Id.*

141. Regulation of Fuels and Fuel Additives, 77 Fed. Reg. at 711.

142. *Id.* at 711-12.

143. *Id.* at 712.

these grasses is approximately equivalent.[144] Even so, yields are expected to increase approximately 2% each year.[145]

Unlike camelina, energy grasses may displace food and other commodity crops.[146] However, energy grasses are thought to have a smaller impact than switchgrass, which displaces soybeans and wheat.[147]

If only 1% of the 587 million acres of U.S. grassland and range was used to grow perennial grasses,[148] more than 3.5 billion gallons of ethanol could be produced.[149] As one example noted earlier, the Dupont Danisco Cellulosic Ethanol facility currently produces approximately 125,000 gallons per year;[150] the facility intends to switch to a perennial grass feedstock.[151]

e. Canola

The more prevalent, distant relative of camelina, canola is also an oilseed crop primarily grown in Canada. Canola oil is primarily used for cooking, while the canola plant residual is used for animal feed. The EPA recently approved a pathway for canola in the categories of advanced biofuel and biomass-based diesel.[152] The EPA estimates that 200 million gallons of canola-based biodiesel will be produced by 2022.[153] Although canola can be considered a food product, its potential role in RFS will be somewhat minimal. With a well-defined food market application, markets will dictate when it is beneficial for biofuel producers to utilize canola oil as a feedstock. Otherwise, canola will be used for food grade oils.

f. Corn Oil

Unlike many of the above feedstocks, corn oil is derived from a food crop. However, an inedible type of corn oil is produced during the process to convert corn to ethanol. Thus, corn plays a role in both ethanol and biodiesel production.

In its initial RFS rulemaking, the EPA overestimated the advancement of

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144. *Id.*
145. *Id.*
146. *Id.*
147. *Id.*
148. *See* Ruben N. Lubowski, et al., *Major Uses of Land in the United States, 2002*, U.S. DEPT. OF AGRIC. ECON. RESEARCH SERV. (May 2006), http://www.ers.usda.gov/media/249896/eib14_reportsummary_1_.pdf.
149. Rocky Lemus & David J. Parrish, *Herbaceous Crops With Potential for Biofuel Production in the USA*, CAB REVIEWS: PERSPECTIVES IN AGRICULTURE, VETERINARY SCIENCE, NUTRITION AND NATURAL RESOURCES 2009, 4, No. 057, at 12 (Oct. 2009) (noting 5,700 liters per hectare for switchgrass). This number assumes high yields, but it also uses switchgrass yields, which are the lowest among perennial grasses.
150. Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. 1320, 1326 (Jan. 9, 2012) (to be codified at 40 C.F.R. pt. 80)..
151. Regulation of Fuels and Fuel Additives: 2011 Renewable Fuel Standards, 75 Fed. Reg. 76790, 76796 (Dec. 9, 2010) (to be codified at 40 C.F.R. pt. 80).
152. Supplemental Determination for Renewable Fuels Produced Under the Final RFS2 Program From Canola Oil, 75 Fed Reg. 59622, 59623 (Sept. 28, 2010) (to be codified at 40 C.F.R. pt. 80).
153. *Id.* at 59624.

technology to extract inedible corn oil from ethanol production.[154] However, this overestimate has been offset by wider adoption of some form of corn oil extraction technology by the ethanol industry.[155] It is now estimated that more than 50% of ethanol facilities will use some form of corn oil extraction technology by the end of 2012.[156] If 60% of ethanol facilities utilized current technology, the industry could produce 270 million gallons of corn oil by the end of 2013.[157] With even more widespread adoption and technological breakthroughs, inedible corn oil could continue to play a significant role in meeting the BBD requirement and the overall goals of RFS. Already, the EPA estimates 680 million gallons of biofuel from corn oil in 2022, the equivalent of 1.02 billion ethanol-equivalent gallons.[158] It is important to note, though, that ethanol from cornstarch is capped at 15 billion gallons in 2015 and remains at that level until 2022. Therefore, although corn oil will play a major role in RFS, increased biofuel production from inedible corn oil may be limited by what is referred to as the "ethanol wall."

g. Crop Residue and Crop Waste

Crop residue is the biomass remaining in the field after harvest; corn stover is the most common.[159] Each year, more than 500 million tons of crop residue is produced.[160] Quite clearly, crop residue and crop waste do not compete with food. However, crop residue plays an important role in agricultural practice, limiting the amount that can be used for biofuel production.[161] For corn stover, depending on the practices of the specific farm, removal rates range from 35% to 50% of the total biomass left on the field.[162]

Of note, the EPA considered corn stover, which in the original rulemaking was seen as having the potential to produce 5.7 billion gallons of ethanol.[163] The quantity of biofuel from other sources will be much smaller, approximately 800 million ethanol-equivalent gallons from wheat, sugarcane, and sorghum residue.[164] These quantities from non-food sources can have a significant impact on RFS, accounting for nearly one-fifth of the total amount required in 2022.

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154. Regulation of Fuels and Fuel Additives: 2013 Biomass-Based Diesel Renewable Fuel Volume, 77 Fed. Reg. 59458, 59464 (Sept. 27, 2012) (to be codified at 50 C.F.R. pt. 20).

155. *Id.*

156. *Id.*

157. *Id.*

158. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg 14670, 14756 (Mar. 26, 2010) (to be codified at 40 C.F.R. pt. 80).

159. *Id.* at 14753.

160. *Id.*

161. *Id.*

162. *Id.*

163. Regulation of Fuels and Fuel Additives: Identification of Additional Qualifying Renewable Fuel Pathways Under the Renewable Fuel Standard Program, 77 Fed. Reg. 700, 715 (Jan. 5, 2012), *withdrawn*, 77 Fed. Reg. 13009 (Mar. 5, 2012) (withdrawn pending further comment).

164. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg at 14754.G

h. Jatropha

Primarily found in tropical and subtropical regions, jatropha is a flowering shrub that produces oilseeds. As a hardy plant, jatropha can be grown on non-arable land, limiting competition with food crops. Furthermore, jatropha seeds are not edible.[165] On a gallon/per acre/per year basis, jatropha out-produces soy, 48 to 202.[166]

Jatropha growth and testing largely occurs internationally, especially in China and India, but domestic test flights have been completed using jet fuel blends that included jet fuel from jatropha oil.[167] Nevertheless, jatropha may be grown domestically, particularly in the southern United States.[168] Through selective breeding and other genetic research, the geographic viability of jatropha might expand into larger portions of the United States.

For the RFS control case, the EPA assumed no volumes from jatropha.[169] Thus, the EPA believed that jatropha-based fuel would not enter the market without intervening policy such as RFS. While jatropha projects move forward in Arizona and Florida, it is difficult to estimate the success of jatropha of the United States. However, imported biofuels can qualify for RFS so it is likely that jatropha will provide some volumes, especially if the large scale field trials underway internationally prove to be successful. But without accurate estimates and without a current approved pathway, this Essay will not project estimated volumes. Nevertheless, jatropha could have a significant impact on RFS.

i. Urban Waste: Municipal Solid Waste and Construction & Demolition Debris

Municipal Solid Waste (MSW) differs from biogas from landfills in that biogas production will occur at landfills where MSW has already been buried. For biofuel production from MSW, the waste stream is utilized prior to landfill disposal.

In total, there are approximately 120 million tons of MSW produced annually.[170] With certain assumptions regarding contamination and moisture, the EPA estimates 44.5 million tons of MSW that qualifies as renewable biomass (wood, yard trimming, paper, and food waste),[171] and the EPA estimates that 26

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165. Although, jatropha grown on marginal land in drought-like conditions will produce less oil. Dan Charles, *How A Biofuel Dream Called Jatropha Came Crashing Down*, NAT'L PUB. RADIO (Aug. 21, 2012), http://www.npr.org/blogs/thesalt/2012/08/22/159391553/how-a-biofuel-dream-called-jatropha-came-crashing-down.

166. U.S. DEP'T OF ENERGY, *supra* note 94, at 3.

167. *See, e.g.,* Peter Pae, *Continental Airlines Uses Biofuel On Test Flight*, L.A. TIMES, Jan. 8, 2009, http://articles.latimes.com/2009/jan/08/business/fi-biofuel8.

168. *See, e.g.,* Laura Layden, *New Biodiesel Crop Jatropha Taking Off in S.W. Florida*, NAPLESNEWS.COM (Apr. 5, 2008), http://www.naplesnews.com/news/2008/apr/05/new-biodiesel-crop-jatropha-taking-sw-florida.

169. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. at 14742.

170. *Id.* at 14704.

171. MSW will qualify as renewable biomass after the recyclable materials (plastic, glass, etc.) have been removed, even non-renewable material remains in the mix. Regulation of Fuels and Fuel

million tons can be used for biofuel production, providing 2.3 billion ethanol-equivalent gallons.[172] As technology and even sorting methods progress, a larger portion of this amount might be available for biofuels, providing significant quantities of fuel to meet the goals of RFS. Additionally, the EPA figures do not account for the availability of plastics and rubbers, which do not qualify as a feedstock under the RFS.[173] However, technology does exist to convert these materials into fuel.

j. Pennycress

A member of the mustard family, pennycress is a non-invasive weed-like plant that produces oilseeds. Pennycress provides many advantages as a biofuel feedstock: it is a non-food crop; it can be grown in rotation with corn and soy, capable of growth during winter months; it is a hardy plant, requiring minimal inputs, that protects against erosion and does not strip the soil of key nutrients; and the seeds contain twice the oil of soybeans.

When only utilizing fallow fields in between corn and soybean plantings, pennycress could be grown on more than 40 million acres.[174] Using an approximate midpoint of expected yield, 96.25 gallons per acre per year, 40 million acres would yield 3.85 billion gallons of pennycress oil each year.[175] This could dramatically increase with improved agricultural practices and utilization of marginal, non-arable land for pennycress production. The United States Department of Agriculture (USDA) estimate of biofuel potential from pennycress is 6 billion gallons per year.[176] Because pennycress is an oilseed, the resulting fuel will likely be biodiesel, renewable diesel, or aviation fuel. These fuels have equivalence values ranging from 1.5 to 1.7, meaning the RFS impact of pennycress could exceed 9 billion ethanol-equivalent gallons, more than half of the total advanced biofuel requirement in 2022. However, biofuel produced from pennycress could not be used for RFS compliance; pennycress is not currently approved as a feedstock for any RFS pathways.

k. Waste Oils

The production of grease and rendered fats is on the rise after several years of decline.[177] The total volume is over 800 million gallons.[178] In determining these

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Additives: Changes to Renewable Fuel Standard Program. *Id.* at *14704*. It is impractical to require complete separation. *Id.*

172. *Id.* at 14753. The analysis did not account for renewable biomass from natural disasters, which can be significant. *Id.*

173. *Id.*

174. *See Pennycress Energy Crop Strategy*, GROW PENNYCRESS, http://www.growpennycress.com/strategy.html (last visited Jan. 1, 2013).

175. Bryan R. Moser et al, *Production and Evaluation of Biodiesel from Field Pennycress (*Thalspi arvense L.) *Oil*, 23 ENERGY & FUELS 4149, 4150 (2009), *available at* http://www.biodiesel.org/reports/20090601_gen-413.pdf (estimating 600 to 1200 L of oil per hectare).

176. *Pennycress Energy Crop Strategy*, *supra* note 174.

177. Regulation of Fuels and Fuel Additives: 2013 Biomass-Based Diesel Renewable Fuel Volume, 77 Fed. Reg. 59458, 59463 (Sept. 27, 2012) (to be codified at 50 C.F.R. pt. 20).

178. *Id.*

figures, the EPA did not consider edible tallow, lard, or poultry fat because the market already absorbs these products for other uses.[179] Of course, as the EPA notes, these products may become feedstock for BBD if economics shift.[180] The oleochemical industry raised concerns that RFS drives its current feedstocks to biofuel production.[181] The EPA rebuts that the market will determine what products are ultimately derived from these feedstocks.[182] Due to the significant and expanding quantities of waste grease, the EPA does not foresee a significant diversion of edible tallow, lard, or poultry fat toward biofuel production.[183] For the current mandate, the EPA estimated that approximately 30% of the biomass-based diesel mandate would be met with grease and rendered fats.[184] Obviously, the total volume from waste oils can be expected to grow, particularly as the price of petroleum increases.

l. Wood Waste

Wood waste may be available from multiple operations: conventional logging harvest, forest management, and clearing.[185] Accounting for volume of waste left at the site itself, 67 million dry tons were available in 2004.[186] Wood from national and virgin forests cannot be used to produce qualifying fuels under RFS.[187] There are additional feedstock opportunities from mill residue and other timber operations.[188] Overall, the EPA estimates that 100 million ethanol-equivalent gallons can be generated from wood waste.[189]

5. Cumulative Impact of Non-Food Feedstocks

By utilizing the above information, one can make a reasonable determination of the potential mix of fuels that could be used to meet the RFS goal of 36 billion gallons of fuel.

As noted above, ethanol from cornstarch is capped at 15 billion gallons in 2015 and remains at that level until 2022. The ethanol market has grown rapidly in the past decade and there is little doubt that the 15 billion gallon requirement will be met. Derived from the ethanol process, corn oil will be used to produce at least 300 million gallons of biofuel.[190] Corn stover can provide 5.7 billion gallons of

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179. *Id.*
180. *Id.*
181. *Id.*
182. *Id.*
183. *Id.* at 59463-64.
184. *Id.* at 59463.
185. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. 14670, 14754 (Mar. 26, 2010) (to be codified at 40 C.F.R. pt. 80).
186. *Id.*
187. *Id.*
188. *Id.*
189. *Id.*
190. Current production is approximately 270 million. This is likely a conservative estimate because the renewable fuel category (the corn ethanol category) will still grow by 12%, additional facilities will continue to integrate the technology, and the technology will continue to improve. Corn ethanol increases and technology should increase ethanol production with cellulosic portion of corn kernel.

biofuel, while other sources of crop residue add 800 million. Perennial grasses can provide at least another 3.5 billion gallons.

Waste oils can be expected to produce at least 500 million gallons, probably more. Non-food oil crops can provide significant volumes: 1 billion gallons from camelina; 6 billion gallons from pennycress;[191] and algae contributing 100 million gallons. Adding in waste streams, biogas in total could provide 3.93 billion gallons.[192] Urban waste can provide another 2.3 billion gallons, and wood waste can provide 100 million gallons.

Using low production levels of food crops, soybeans can provide 600 million gallons, and canola can provide 200 million gallons. With the rise of electric vehicles and biomass provided to meet renewable portfolio standards, bioelectricity can provide the equivalent of 300 million gallons.

This Essay does not account for every possible biofuel feedstock, as a multitude of feedstocks are under research and development. Of note, the totals do not include various other feedstocks, such as: sustainably grown trees, such as populars; sorghum; kudzu; other microorganisms; and roots and tubers. Of course, RFS is the driver of this development.

In all, these figures total 40.33 gallons of renewable biofuel. In many cases, the technology is available to achieve these goals. However, the economics still need to be demonstrated. Because RINs are important to any emerging company's business plan, RFS plays a key role in getting biofuels to the market.

IV. CONCLUSION

RFS has the potential to dramatically alter the mix of transportation fuels in the United States, increasing the supply of renewable fuels. While RFS has raised concerns about the food and feed industry competing with a fuel industry that must meet government mandates, RFS does not necessarily require the use of feedstocks that are traditionally used for food and feed. Quite contrary, there are numerous opportunities for non-food feedstocks to thrive. In the coming years with rapidly increasing advanced biofuel requirements, RFS all but demands that these fuels come from non-food sources. This Essay identified a path to more than 40 billion gallons of fuel, with more than half of the total amount coming from feedstocks not competing with food crops. As the EPA continues to approve pathways and with technological breakthroughs, particularly in the area of the cellulosic biofuel industry, the total number of gallons of biofuel that can be produced will increase. Without a doubt, the percentage of biofuel coming from non-food feedstocks will also increase.

Clearly, Congress did not intend to force different industries to compete for agricultural commodities. Instead, our policymakers saw an opportunity to grow an

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Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards, 77 Fed. Reg. 1320, 1328 (Jan. 9, 2012) (to be codified at 40 C.F.R. pt. 80).

191. An appropriate midpoint, actual projections range from 3.85 billion to 9 billion.

192. 2.7 billion gallons from sewage sludge, 580 million from animal manure, and 650 million gallons from landfills. The landfill volume is actually the current production level; it has the potential to increase to over 1 billion gallons. However, not all of the energy will be converted to fuel or used as electricity to power vehicles.

industry that provides economic, environmental, and energy security benefits. As the EPA has noted, "RFS is a forward-looking program."[193] Therefore, RFS must be allowed to continue on its path to provide significant quantities of renewable transportation fuels produced from non-food feedstocks.

193. Regulation of Fuels and Fuel Additives: 2013 Biomass-Based Diesel Renewable Fuel Volume, 77 Fed. Reg. 59458, 59469 (Sept. 27, 2012) (to be codified at 50 C.F.R. pt. 20).