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Department of Agricultural and Consumer Economics, University of Illinois Urbana-Champaign

The RFS and Domestic Consumption of Conventional Ethanol and Biomass-Based Diesel to 2022

Scott Irwin and Darrel Good

Department of Agricultural and Consumer Economics
University of Illinois

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In the *farmdoc daily* article of November 30, 2016, we examined the magnitude of the "push" in production and consumption of biofuels implied by the U.S. Environmental Protection Agency (EPA) final rulemaking for the Renewable Fuels Standard (RFS) for 2017 and the biomass-based diesel volume requirement for 2018 announced on November 23rd. Two important questions arose from that analysis. First, given our projection that domestic consumption of conventional ethanol could reach 14.41 billion gallons in 2017, when will domestic consumption reach the statutory mandate of 15 billion gallons and completely eliminate the conventional mandate gap? The answer has important policy implications, including the value of conventional ethanol (D6) RINs. Second, the advanced biofuels mandate for each year from 2014 to 2017 represent a push in production and consumption in that the write down in the total advanced mandate was less than the write down in the cellulosic mandate. That difference is 520 million gallons in 2017, much larger than in the previous two years. An important issue with regards to future implementation of the RFS, then, is the magnitude of the advanced mandate push, if any, under a new Administration. The answer has important implications for the demand for biomass-based diesel, required feedstocks, and the value of biomass-based biodiesel (D4) RINs. We analyze those questions in detail in this article.

Projecting Conventional Ethanol Consumption

In the article of November 30, we calculated the expected magnitude of domestic consumption of conventional ethanol (and the resulting conventional ethanol gap) for the years 2014 through 2017 based on our forecasts of (1) gasoline and diesel consumption, (2) the ethanol inclusion rate, and (3) the domestic consumption of ethanol other than conventional ethanol. Those calculations are repeated in Table 1 and assume year-over-year increases in total gasoline consumption of 2.5 percent in 2016 and 1.5 percent in 2017. Our projection of both total diesel use and the ethanol inclusion rate also differ from the EPA projections for some years. Based on calculations using our projections, domestic consumption of conventional ethanol is expected to reach 14.41 billion gallons in 2017, 590 million gallons less than the statutory mandate of 15 billion gallons and 781 million gallons less than the projected 2017 actual mandate of 15.191 billion gallons (based on our higher projection of domestic gasoline consumption compared to the EPA and a fixed fractional mandate of 8.33 percent).

Table 1. Conventional Mandate Gap under EPA Final RFS Rulemakings for 2014-2017 and Assumed Rulemakings for 2018-2022

Item	2014	2015	2016	2017	2018	2019	2020	2021	2022
(1) Total Gasoline Use	136.480	140.438	143.949	146.108	146.839	147.573	148.311	149.052	149.798
(2) Total Diesel Use	55.670	53.506	51.725	53.150	53.416	53.683	53.951	54.221	54.492
(3) Total Gasoline and Diesel Use	192.150	193.944	195.674	199.258	200.254	201.256	202.262	203.273	204.290
(4) E10 Blend Wall [(1) X 0.10]	13.648	14.044	14.395	14.611	14.684	14.757	14.831	14.905	14.980
(5) Total Ethanol Use [(7)+(8)+(9)]	13.420	13.900	14.300	14.550	14.640	14.728	14.816	14.905	14.995
(6) Total Ethanol Inclusion Rate [(5)/(1)]	9.83%	9.90%	9.93%	9.96%	9.97%	9.98%	9.99%	10.00%	10.01%
(7) Cellulosic Ethanol Use	0.001	0.002	0.004	0.013	0.014	0.015	0.016	0.017	0.018
(8) Other Advanced Ethanol Use	0.090	0.115	0.068	0.127	0.127	0.127	0.127	0.127	0.127
(9) Conventional Ethanol Use	13.329	13.783	14.228	14.410	14.499	14.586	14.673	14.761	14.850
(10) Conventional Ethanol Mandate	13.604	14.090	14.497	15.191	15.000	15.000	15.000	15.000	15.000
(11) Conventional Mandate Gap [(10)-(9) if >0]	0.275	0.307	0.269	0.781	0.501	0.414	0.327	0.239	0.150
(12) Petroleum Gasoline and Diesel Use	177.140	178.354	179.194	182.428	183.323	184.225	185.131	186.042	186.957
(13) Fractional Ethanol Mandate [(10)/(12)]	7.68%	7.90%	8.09%	8.33%	8.18%	8.14%	8.10%	8.06%	8.02%

Notes: All values stated in terms of billion gallons except (6) and (13), which are in percentage terms. Total petroleum gasoline and diesel use (12) is net of renewable fuel use (ethanol and biomass-bsaed diesel) and the small refinery exemption, and therefore, does not equal total gasoline and diesel use (3). The small refinery exemption is set to zero for 2015-2017.

The analysis is extended for the years 2018 through 2022 (Table 1), under the following assumptions:

(1) Domestic gasoline and diesel consumption increase by 0.5 percent per year;

(2) The ethanol inclusion rate increases by 0.01 percentage point per year, reflecting some increase in the consumption of mid-level ethanol blends;

(3) Consumption of cellulosic ethanol increases by only one million gallons per year, and;

(4) Consumption of other advanced ethanol (mostly Brazilian ethanol) stabilizes at the level projected for 2017.

The analysis found in Table 1 indicates that domestic ethanol consumption continues to increase annually, but reaches only 14.85 billion gallons in 2022, 150 million gallons less than the statutory volumetric mandate. The projected conventional ethanol gap declines from 781 million gallons in 2017 to 150 million gallons in 2022, but it is not eliminated.

The projected annual increase of 0.5 percent in domestic fuel consumption used in the analysis for 2018-2022 is conservative compared to the current rate of increase being experienced. So, we repeated the analysis in Table 1 under two alternative assumptions: (1) domestic fuel consumption increases at 1.0 percent per year and (2) domestic fuel consumption increases at the average annual rate of 1.7 percent experienced from 1990 through 2004 (see the *farmdoc daily* article of June 10, 2016). The results are summarized in Table 2. Under the assumption of a 1.0 percent growth rate, domestic consumption of conventional ethanol is projected to slightly exceed the statutory mandate by 2021. Under the assumption of a 1.7 percent growth rate, domestic consumption of conventional ethanol is projected to be very close to the statutory mandate by 2019. These results underscore the central role of crude oil and gasoline prices and the resulting rate of increase in domestic fuel consumption in determining how soon the conventional ethanol mandate gap is eliminated. It is possible that consumption of conventional ethanol could reach the statutory mandate of 15 billion gallons sooner than the market anticipates. If those prospects are confirmed by a continuation of increases in domestic gasoline consumption,

substantial downward pressure on D6 RINs prices would be expected. Stated differently, if domestic gasoline consumption continues to increase near recent rates, the only thing on the horizon to hold up D6 prices would be a court ruling against the EPA on its authority to waive the conventional ethanol mandate in 2014-2016. Based on the computations in Table 1, the sum of the waivers for these three years is 2.2 billion gallons.

Table 2. Conventional Ethanol Use and the Conventional Mandate Gap under Alternative Growth Rate Assumptions for Gasoline and Diesel Use over 2018-2022

		Annual Growth Rate in Gasoline and Diesel Consumption over 2018-2022					
		+0.5%		+1.0%		+1.7%	
Year	Conventional Mandate	Conventional Ethanol Use	Conventional Gap	Conventional Ethanol Use	Conventional Gap	Conventional Ethanol Use	Conventional Gap
2014	13.604	13.329	0.275	13.329	0.275	13.329	0.275
2015	14.090	13.783	0.307	13.783	0.307	13.783	0.307
2016	14.497	14.228	0.269	14.228	0.269	14.228	0.269
2017	15.191	14.410	0.781	14.410	0.781	14.410	0.781
2018	15.000	14.499	0.501	14.572	0.428	14.674	0.326
2019	15.000	14.586	0.414	14.733	0.267	14.940	0.060
2020	15.000	14.673	0.327	14.895	0.105	15.210	0.000
2021	15.000	14.761	0.239	15.060	0.000	15.486	0.000
2022	15.000	14.850	0.150	15.226	0.000	15.767	0.000

Note: All values stated in terms of billion of gallons.

Potential Increases in Biomass-Based Diesel Production

As indicated in the *farmdoc daily* article of November 30, the EPA final RFS rulemaking for advanced biofuels also represented a "push" in in the production and consumption of advanced biofuels. The EPA is authorized to reduce (write down) the statutory mandate for cellulosic fuels to levels that reflect actual production capacity. Those write downs have been large, resulting in very small cellulosic mandates. When those write downs occur, the EPA is also authorized to write down the total advanced biofuels mandate by an amount up to the cellulosic write down. For the years 2014 through 2017, the write downs in the total advanced mandates were less than the write downs in the cellulosic mandates. The magnitude of those differences represents the magnitude of the push in production and consumption of advanced biofuels. The magnitude of the push for 2014 through 2017 is shown in Table 3. The annual statutory cellulosic mandates are shown in line 1 while the actual mandates are shown in line 2. The difference (line 3) is the size of the annual write down in the cellulosic mandate. Similarly, the annual statutory advanced mandates are shown in line 4 while the actual mandates are shown in line 5. The difference (line 6) is the size of the annual write down in the total advanced mandate. Line 7 shows the difference between the cellulosic write down and total advanced write down and represents the magnitude of the advanced biofuels push. That difference for 2017 is 520 million gallons, based on our projections of gasoline and diesel consumption and consumption of undifferentiated ethanol and other non-ethanol advanced biofuels. Stated alternatively, 520 million gallons of the cellulosic mandate is effectively converted into additional biomass-based diesel mandate.

The push in the advanced biofuels mandate results in an advanced biofuels gap for 2016 and 2017. The advanced gap is calculated as the total advanced biofuels mandate as implemented minus the sum of the cellulosic and biomass-based diesel mandates minus the expected consumption of undifferentiated ethanol (Brazilian and domestic) and other non-ethanol biofuels. Repeating the analysis of the *farmdoc daily* article of November 30, the advanced biofuels gaps for 2014 through 2017 are calculated in Table 4 and are presented along with the calculated conventional ethanol mandate gaps in order to estimate the total RFS gaps resulting from implementing the EPA mandates. The advanced gap for each year is calculated as the total advanced biofuels mandate as implemented minus the sum of the cellulosic and biomass-based diesel mandates minus the expected consumption of undifferentiated ethanol (Brazilian and domestic) and non-ethanol biofuels. While the calculated advanced gap is zero for both 2014 and 2015, it reaches 428 million gallons in 2016 and 804 million gallons in 2017. The calculated total RFS gap (line 11) grows from 276 million gallons in 2014 to 1.586 billion gallons in 2017. These gaps would have to be met with some combination of additional production and consumption of advanced biofuels and the use of the existing stock of biofuels credits in the form of outstanding Renewable Identification

Numbers (RINs). Assuming that the gaps are filled entirely by biomass-based biodiesel, we calculate total biomass-based diesel production and consumption requirements for each year. The total includes the biomass-based diesel mandate plus the total RFS gap divided by 1.5. The RFS gap is divided by 1.5 since the gap in Table 4 is calculated as ethanol equivalents. Implied total biomass-based diesel consumption (line 12), then, is calculated in terms of wet physical gallons. The implied increase in potential biomass-based diesel is truly eye-popping, jumping from about 2.0 billion gallons in 2015 to 3.1 billion gallons in 2017.

Table 3. Writedown of Advanced RFS Mandates for 2014-2017

Item	2014	2015	2016	2017	2018	2019	2020	2021	2022
(1) Statutory Cellulosic Mandate	1.75	3.00	4.25	5.50	7.00	8.50	10.50	13.50	16.00
(2) Actual Cellulosic Mandate	0.034	0.123	0.229	0.315	0.336	0.357	0.378	0.399	0.420
(3) Writedown of Cellulosic Mandate [(1)-(2)]	1.716	2.877	4.021	5.185	6.664	8.143	10.122	13.101	15.580
(4) Statutory Advanced Mandate	3.75	5.50	7.25	9.00	11.00	13.00	15.00	18.00	21.00
(5) Actual Advanced Mandate	2.675	2.889	3.602	4.335	4.956	5.577	5.698	5.819	6.440
(6) Writedown of Advanced Mandate [(4)-(5)]	1.075	2.611	3.648	4.665	6.044	7.423	9.302	12.181	14.560
(7) Difference between Writedowns [(3)-(6)]	0.641	0.266	0.372	0.520	0.620	0.720	0.820	0.920	1.020

Note: These volumes are stated in billion gallons of ethanol equivalents

Table 4. Conventional Ethanol and Advanced Mandate Gaps under EPA Final Rulemakings for 2014-2017 and Assumed Rulemakings for 2018-2022

Item	2014	2015	2016	2017	2018	2019	2020	2021	2022
(1) Conventional Ethanol Mandate	13.604	14.090	14.497	15.191	15.000	15.000	15.000	15.000	15.000
(2) Conventional Ethanol Use	13.329	13.783	14.228	14.410	14.499	14.586	14.673	14.761	14.850
(3) Conventional Mandate Gap [(1)-(2)]	0.275	0.307	0.269	0.781	0.501	0.414	0.327	0.239	0.150
(4) Advanced Mandate	2.675	2.889	3.602	4.335	4.956	5.577	5.698	5.819	6.440
(5) Cellulosic Mandate	0.034	0.123	0.229	0.315	0.336	0.357	0.378	0.399	0.420
(6) Biomass-Based Diesel Mandate	1.665	1.772	1.899	2.026	2.100	2.200	2.300	2.400	2.500
(7) Undifferentiated Brazilian Ethanol	0.064	0.089	0.041	0.100	0.100	0.100	0.100	0.100	0.100
(8) Undifferentiated Domestic Ethanol	0.026	0.026	0.027	0.027	0.027	0.027	0.027	0.027	0.027
(9) Undifferentiated Non-Ethanol	0.053	0.033	0.027	0.050	0.050	0.050	0.050	0.050	0.050
(10) Advanced Mandate Gap [(4)-(5)-(6)*1.5-(7)-(8)-(9) if >0]	0.000	0.000	0.428	0.804	1.293	1.743	1.693	1.643	2.093
(11) Total RFS Gap [(3)+(10)]	0.276	0.307	0.697	1.586	1.794	2.157	2.020	1.882	2.243
(12) Implied Total Biomass-Based Diesel [(6)+(11)/1.5]	1.849	1.976	2.364	3.083	3.296	3.638	3.647	3.655	3.996

Notes: These volumes are all stated in billion gallons of ethanol equivalents, except for (6) biomass-based diesel and (12) implied total biodiesel, which are stated in billion gallons of "wet" physical volume terms

The policy question is, how aggressive will the advanced biofuels push be in the future? The push was increased for both 2016 and 2017, so we start with the scenario of a larger push each year from 2018 through 2022 (Table 3). Again, line 1 shows the annual statutory cellulosic mandate through 2022 and line 2 shows the projected actual cellulosic mandate assuming a 20 million gallon annual increase in production capacity. The magnitude of the projected write down, then, is presented in line 3. The statutory advanced biofuels mandate is shown in line 4 and the projected actual mandate is shown in line 5 under the assumption that the difference between the cellulosic and total mandate write down increases by 100 million gallons per year, reaching 1.02 billion gallons in 2022 (line 7). Table 4 then presents the calculation of the conventional, advanced, and total RFS gaps to 2022 assuming no growth in consumption of undifferentiated ethanol (Brazilian and domestic) and non-ethanol advanced biofuels. The calculated RFS gap grows to 2.243 billion gallons by 2022. Assuming that the biomass-based diesel mandate is increased by 100 million gallons from 2019 through 2022 and that the entire RFS gap is satisfied with biomass-based biodiesel, we calculate total production of biomass-based diesel to 2022. That calculation grows from 3.083 billion gallons in 2017 to 3.996 billion gallons in 2022.

We also consider two alternatives to the base scenario, which assumes that the advanced mandate write down decreases by 100 million gallons relative to the cellulosic mandate each year over 2018-2022 (Table 5). The first alternative ("Minimum") assumes that the write down in the total advanced mandate equals the write down in the cellulosic mandate. This scenario might be consistent with a new Administration that is less supportive of advanced biofuels production. The second alternative ("Increase") assumes that the advanced mandate write down decreases by 200 million gallons relative to the cellulosic mandate each year. This scenario represents a continuation of recent biofuels policy that appears to be increasingly aggressive in pushing biofuels consumption. The calculations for projected production of biomass-based diesel and implied feedstock use for each year for each of the three scenarios are summarized in Table 5.

Table 5. Potential Total Biomass-based Diesel and Total Feedstock Use under Alternative Total Advanced Writedown Policies over 2014-2022

	Total Advanced Writedown Policy					
	Current		Minimum		Increase	
Year	Implied Total Biomass-based Diesel	Implied Total Feedstock Use	Implied Total Biomass-based Diesel	Implied Total Feedstock Use	Implied Total Biomass-based Diesel	Implied Total Feedstock Use
2014	1.849	13.683	1.849	13.683	1.849	13.683
2015	1.976	14.625	1.976	14.625	1.976	14.625
2016	2.364	17.495	2.364	17.495	2.364	17.495
2017	3.083	22.812	3.083	22.812	3.083	22.812
2018	3.296	24.391	2.883	21.333	3.363	24.885
2019	3.638	26.922	3.158	23.370	3.771	27.909
2020	3.647	26.984	3.100	22.939	3.847	28.464
2021	3.655	27.043	3.041	22.505	3.921	29.017
2022	3.996	29.567	3.316	24.535	4.329	32.033

Notes: Biomass-based diesel use is stated in terms of billion of "wet" physical gallons, while feedstock use is stated in terms of billion pounds. The current policy scenario assumes the advanced mandate writedown decreases by 100 million gallons relative to the cellulosic mandate writedown each year over 2018-2022. The minimum policy scenario assumes that the advanced and cellulosic mandate writedowns are the same. The increased policy scenario assumes the advanced mandate writedown decreases by 200 million gallons per year relative to the cellulosic mandate writedown over 2018-2022

The base scenario points to a 69 percent increase in annual biomass-based diesel and feedstock consumption from 2016 to 2022, while the increase scenario points to an 83 percent increase and the minimum scenario points to an increase a 40 percent. Considering the final year, the alternative scenarios result in a range of about one billion gallons in annual biomass-based diesel production and 7.5 billion pounds in feedstock use. Increases under all three scenarios are large, but the results underscore the importance of policy towards setting the advanced mandate push going forward.

Implications

We have examined two central questions about domestic biofuels consumption through 2022 as they relate to the RFS. First, when will domestic consumption of ethanol reach the statutory RFS mandate ceiling of 15 billion gallons and completely eliminate the conventional ethanol mandate gap? Second, what will be the magnitude of the push in the production and consumption of advanced biofuels to the year 2022? The answer to the first question depends heavily on the rate of increase in domestic fuel consumption, while the answer to the second question will depend on how the new Administration chooses to implement the advanced RFS mandate starting in 2018. We conclude that: (1) consumption

of conventional ethanol could reach the statutory mandate of 15 billion gallons sooner than the market anticipates, which could result in substantial downward pressure on D6 RINs prices; and (2) while annual production and consumption of biomass-based diesel and its feedstocks will likely increase substantially by 2022 in order to fulfill the advanced mandate, the magnitude of the increase could vary over a wide range depending on how much of the cellulosic mandate is effectively converted into additional biomass-based diesel mandate.

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