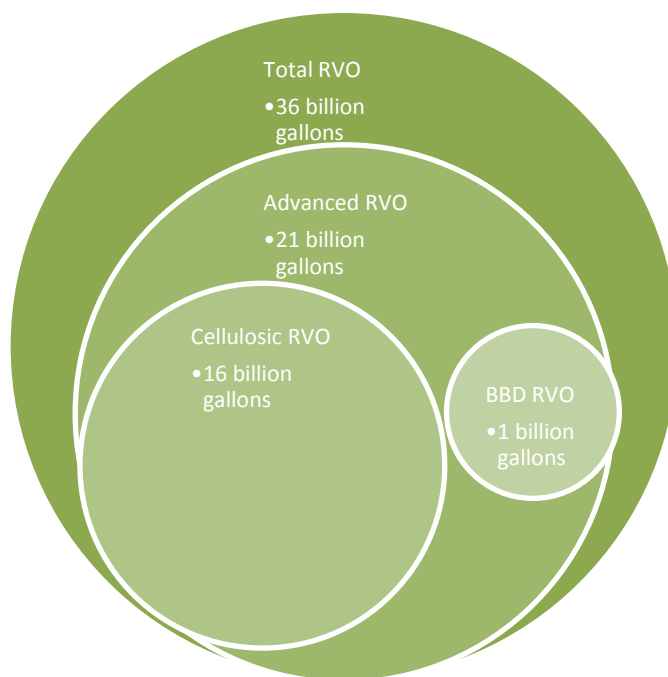


Estimating GHG Emissions from Proposed Changes to the Renewable Fuel Standard through 2022

Background

The Renewable Fuel Standard establishes annually increasing requirements for renewable fuels to be produced and used in the United States – rising to 36 billion gallons in 2022. Broadly, the goals of the statute are to reduce both greenhouse gas emissions from the U.S. transportation sector and the nation’s reliance on imported oil by displacing petroleum fuels. The program, which is part of the Clean Air Act, is administered by the U.S. Environmental Protection Agency (EPA). Specifically, the statute establishes a set of nested Renewable Volume Obligations (RVOs) for use of cellulosic biofuels, biomass-based diesel, and unspecified advanced and conventional renewable fuels.¹ Figure 1 depicts the nested structure of the RVOs.

Figure 1: Nested Structure of 2022 Statutory Renewable Volumes Obligations



To meet the cellulosic RVO, a biofuel must reduce greenhouse gas emissions on a lifecycle basis by at least 60 percent, compared to the 2007 baseline for petroleum gasoline, and be derived from a qualifying biomass feedstock. Likewise, biomass-based diesel and all other advanced biofuels must reduce greenhouse gas emissions by 50 percent and be derived from a qualifying source of biomass. Conventional fuels must reduce greenhouse gas emissions by 20 percent compared to the same

¹ Fed. Reg. 75(58), Friday, March 26, 2010.

baseline. The nested RVOs are designed to achieve reductions (not just to slow growth) in greenhouse gas emissions associated with transportation, jet and heating fuels.

Of the total obligation, at least 1 billion gallons must be biomass-based diesel (BBD) and an annually increasing volume must be qualifying gallons of cellulosic biofuel (which can be transportation, jet or heating fuel). Though the statutory volumes of cellulosic biofuel grow to 16 billion gallons in 2022, EPA is required to reset the annual RVO to the projected available quantity. Both BBD and cellulosic biofuels meet the advanced category, but the remaining advanced RVO can be filled with any additional qualifying advanced biofuel (transportation, jet or heating fuel). Likewise, all advanced biofuels meet the total RVO, but the portion not set aside for advanced can be met with conventional biofuels (defined as renewable fuels, such as ethanol, from corn). The statutory RVOs are displayed in Table 1.

Table 1: Statutory RVOs under the Renewable Fuel Standard

Year	Cellulosic RVO	BBD RVO	Total Advanced RVO	Unspecified Advanced (Total - Cellulosic + BBD)	Total Renewable RVO	Conventional Biofuel Maximum (Total - Advanced)
2009	0	0.5	0.6	0.1	11.1	10.5
2010	0.1	0.65	0.95	0.2	12.95	12
2011	0.25	0.8	1.35	0.3	13.95	12.6
2012	0.5	1	2	0.5	15.2	13.2
2013	1	1	2.75	0.75	16.55	13.8
2014	1.75	1	3.75	1	18.15	14.4
2015	3	1	5.5	1.5	20.5	15
2016	4.25	1	7.25	2	22.25	15
2017	5.5	1	9	2.5	24	15
2018	7	1	11	3	26	15
2019	8.5	1	13	3.5	28	15
2020	10.5	1	15	3.5	30	15
2021	13.5	1	18	3.5	33	15
2022	16	1	21	4	36	15

When EPA waives the statutory cellulosic RVO to the projected available volume, it is authorized to reduce the overall and advanced RVOs by up to the same amount. Since 2010, EPA has waived nearly all of the statutory cellulosic RVO, but maintained the overall advanced and total RVOs. EPA has set the annual RVOs at the maximum achievable levels of production of renewable fuels, taking into account the availability of compliance credits from prior years. Biomass-based diesel (BBD) and other advanced biofuels have been produced, imported and sold in

sufficient quantities to meet the advanced RVO. Corn ethanol – which has proven to be a very cost-effective additive to fuel – has met the remaining portion of the total RVO.

Discussion

EPA's proposed 2014 Standards for the RFS Program would set aside the statutory RVOs and establish a new methodology for determining the annual requirements for renewable fuel use.² Under this proposed new methodology, EPA would first determine the amount of ethanol that could be used with gasoline in E10 and E85 blends. EPA would next project the amount of non-ethanol cellulosic, biomass-based diesel and other advanced biofuels that could be produced and used within the United States. As a third step, the agency would establish the cellulosic, BBD and undifferentiated advanced RVOs at or below the projected volumes available, to ensure that the ethanol content does not exceed the volume determined in the first step.

The new methodology will limit ethanol use to 10 percent of the gasoline supply for the next few years. The methodology will likely ensure that corn ethanol fills the vast majority of the RVO used in E10 gasoline blends. The proposed methodology will also limit RVOs for non-ethanol biofuels and higher blends of ethanol to below their already established share of the market. If the proposed rule is finalized, the use of biofuels will decline in 2014, compared both to 2013 and to the volumes specified in the statute.

The resulting increase in emissions for 2014 can be modeled using GREET1.2013. The GREET model estimates of the greenhouse gas intensity of petroleum and biofuels, measured in carbon dioxide equivalents (CO₂e), were updated in 2012.³ Because the United States now imports more oil from Canada and Venezuela than it did in 2007, and more of Canada's oil exports come from oil sands, the greenhouse gas intensity of petroleum fuels has increased. Comparatively, the greenhouse gas intensity of biofuels is decreasing.

Emissions can be estimated for 2022 using U.S. Energy Information Administration (EIA) projections of fuel use and the market penetration of various fuel sources combined with GREET1.2013 emissions values.⁴ EIA's projections are based on assumptions of current policy carried forward and market growth of existing technologies. GREET emissions values are based on 2012 data. EIA projects that

² Fed. Reg. 78(230), Friday, Nov. 29, 2013, p.71754.

³ Wang, M., J. Han, J. Dunn, H. Cai, and A. Elgowainy, 2012, "Well-to-Wheels Energy Use and Greenhouse Gas Emissions of Ethanol from Corn, Sugarcane and Cellulosic Biomass for US Use," Environmental Research Letter, 7 (2012) 045905 (13pp).

⁴ U.S. Energy Information Administration, Annual Energy Outlook 2014 Early Release, Report No.: DOE/EIA-0383ER(2014), Dec. 16, 2013.

U.S. imports of petroleum from Canada will increase through 2022, even while overall petroleum import levels fall. However, the greenhouse gas intensity of petroleum in 2022 is not captured or estimated in GREET1.2013.

Use of transportation fuels is expected to increase in 2014 compared to 2013.⁵ Even though gasoline use will decline, diesel use is expected to increase in 2014. The use of additional petroleum in 2014, compared to 2013, will automatically increase greenhouse gas emissions. Through 2022, EIA projects overall transportation fuel consumption to decline. Gasoline consumption is expected to decline by nearly 10 percent, from 132.8 billion gallons in 2014 to 121.1 billion gallons in 2022. Diesel fuel consumption is expected to increase, from 55.2 billion gallons in 2014 to 61.5 billion gallons in 2022. The decline in gasoline use will more than offset the increase in diesel use in 2022, resulting in an overall decrease in transportation fuel use.

If fuel use declines along the lines of EIA projections, greenhouse gas emissions would also fall between 2014 and 2022. However, with ongoing changes in the sources of U.S. petroleum supply, the decline in emissions is not guaranteed. Use of more petroleum from Canada and from enhanced oil recovery technologies in the United States could increase emissions from each gallon of petroleum.

EIA also projects E85 use to grow 20-fold from its current level of 153.3 million gallons to nearly 3.1 billion gallons per year by 2022. Production and use of biodiesel remains unchanged from 2014 to 2022.

The GREET1.2013 model uses 2012 measurements of greenhouse gas emissions for petroleum fuels, which are 94 grams CO₂e per megajoule (gCO₂e/MJ) average for gasoline blendstock and 96 gCO₂e/MJ for diesel. The GREET value for corn ethanol of 65 gCO₂e/MJ, which includes a measurement of land use change, is used to estimate emissions for the conventional biofuel RVO. A soybean biodiesel value of 23 gCO₂e/MJ is used to estimate emissions from the BBD RVO; and a Brazilian sugarcane value of 35 gCO₂e/MJ is used to estimate emissions from the advanced biofuel RVO. The GREET value for corn stover ethanol of 13 gCO₂e/MJ, with land use change, is used to estimate emissions from the cellulosic biofuel RVO.

It is assumed that use of ethanol and biodiesel directly displace consumption of gasoline blendstock and biodiesel. The volume of displacement is adjusted by the difference in heating values. To enable comparison, all values are converted to a gasoline gallon equivalent of gCO₂e.

Results

⁵ "EPA proposes 2014 Renewable Fuel Standard, with EIA to provide input to the final rule," This Week in Petroleum, Nov. 20, 2013.

EPA's proposed RVOs for 2014 result in an estimated increase of 6.66 million metric tons of CO₂e from 2013 to 2014. If EPA were to maintain the RFS at the statutory volumes in 2014, the United States would achieve an estimated reduction of emissions of 24.2 million metric tons CO₂e. The results of the modeling of GREET1.2013 values are displayed in Table 2.

Table 2: Estimated Changes in Greenhouse Gas Emissions from 2013 to 2014

Emissions Source	GHG Emissions (thousand metric tons CO ₂ e)			Changes in GHG Emissions from 2013	
	2013	2014 Proposed RVO	2014 Statutory RVOs	2014 Proposed RVO	2014 Statutory RVO
Gasoline Blendstock	1,394,363	1,387,719	1,342,689	-6,643	-51,674
Diesel	685,039	704,068	707,718	19,029	22,678
Conventional (Corn ethanol)	72,003	67,829	75,134	-4,174	3,131
BBD (soy biodiesel)	3,757	3,757	2,935	0	-822
Advanced (Brazilian sugarcane ethanol)	2,238	681	2,826	-1,557	588
Cellulosic (corn stover ethanol)	7	18	1,897	12	1,891
Total	2,157,407	2,164,073	2,133,199	6,666	-24,208

The statutory volume of 1 billion gallons of BBD is less than the proposed volume for 2014 of 1.28 billion gallons, which results in additional use of petroleum diesel under the statute when compared to the proposal. Additionally, EPA proposes to lower the cellulosic biofuel RVO to the projected available volume of 17 million gallons, as required. If these values are substituted for the statutory volumes, allowing the overall advanced RVO to remain at the statutory level as EPA has done in prior years, the achieved reduction in greenhouse gas emissions would be 21.6 million metric tons CO₂e. If EPA were to reduce the advanced and overall RVOs by the same amount as they reduce the cellulosic RVO, the reduction in greenhouse gas emissions would be 8.9 million metric tons CO₂e. These results are presented in Table 3. EPA's proposed change in methodology results in a net increase of 28.2 million metric tons CO₂e in 2014 relative to previously established methodology. This is equivalent to the emissions of 5.9 million additional vehicles.

Table 3: Estimated Changes in Greenhouse Gas Emissions from 2013 to 2014 under Varying RVO Assumptions

Emissions Source (thousand metric tons CO ₂ e)	Proposed RVOs	Statutory RVOs	Proposed RVOs for BBD and Cellulosic, Statutory Total Advanced	Proposed RVOs for BBD and Cellulosic, Equivalent Reduction of Advanced
Gasoline Blendstock	-6,643	-51,674	-48,434	-31,623
Diesel	19,029	22,678	19,029	19,029
Conventional (Corn ethanol)	-4,174	3,131	3,131	3,131
BBD (soy biodiesel)	0	-822	0	0
Advanced (Brazilian sugarcane ethanol)	-1,557	588	4,695	588
Cellulosic (corn stover ethanol)	12	1,891	12	12
Total	6,666	-24,208	-21,568	-8,864

To estimate emissions in 2022, we assume a continuation of EPA’s newly proposed methodology of limiting RVOs to the estimated market use of various biofuel categories. The estimate of market use of various renewable fuels is taken from EIA’s Annual Energy Outlook 2014 Early Release. We also assume no additional cellulosic biofuel growth beyond the 100 million gallons of capacity currently in production or under construction, due to the uncertainty for investors created by the change in the rules.

Under the model, in 2022 EPA could be expected to establish the total amount of ethanol to be used in the market at 15.2 billion gallons – equivalent to 10 percent of estimated gasoline use of 121.1 billion gallons plus market growth of E85, equivalent to 3.1 billion gallons. EIA projects that 1.1 billion gallons of ethanol will be imported, so emissions are estimated as though these gallons make up the undifferentiated portion of the advanced RVO. The overall advanced RVO is therefore estimated to be 2.6 billion gallons and the total RVO is estimated at 16.7 billion gallons.

EIA also projects that 61.5 billion gallons of petroleum diesel will be used. EPA would be expected to establish the BBD RVO at 1.4 billion gallons, based on steady market demand from 2014 to 2022, directly displacing an equivalent volume of petroleum diesel.

Under these assumptions, and using 2012 estimates of greenhouse gas intensity from GREET that include land use change, emissions would be expected to fall by 68.9 million metric tons of CO₂e when compared to 2013. However, by not

maintaining the statutory advanced and total RVOs, EPA is foregoing additional emission reductions of more than 168 million metric tons CO₂e relative to previously established methodology. This is equivalent to the emissions of more than 35 million additional vehicles. Results are presented in Table 4.

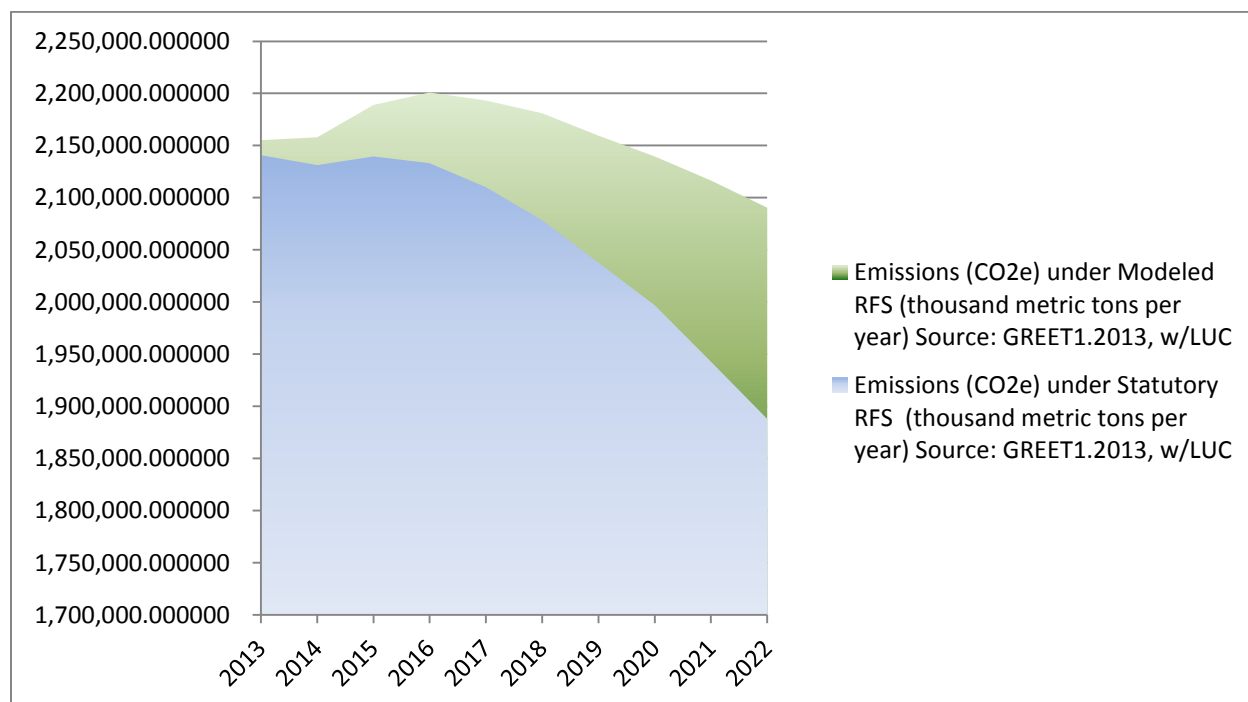
Table 4: Estimated GHG Emissions in 2022 under Varying RVO Assumptions

Emissions Source (thousand metric tons CO ₂ e)	Modeled RVOs	Statutory RVOs	Statutory RVOs, with Cellulosic Waiver and Statutory Total Advanced	Statutory RVOs with Cellulosic Waiver and Equivalent Reduction of Advanced
Gasoline Blendstock	1,224,097	1,070,680	1,008,133	1,192,095
Diesel	783,572	706,675	775,062	775,062
Conventional (Corn ethanol)	73,569	78,264	78,264	78,264
BBD (soy biodiesel)	4,050	5,870	5,870	5,870
Advanced (Brazilian sugarcane ethanol)	3,109	8,479	53,417	8,479
Cellulosic (corn stover ethanol)	108	17,344	108	108
Total	2,088,506	1,887,313	1,920,855	2,059,879
Difference from 2013	-68,901	-270,094	-236,552	-97,529

Using similar methodology, cumulative foregone emissions reductions over the period 2014-2022 approach 1 billion metric tons CO₂e. This is roughly equivalent to adding more than 202 million cars to the road between 2013 and 2022.

Additionally, due to a projected increase in gasoline consumption in 2015 and 2016 (compared to 2013), the change in methodology increases the use of petroleum fuels and associated emissions of greenhouse gases. Overall petroleum use does not fall below 2013 levels until 2019, increasing the emissions of greenhouse gases measured in CO₂e, as shown in Figure 2.

Figure 2: CO₂e Emissions under Statutory RFS and Modeled RFS Biofuel Levels



Conclusion

EPA's proposal to change the methodology of setting the RVOs for the Renewable Fuel Standard will have an immediate impact on greenhouse gas emissions in 2014, since it will lower biofuel use as transportation fuel use increases. These emissions can be modeled with EPA's own estimates of the greenhouse gas intensity of various fuel options, but the increase still occurs. EPA's proposed change in methodology results in an estimated net increase of 28.2 million metric tons CO₂e in 2014 relative to previously established methodology. This is equivalent to the emissions of 5.9 million additional vehicles. By maintaining the current methodology for setting the RVOs, based on the availability of renewable fuel, EPA can ensure a reduction in greenhouse gas emissions in 2014 compared to 2013.

As fuel use declines through 2022, associated greenhouse gas emissions will naturally decline as long as the emissions intensity of various fuel choices remains stable. However, if EPA's proposed new methodology is applied in 2022, when statutory levels of biofuel use would reach 36 billion gallons, the country will forego additional emission reductions of more than 168 million metric tons CO₂e relative to previously established methodology. This is equivalent to the emissions of more than 35 million additional vehicles. Cumulative foregone emissions reductions over the period 2014-2022 approach 1 billion metric tons CO₂e. EPA should carefully consider the impact on transportation sector CO₂ emissions in assessing its proposed change in methodology.