The Social Costs and Burdens of Potential Future RFS Policies

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Executive Summary

This policy brief highlights the potential social costs and burdens of future RFS volume mandates in the face of falling fuel demand. Depending on the renewable fuel volumetric target, this means the total RFS blend requirement could increase markedly from its current 10.97% [1]level up to 11.8% for 2022 and as high as 13.6% in 2027, depending on transportation fuel demand in the high *versus* low oil price scenarios projected in 2019 by the Energy Information Administration (EIA). We estimate the welfare costs of the RFS mandate and blend wall for fuel consumers to therefore range from $17 billion in 2022 to $30 billion in 2027.[2]

The consumption of higher ethanol blends (E15, E85 and mid-blends that we refer to as E10+ fuels) is very low because infrastructure is costly as are incentives to induce consumers to adopt E10+ fuels. Hence, most of the shortfall in biofuels due to the ethanol blend wall has been met by blending incremental volumes of biomass based diesel (BBD)[3] in excess of its mandated volume. Therefore, diesel fuel consumers bear the largest share of this burden, which has important general equilibrium ramifications since heavy trucks and trains account for most of the diesel fuel consumption in the U.S. The increased cost of transportation could lead to higher prices for consumers.

It is therefore becoming increasingly clear that industry and policy makers need to find a joint way forward to keep the mandates both physically and economically feasible. Fundamental changes in the market affecting annual renewable volume obligations beyond 2020 include lower gasoline consumption as projected by EIA and the uncertainty in cost and availability of biodiesel and renewable diesel as the ethanol blend wall continues to constrain ethanol blending. Most previous economic research on the RFS and the ethanol blend wall has focused on certain aspects or a type of renewable fuel, leaving an analytical gap. We fill that gap here and show developments in fuel demand will require the EPA to make significant downward adjustments in the RFS volume to make the RFS sustainable in this new environment.

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[1] 2019 final percentage standard set at 10.97% by EPA. Federal Register / Vol. 83, No. 237 / Tuesday, December 11, 2018 / Rules and Regulations.
[2] Welfare costs are estimated as the sum of fuel consumer and producer surplus, government expenditures as well as the value of CO_2 emission reductions.
[3] Biomass-based diesel is an advanced renewable fuel category in the RFS program. Biomass-based diesel can be from feed stocks including vegetable oil, animal fat or waste grease. Typically, biodiesel is made from vegetable oil and renewable diesel is made from animal fat and waste grease

Introduction

This policy brief takes stock of lessons learned regarding the incidence of increased blend mandate requirements in light of the upcoming EPA "reset" rulemaking as well as continuation of RFS annual volumetric mandate obligations beyond 2022.[4] Most of the academic economics literature on the costs of the RFS and the ethanol blend wall ignores the nested mandate structure and joint compliance base.[5,6] In contrast, recent peer reviewed published papers in the prestigious journals *Energy Economics* and the *American Journal of Agricultural Economics* by Korting and Just (2017) and Korting, de Gorter and Just (2018) take a more realistic approach. More specifically, these two papers acknowledge the reality of a constraining ethanol blend wall (and its high cost), the joint compliance base introduced in 2010 by the EPA (creating a link between motor gasoline and diesel fuel markets) and the nested mandate structure causing imports of BBD and renewable diesel (and net exports of ethanol). These two studies show a very high cost to society if the total RFS blend requirement increases to 12% (and by extension, if it goes beyond 12% in 2022 and 2027, as it could do by a wide margin if current RFS volumes are used, given recent EIA fuel consumption projections). The social cost will be at a minimum of an additional $17 bil. in 2022 for motor gasoline and diesel fuel consumers and a total of $30 bil. in 2027 for worst case scenario considered in this briefing paper. Most of the burden is borne by diesel fuel consumers but motor gasoline consumers lose increasing amounts as the blend requirement reaches higher levels.

Future Policy Scenario Impacts of the RFS

Motor gasoline and diesel fuel consumption are both projected by EIA[7]; gasoline is projected to decline while diesel remains relatively constant to 2027 compared to consumption levels in 2018-2019. The effect of this overall declining consumption combined with assumed biofuel volume requirements could result in an unsustainable policy scenario manifested in blending percentage requirements.

Tables 1 and 2 present modeled scenarios for the years 2022 and 2027, respectively.

For each scenario year (2022 and 2027), we used input data from EIA's 2019 Annual Energy Outlook (2019 AEO) for gasoline and diesel consumption; these are clearly indicated in the Table

[4] RFS statutory provisions require the EPA to modify volume requirements for compliance years 2020-2022 (https://www.eia.gov/todayinenergy/detail.php?id=37712) and determine volumes for future years (Energy Independence and Security Act of 2007).

[5] As explained in more detail below, the RFS implements a nested compliance structure, which allows for overage of biofuels that achieve relatively larger GHG emission reductions relative to the fossil-based fuel they offset towards the broader mandate categories. For example, biodiesel overage can be used to meet part of the mandate for conventional fuels. In addition, since 2010, all mandates apply to the total volume of petroleum-based diesel and gasoline jointly.

[6] The more prominent of such papers include Moschini et al. (2017), Pouliot and Babcock (2016) and Cui et al. (2011). This is in line with an earlier finding by NERA (2012) based on a proprietary model. Given the nested structure of the RFS, the joint compliance base for setting biofuel percentage mandates legislated in 2010, and the ethanol blend wall that became binding in 2013, adding biodiesel should provide important insights into the relative effects on different markets. However, these studies do not capture any of these three features in their model, which we argue are central to the economics of the RFS going forward.

[7] 2019 Annual Energy Outlook (AEO)

rows and explained in the footnotes. The modeled volumes for ethanol and BBD are also clearly explained.

EIA gasoline and diesel consumption volumes for three 2019 AEO cases are used: Reference, High Oil Price and Low Oil Price cases. The modelled ethanol volumes are 10% of motor gasoline consumption (Base Case) and 15 billion gallons (Case A and B). The modelled biomass-based volumes are 2.8 (Base and Case A) and 3.3 (Case B) billion gallons.[8] The downward trend in total transportation fuel consumption is illustrated by comparing projected demand for gasoline and diesel for the years 2022 and 2027.

The final line in Tables 1 and 2 gives the total renewable fuel percentage standard, which is a critical input into our model simulations. Notice in the two tables that the lowest value of the total renewable fuel percentage standard is 10.2%. Furthermore, depending on the scenario, it reaches a possible high of 13.6%. These values drive the social costs of the RFS in the future to which we now turn.

Table 1: Modelled Scenarios for 2022 (all units in bil. Gallons, unless specified otherwise)

	Reference Scenario			High Oil Price			Low Oil Price		
	Base Case	Case A	Case B	Base Case	Case A	Case B	Base Case	Case A	Case B
EIA[(1)] projected gasoline demand	136.8	136.8	136.8	132.8	132.8	132.8	139.3	139.3	139.3
Modeled ethanol volume[(2)]	13.7	15.0	15.0	13.3	15.0	15.0	13.9	15.0	15.0
EIA[(1)] projected diesel fuel demand	56.6	56.6	56.6	57.0	57.0	57.0	56.8	56.8	56.8
Modeled BBD volume	2.8	2.8	3.3	2.8	2.8	3.3	2.8	2.8	3.3
RFS obligated volume[(3)]	176.9	175.6	175.1	173.7	172.0	171.5	179.4	178.3	177.8
Total Renewable RINs[(4)]	18.1	19.4	20.2	17.7	19.4	20.2	18.3	19.4	20.2
Total Renewable % Standard	**10.2%**	**11.0%**	**11.5%**	**10.2%**	**11.3%**	**11.8%**	**10.2%**	**10.9%**	**11.3%**

[(1)] Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2019: Reference case, high oil price and low oil price scenarios

[(2)] Base case calculates volume as 10% of gasoline demand; Cases A and B assume 15 bil gallons

[(3)] Obligated volume is calculated as the sum of the projected gasoline and diesel demand minus the ethanol and BBD volumes

[(4)] Total Renewable RINs calculation uses 1.57 energy equivalent factor for BBD

[8] The modelled biomass-based volume includes biodiesel and renewable diesel. We assume that renewable diesel remains constant at 0.4 billion gallons across scenarios, while the amount of biodiesel increases from 2.4 to 2.9 billion gallons in Case B.

Table 2: Modelled Scenarios for 2027 (all units in bil. Gallons, unless specified otherwise)

	Reference Scenario			High Oil Price			Low Oil Price		
	Base Case	Case A	Case B	Base Case	Case A	Case B	Base Case	Case A	Case B
EIA(1) projected gasoline demand	122.9	122.9	122.9	113.2	113.2	113.2	128.9	128.9	128.9
Modeled ethanol volume(2)	12.3	15.0	15.0	11.3	15.0	15.0	12.9	15.0	15.0
EIA(1) projected diesel fuel demand	55.7	55.7	55.7	53.5	53.5	53.5	56.6	56.6	56.6
Modeled BBD volume	2.8	2.8	3.3	2.8	2.8	3.3	2.8	2.8	3.3
RFS obligated volume(3)	163.5	160.8	160.3	152.5	148.9	148.4	169.8	167.7	167.2
Total Renewable RINs(4)	16.7	19.4	20.2	15.7	19.4	20.2	17.3	19.4	20.2
Total Renewable % Standard	**10.2%**	**12.1%**	**12.6%**	**10.3%**	**13.0%**	**13.6%**	**10.2%**	**11.6%**	**12.1%**

(1) Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2019: Reference case, high oil price and low oil price scenarios

(2) Base case calculates volume as 10% of gasoline demand; Cases A and B assume 15 bil gallons

(3) Obligated volume is calculated as the sum of the projected gasoline and diesel demand minus the ethanol and BBD volumes

(4) Total Renewable RINs calculation uses 1.57 energy equivalent factor for BBD

The Social Costs of Increasing Blend Mandate Levels

The model presented in Korting and Just (2017) and Korting, de Gorter and Just (2018) focuses on the impacts of a binding blend wall given the policy nuances of the RFS such as the nested mandate structure and the joint compliance.[9] The model simulates market outcomes under a series of alternative total renewable blend mandate requirements up to 12%. As Tables 1 and 2 show, the forecast blend ratios may reach 13.6% in the future so we extrapolate the model results to study welfare effects at these elevated blend mandate requirements.

Using this framework, the mandate compliance under the RFS can be achieved via four distinct compliance mechanisms[10]:

1. Increasing ethanol blend ratio in motor gasoline up to 10%,
2. Increasing E10+ sales,
3. Relying on BBD overage, and
4. Decreasing the obligated volume of gasoline and/or diesel (thereby reducing the RIN obligation required of obligated parties).

The first two compliance mechanisms represent using increasing ethanol shares in motor gasoline. The first compliance mechanism was available in the early years of the RFS, but is no longer available now that the gasoline pool has become saturated with E10 gasoline. The blend wall limits option 2 as a result of the high cost for E10+ infrastructure including at the retail gas station level, the price discounts (miles adjusted) for E10+ blends required to induce consumers to purchase such fuels, and the limited availability of Flex Fuel Vehicles (FFVs). Although increasing over time, the current share of E10+ compatible vehicles is estimated at approximately 25% of the LDV fleet.

[9] In particular, the model explicitly accounts for refiners facing both BBD and total renewable percentage blend mandates where a non-integrated blender and refiner seek to maximize profits while ensuring that all considered markets for petroleum products, biofuels, and consumer fuels are balanced.

[10] See Korting and Just (2017) for their discussion of achieving compliance with the RFS via four pathways available under the policy.

The ability to expand E10+ fuel will depend on the D6 RIN price that could provide price discounts for E15, E85 and mid-blends relative to the price of E10. A recent study by Pouliot et al. (2018) concludes: "we find a median willingness-to-pay for the energy-adjusted E85 price between 55% and 76% of the price of E10, a significant discount." Although E15 is a slightly different situation in that the costs of finding a retail outlet would be lower, nonetheless a discount will be required just to get to a miles equivalent basis with the price of E10. Instead of assuming a discount "between 55% and 76% of the price of E10", Lade et al. (2018) calculate the required RIN price to achieve a 5% discount for the price of E15 relative to the price of E10. The results are summarized in Table 3 (reproduced from Lade), which illustrates the large RIN prices required, at various price combinations for ethanol and gasoline, to bring E15 prices into a miles equivalent basis to E10.[11] The extreme magnitude of the required RIN prices under some of these scenarios suggests that expanding E10+ consumption is unlikely to be the main mechanism used to overcome the blend wall. Instead, we may see a continuation of the trend of increasing ethanol exports as ethanol production and supplies in excess of blending have resulted in reallocation of these volumes of ethanol to their next most economically valuable usage.

Table 3: Required D6 RIN price for E15 to be 5% below E10 price*

		Gasoline Price ($/gal.)			
		1.50	1.80	2.10	2.40
Ethanol price ($/gal.)	1.20	1.75	1.72	1.69	1.66
	1.50	2.05	2.02	1.99	1.96
	1.80	2.35	2.32	2.29	2.26
	2.10	2.65	2.62	2.59	2.56

* Wholesale E15 prices and retail E10 prices.
Source: Lade et al. (2018).

The third compliance mechanism relies on the nested mandate structure of the RFS whereby biodiesel blended into diesel fuel beyond the required BBD blend mandate counts towards the wider total renewable blend requirement.

Rather than relying on an increase in renewable volume, the fourth compliance mechanism operates through a reduction in the overall obligated volume. Since annual mandates are implemented as percentage blend mandates, i.e. a ratio of biofuels to petroleum based fuels, both an increase in the numerator or a decrease in the denominator lead to a larger blend ratio overall. The way this mechanism operates becomes more nuanced due to the difference in the denominator for blend mandates versus the blend wall: the blend wall pertains to the amount of ethanol relative to the amount of motor gasoline, rather than relative to the compliance base of the RFS. There is therefore a difference in welfare outcomes depending on whether motor gasoline demand or diesel fuel demand changes. If motor gasoline demand goes down, the blend wall implies that less ethanol can be blended in volume terms. If diesel fuel demand goes down on the other hand, the feasible amount of ethanol blending does not change, and the existing amount of ethanol blending would represent a larger share towards the total compliance base, which is less costly in welfare terms.

[11] One reason these D6 RIN prices are so high for such a small discount on a miles-equivalent basis is the Lade et al. (2018) correctly adjust for marketing margins and the fuel tax applied on a volumetric basis on all fuels.

As long as the biodiesel share in diesel fuel remains much lower than the ethanol share in motor gasoline (about 1/3rd lower), a downward shock to motor gasoline demand, as is the case in EIA's projections, will reduce ethanol's achievable blending towards the total renewable mandate, thereby making the ethanol blend wall more costly going forward.

Korting and Just (2017) use simulation results to provide evidence for the relative importance of the four different compliance mechanisms in the presence of a binding blend wall. Once ethanol blended volume reaches 10% of gasoline demand and the potential for increased E10+ demand becomes very costly, BBD overage plays the dominant role in achieving mandate compliance. For total renewable blend mandates of 10.8% or above, BBD overage dominates the combined effects of the ethanol-related mechanisms 1 and 2. Reducing the joint compliance base, as the fourth mechanism to compliance, is shown to be the most expensive way to ensure compliance and only comes into play for blend mandate requirements of 11.1% and above, which is the case for most scenarios in Tables 1 and 2.

These findings regarding the relative importance of the four compliance options at different mandate levels provide important context to understand and interpret the welfare estimates presented in de Korting, de Gorter and Just (2018).[12] Using the same underlying model, Korting, de Gorter and Just (2018) derive estimates of the social cost of the RFS to consumers and producers.

Korting, de Gorter and Just (2018) find that diesel fuel consumers suffer significant welfare losses as percentage blend mandates increase in the presence of a binding blend wall. Since biodiesel prices were higher than diesel prices in 2015 on average,[13] increased biodiesel blend ratios increase prices at the pump. In addition, the compliance burden on the refiner could also lead to increased costs of diesel sold to the blender, thereby exacerbating the welfare losses. The same is true for motor gasoline with E10 prices eventually rising due to increased gasoline prices, while E10+ prices drop off to encourage consumption.

Figure 1 summarizes the results and highlights the evolution of diesel fuel (DF) and motor gasoline (MG) consumer welfare at mandate levels ranging from the 2015 baseline of 9.5% up to 12% (unshaded area). Comparing Tables 1 and 2 with Figure 1, note that the lowest total renewable blend mandate for all possible scenarios in 2022 and 2027 is 10.2%, representing social costs to fuel consumers of $9 billion compared to a free market of no RFS.

Figure 1 shows that increases in the percentage blend (on the X axis) beyond 9.5% lead to diesel welfare (on the Y axis) dropping off precipitously and then declining more or less linearly Motor gasoline consumers on the other hand see temporary welfare increases as mandate levels rise as prices for E10+ blends fall to encourage consumption. However, this effect wears off quickly at percentage blend requirements over 10%. Nevertheless, welfare losses to motor gasoline consumers remain relatively contained even at a 12% total renewable mandate level where they suffer a welfare loss of $ 2.7 bil. However, diesel fuel consumers lose as much as $ 15.5 bil. (an

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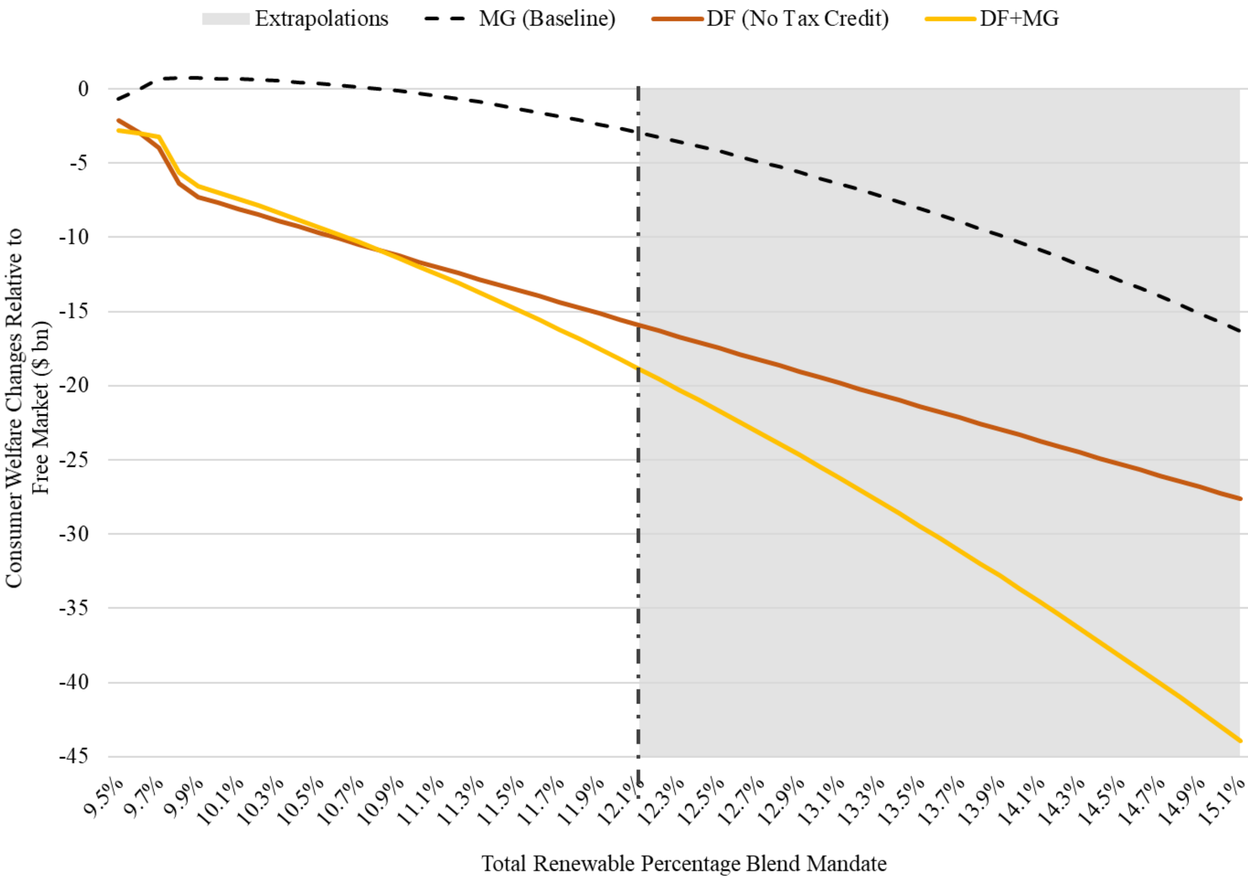
[12] Korting, de Gorter and Just (2018) calculate total welfare as the sum of producer profits, consumer surplus as measured by the area under the demand curve, total government expenditures, and the value of carbon savings.
[13] Alternative Fuels Data Center B99/B100 price versus EIA Monthly Energy Review Refiner Price of No. 2 Diesel Fuel for Resale.

extra cost of $ 4 bil. compared to if the BBD tax credit was maintained) [14] at the 12% mandated blend level. Diesel fuel consumers clearly have incurred the biggest burden.[15] This is a substantial change relative to the welfare results at the 9.5% total renewable mandate level, which actually prevailed in 2015. At this mandate level, the total welfare result is a loss of only $ 1.2 bil. relative to the free market scenario, once again driven by losses in consumer welfare partially offset by gains to biofuel producers.

Figure 1: Consumer Welfare at Alternative at Total Renewable Percentage Blend Mandate Levels



The lines in the grey area of Figure 1 are extrapolated based on trends from our simulations results.[16]

[14] One could speculate that part of the burden shift onto diesel fuel consumers is driven by blenders' trying to capitalize on the biodiesel tax credit, which might incentivize them to favor diesel fuel production over motor gasoline. Instead, our analysis suggests that the biodiesel tax credit in past years actually insulates diesel fuel consumers from part of the welfare burden of the RFS as most of tax credit is passed down to consumers in the form of lower prices (Korting, de Gorter and Just 2018).

[15] These social costs on consumers are partly offset by significant benefits to biodiesel producers although much of this extra production is in foreign countries.

[16] We expect increased approximation error as we move away from the 12% levels based on our papers. The graph shows alternative scenarios under 2015 market conditions, which we calibrated our model to and as such are not actual forecasts. This is the approach followed by all other studies cited in this policy brief.

The total social costs to fuel consumers reach $ 30 bil. at a 13.6% blend requirement (the highest case in Tables 1 and 2). Notice that the share of this burden on motor gasoline consumers' increase at higher percent blend mandate levels.

The fourth compliance mechanism (a reduction in the RFS obligated volume), becomes more prominent with higher total renewable percentage standards. At a 14% renewable percentage standard, we found a reduction of almost 1 bil. gallons of the total obligated volume that cannot be attributed to the price and quantity effects of mechanisms 1-3 (the approach for how we net out the price and quantity effects of mechanisms 1-3 is explained in Appendix D of Korting and Just (2017)). At percentage blend mandates above 11%, it could therefore be expected to see a reduction in gasoline and diesel fuel consumption partly due to this effect. Therefore, this can become a force going forward that does not bode well for the consumers and producers of fuel.

Policy Implications

To date, no welfare economic analysis has been forward looking, while taking into account the ethanol blend wall, obligated renewable fuel volumes consisting of both gasoline and diesel, and the nested structure of the RFS. Once these aspects are analyzed in our holistic framework, combined with EIA projections for gasoline and diesel consumption and assumptions for ethanol and BBD consumption, the welfare costs of the RFS for fuel consumers are shown to skyrocket.

We show that the cost of increasing biofuel mandates given a binding ethanol blend wall fall disproportionately on diesel fuel consumers. Diesel fuel consumers would suffer a minimum welfare loss of $ 15 bil. in the current policy environment that does not include a blender's tax credit. (see Figure 1). However, this refers to the minimum expected RFS total percentage blend mandate of 11.9%, far above the 2019 level of 10.97%, and far below the projected percentage mandates given in Tables 1 and 2. We find welfare costs to fuel consumers can reach as high as $30 bil. with motor gasoline consumers' share increasing significantly beyond the 12% total biofuel blend mandate requirement.

The extent of the burden on diesel fuel consumers is not explained by their relatively more inelastic demand and this burden is exacerbated by the elimination of the biodiesel tax credit. The high costs imposed on diesel fuel consumers are likely to have important general equilibrium ramifications: it not only risks more BBD and renewable diesel imports, but heavy trucks and trains account for most of the diesel fuel consumption in the U.S. so the increased cost of transportation could lead to higher prices for consumers.

Therefore, the RFS will not be economically or politically sustainable any longer. A significant restructuring of the RFS is inevitable, given the past performance of the RFS and these future scenarios.

Note that the welfare estimates in Korting, de Gorter and Just (2018) build on the demand estimates of Pouliot and Babcock (2014) and Pouliot and Babcock (2016). Revised demand estimates of Pouliot et al. (2018) using survey data suggest an even larger required E10+ price discounts in order to encourage consumption. This suggests that the results in Korting, de Gorter and Just

(2018) and those presented above are very conservative since the blend wall may be even more stringent than assumed in this model.

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