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E15 and E85 Demand Under RIN Price Caps and an RVP Waiver

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Summary of Findings

- A leading Renewable Fuel Standard reform proposal considered by policymakers would allow E15 (fuel containing 15% ethanol) sales throughout the year and implement a cap on D6 RIN prices between $0.10 to $0.20/RIN.
- While year-round sales of E15 would encourage retailers to sell the fuel, capping D6 RIN prices would reduce consumption of E15 and E85.
- A cap on D6 RIN prices between $0.10/gal to $0.20/gal would likely reduce the effective ethanol mandate from 15 billion gallons to about 14.3 billion gallons in 2018.
- Unless increased ethanol exports compensate for the reduced mandate, corn prices would decrease under the proposal's D6 RIN price cap.

INTRODUCTION

The United States Congress enacted the Renewable Fuel Standard (RFS) through the Energy Independence and Security Act in 2007. The U.S. Environmental Protection Agency (EPA) administers the program. The RFS laid a path to significantly expand production and use of both conventional (corn ethanol) and advanced (low greenhouse gas) biofuel production and consumption in the United States. The policy objectives include (i) lowering greenhouse gas emissions of transportation fuels; (ii) supporting rural economies; and (iii) enhancing energy security by expanding domestic transportation fuel production.

Until 2013, the fuel industry was able to comply with the RFS mandates by blending 10% ethanol into most gasoline sold in the United States. E10 (fuel containing 90% gasoline and 10% ethanol) now constitutes more than 95% of fuel used in gasoline-powered vehicles, and expanding ethanol consumption by increasing E10 market penetration is no longer a viable compliance option.[i] The E10 blending limit is commonly referred to as the E10 blend wall. The fuel industry has complied with RFS mandates beyond the E10 blend wall by increasing sales of E85 (which contains between 51 and 83 percent ethanol), other advanced biofuels, and biodiesel. If EPA is to continue expanding biofuel mandates, which is the current congressional intent, the remaining compliance options are limited because of both economic and technical barriers.

The saturation of E10 in the marketplace, limited demand for higher blend ethanol fuels, and high production costs for biodiesel mean that compliance with the program is costly. This is best evidenced by the high and volatile prices for RFS tradeable compliance credits, known as RINs, since 2013. High RIN prices increase compliance costs for refiners, the obligated party under the policy, who must purchase or generate RINs to demonstrate compliance to the EPA. The economics literature finds that refiners are likely fully compensated for high RIN costs through higher wholesale gasoline prices. Despite this, RIN costs have dominated recent headlines due to the bankruptcy proceedings of Philadelphia Energy Solutions (PES).[ii] PES partly blames the cost of RINs as a cause of its financial troubles in its bankruptcy proceedings.

The PES bankruptcy has led to a standoff between U.S. senators representing Midwestern states and senators from states with significant petroleum refining capacity. Recent White House meetings between these parties have led to one compromise proposal that is receiving a significant amount of attention. Under this proposal, RIN prices (i.e., D6 RINs, on which we focus in this document) would be capped at between 10 and 20 cents in exchange for allowing year-round sales of E15. E15 is a gasoline blend containing 15% ethanol. The lack of an E15 waiver from the Clean Air Act rules restricts E15 sales to non-summer months. This restriction is one reason why major gasoline retailers are reluctant to invest in fuel pumps and tanks that are needed before they can offer E15 in their stations.

In this policy brief, we discuss the economics of this proposal.[iii,iv] We first provide relevant background on technical issues currently limiting E15 sales, the economics of RIN price caps, and the role of RINs in expanding ethanol use in the United

States. We then discuss the demand for higher-blend ethanol fuels (E15 and E85), and implications for RIN price caps for E15 and E85 sales.

Background

An understanding of several technical and economic factors is needed to understand the current discussions about the RFS and E15. Here we briefly discuss how the EPA could implement a RIN price cap. We then summarize how fuel content restrictions currently limit year-round sales of mid-ethanol blend fuels. Last, we summarize the role of RINs in incentivizing consumption of high ethanol-blend fuels.

Implementing a RIN price caps

The EPA could implement a cap on RIN prices in two ways. First, EPA could offer "waiver credits" much like they currently do for the cellulosic portion of the RFS mandates.[v] The EPA would allow parties to purchase RINs at a fixed price from the Agency instead of on the market. Biofuel production would not generate these waiver credits. Second, the EPA could allow parties to accrue compliance deficits and pay a fixed non-compliance fee.

These two mechanisms would cap RIN prices and reduce the economic incentive for increasing biofuel use. Refiners will comply with RFS mandates by purchasing RINs generated on the open market only when RIN prices are less than the waiver credit price. Suppose that fuel retailers require a RIN price that is higher than the capped price to sell E15 or E85. Rather than compensate the retailer by purchasing a higher-priced RIN, refiners will go to the EPA to purchase RINs at the capped price.

RIN price caps have merit in certain circumstances. High RIN prices since 2013 have led to extensive RFS lobbying by both the biofuels and oil industries. The EPA has responded to this pressure by adjusting the statutory mandates. This process has led to high RIN price volatility. If the EPA or Congress want to meet RFS mandates only if compliance costs are below a certain level, a RIN price cap is the most efficient way to do so.[vi] Under a RIN price cap, investors, producers, and other market participants know that they must produce and sell biofuels at or below the cap, reducing uncertainty caused by policy gyrations.

The level of a RIN price cap is crucial. A low cap signals to markets that only low-cost compliance options can be used to meet the mandates and that remaining compliance will be met through wavier credits purchases or non-compliance fees. A low RIN price cap also reduces the incentive to blend biofuels into motor fuel and increase biofuel fueling infrastructure (e.g., blender pumps).

RVP Waivers and Biofuel Use

Restrictions on Reid vapor pressure (RVP) for retail gasoline-ethanol blends limit sales of E15 and certain higher blend in summer months. RVP is a measure of gasoline's volatility. The U.S. Clean Air Act limits RVP during high ozone seasons to reduce evaporative emissions from gasoline.[vii]

Blending ethanol into gasoline impacts a fuel's RVP nonlinearly. At blending levels below about 50%, RVP levels generally exceed Clean Air Act standards. Blends with greater than 50% ethanol meet the RVP restrictions. Figure 1 graphs the relationship between ethanol blending and RVP along with the nine pounds per square inch (psi) summertime limit.[viii] As can be seen, any ethanol blend below 50% violates current summertime standards.

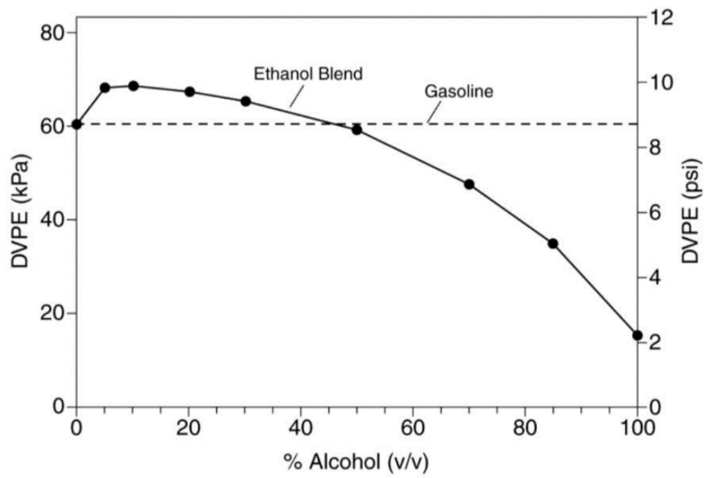

Figure 1: RVP and Ethanol Blending
Source: National Renewable Energy Laboratory

The Clean Air Act includes a waiver for E10, allowing the fuel to be one psi greater than the limit for other fuels. While the Act includes some exceptions, the waiver has generally allowed E10 to be sold year-round in all states. Higher blend ethanol fuels, however, do not have a waiver. For very high ethanol blend fuels like E85, this is not an issue since RVP levels are below the nine psi limit. However, the lack of a one psi waiver for E15 and other mid-level ethanol blends necessarily limits retailers' ability to sell the fuels in the summer.

The economic role of RINs in the consumption of ethanol

The EPA created the RIN system to implement and enforce the RFS blending mandates. RINs are a tradable commodity used to track U.S. ethanol and biodiesel use. Every gallon of biofuel produced in or imported into the United States generates a RIN. The RIN is detached from a gallon of biofuel when it is blended into the U.S. fuel supply at wholesale terminals.[ix] Refiners comply with the RFS either by blending biofuels and selling them to domestic wholesale markets, thereby generating RINs in-house or by purchasing separated RINs from other parties.

RIN prices impact retail fuel prices in two ways. Because refiners must purchase RINs for every gallon of gasoline and diesel they sell, RINs act as an implicit tax on gasoline and diesel. On the other side of the market, every gallon of biofuel generates a RIN that can be sold to refiners, constituting an implicit subsidy for ethanol and biodiesel. Retail fuel prices reflect both the tax on gasoline and diesel and the subsidy for biofuel. Therefore, increasing the blend-rate of ethanol in gasoline increases the subsidized portion of the fuel and decreases the taxed portion of the fuel.

RIN prices reflect the cost of compliance with the RFS. They are determined by the cost of covering biofuel production costs when they exceed gasoline and diesel prices and the need to lower the value of biofuels in fuel blends to increase consumption to meet mandates.[x] High RIN prices create an incentive for the fuel industry to reduce compliance costs by finding the lowest-cost alternatives to meeting mandates. Costs can be lowered either by decreasing biofuel production costs or by increasing the value of biofuels in the marketplace by expanding sales of higher ethanol blend fuels, mainly E15 and E85.

Expanding E15 and E85 sales requires fuel stations to invest in E15 and E85 fueling infrastructure and consumers to buy the fuel. RIN prices play a crucial role in incentivizing E15 and E85 demand. All else equal, an increase in RIN prices increase the ethanol subsidy and gasoline tax in retail fuel blends. The subsidy for the ethanol will outweigh the gas tax for fuels with higher ethanol blends. Therefore, as RIN prices rise, the retail price spread between low- and high-ethanol blend fuels increases.

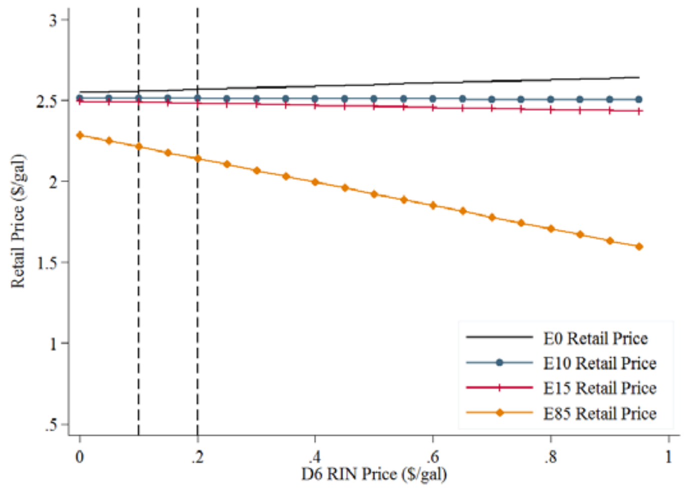

Figure 2: Retail Fuel Prices and RINs ($/gal)
Source: Authors' calculations

Figure 2 illustrates how RIN prices impact E0, E10, E15, and E85 retail prices. To create the Figure, we hold wholesale ethanol and gasoline prices constant at $1.45/gal and $1.80/gal, respectively, and assume retail fuel is marked up over wholesale fuel costs by $0.75/gal.[xi] We then calculate retail fuel prices as a function of RIN prices, which we vary between zero and $1.00/gal.[xii]

When RIN prices are zero, the only factor driving retail prices is the different wholesale costs of ethanol and gasoline. As RIN prices increase, the price of E0 increases, E10 prices remain roughly constant, and E15 and E85 prices decrease. The focus of this report is the impact of RIN prices on E15 and E85 demand. Consumers will have a greater incentive to switch from E10 to E15 or E85 as the price difference between the fuels increases. At a zero RIN price, the (E15-E10) and (E85-E10) price gap is -$0.018 and -$0.23 per gallon, respectively. At a $0.10 RIN price, the price gaps increase to -$0.023 and -$0.30 per gallon. At a $0.50/gal RIN price, roughly the D6 RIN price in early March 2018, the two gaps increase to -$0.045 and -$0.59 per gallon, clearly increasing the incentive for consumers to switch from E10 to E15, but even more increasing the incentives to switch from E10 to E85.

Demand for high ethanol blend fuels

We now turn to E85 and E15 demand factors. We build on research by Babcock and Pouliot (2014) and Liao, Pouliot, and Babcock (2016).[xiii]

E85 consumption

We highlight here several factors that influence E85 demand in the United States.

Flex Fuel Vehicle (FFV): To fuel using E85, a consumer must own a flex fuel vehicle. Many car companies offer vehicle models with FFV options, and for many years FFVs were a standard feature for many cars. Owning an FFV allows a motorist to fuel with any fuel from E0 to E85, affording them maximum flexibility in choosing between low- and high-ethanol blend fuels. Around 20 million out of over 260 million vehicles in the United States today are FFVs. However, most located in major metropolitan areas without easy access to E85. Also, the number of new vehicle models offered as FFVs has declined in the last three years as incentives for their production under the Corporate Average Fuel Economy standards were phased out.

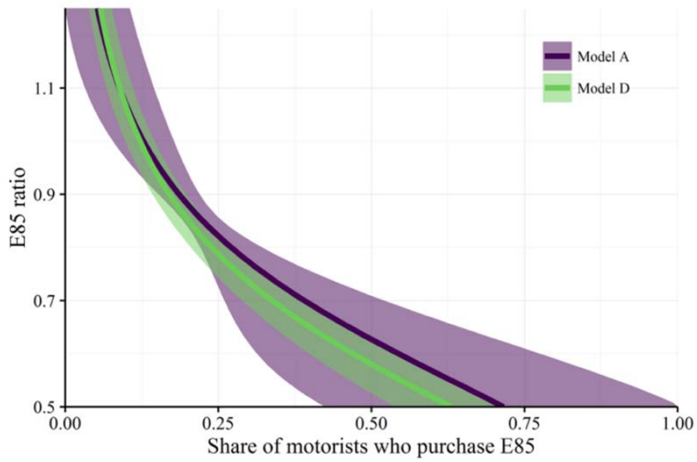

Figure 3: E85 Demand and E85/E10 Price Ratios
Source: Liao, Pouliot, and Babcock, 2016

Fuel Station Availability: E85 requires fuel station owners to invest in specialized fueling infrastructure. This may include installing in new underground tanks or modifying existing tanks, and purchasing above ground dispensing equipment. Many stations looking to offer E15 or E85 install "blender pumps dispensers" that draw fuel from tanks containing E85 or E100 (pure ethanol) and E10. This allows the station owner to offer multiple mid- to high-ethanol blend fuels. According to the Alternative Fuels Data Center, 3,224 stations currently offer E85 in the United States as of early March 2018.

Energy Content Price Discounts: A gallon of pure ethanol contains around 33% less energy than a gallon of pure gasoline.[xiv] As the ethanol content of a fuel increases, vehicle mileage per gallon decreases, and consumers will need to fill up their tanks more often. Therefore, if an ethanol blend (e.g., E10) and gasoline (E0) are sold at the same price, the ethanol blend will be more expensive on a cost per mile driven basis because it contains less energy. Using the example from Figure 2, if we inflate ethanol costs by 50% to account for its lower energy content, the (E15-E10) and (E85-E10) price gap decreases to -$0.01/GGE and -$0.11/GGE when RIN prices are $0.50, where GGE stands for "gasoline-gallon-equivalent." This shows how current RIN prices incentivize retail demand for E5 and E85 by offsetting the lower energy content of ethanol.

Octane Content: While ethanol contains less energy than gasoline, the fuel has a much higher octane rating. Octane is a measure of a fuel's combustion resistance, and higher performance vehicles typically require higher-octane fuels to operate efficiently. Regular gasoline usually has an 87 octane rating, while premium gasoline typically has an octane rating of at least 91. A gallon of ethanol has an octane rating of 113. This higher octane has allowed refiners to decrease the production of octane at the refinery, reducing refining costs. Instead of producing 87 octane gasoline, most refiners today produce 84 octane gasoline and blend 10% ethanol to reach the required 87 octane rating. E85 has an even higher octane rating, typically over 100, while the octane value of E15 is 88. This one-point advantage in octane rating over E10 offsets some of the fuel efficiency disadvantages of E15 relative to E10. The value of octane is likely to increase in future years as demand for high-octane fuel continues to grow. Most light-duty vehicle manufacturers are increasingly producing engines that require 91 and higher octane levels to operate.[xv]

Recent work by Liao, Pouliot, and Babcock (2016) estimate the demand for E85 using observational and survey data gathered in 2015. The authors estimate willingness to pay for E85 fuel. The authors find that the average U.S. flex fuel vehicle owner requires that E85 be discounted well below energy cost parity relative to E10 to switch fuels. Figure 3 graphs the estimated demand for E85 relative to its price ratio to E10 (Price of E85/Price of E10). Few motorists choose E85 when it is priced greater than or equal to E10. Demand for E85 increases as it becomes less expensive than E10. However, even when E85 is priced 40% below E10, so that the fuel is cheaper on an energy-equivalent basis, only around 50% of FFV owners purchase the fuel. The findings suggest that selling large volumes of E85 will require high RIN prices. For reference, in Figure 2, the (E85-E10) price discount exceeds -40% only when RIN prices are over $1.00/RIN.

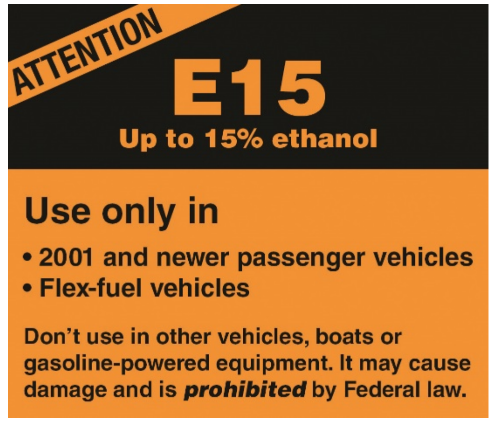

Figure 4(a) E15 Fuel Pump Label
Source: EPA

Figure 4(b): E15 Gas Cap Warning
Source: Author's vehicle

E15 consumption
Many of the same factors that influence E85 demand also will likely influence E15 demand. Like E85, the fuel requires stations to invest in fueling infrastructure, it has around 1.75% lower energy content than E10, and it has an octane advantage over E10. Unlike E85, E15 does not require special vehicles. However, E15 has its own compatibility challenges in light-duty vehicles. Also, sales of E15 are restricted in the summer driving season because the fuel does not currently have an RVP waiver.

E15 use in vehicles: In 2011, EPA granted a waiver that allowed for E15 use in light-duty motor vehicles produced after 2001. This constitutes the vast majority of light-duty vehicles on the road today. Thus, it seems that one could assume that almost all vehicle owners in the United States are potential E15 customers. However, several auto manufacturers still include E15 warnings on newer vehicles. This conflicting message between EPA guidelines on retail pumps (Figure 4a) and vehicle manufacturer guidelines (Figure 4b) depress the potential demand for the fuel.

To the authors' knowledge, there are no academic studies that estimate the demand for E15. However, given the similarities between issues affecting E85 and E15 demand, it seems likely that similar features would arise with E15 that arise with E85. At least in the short run, selling substantial volumes of E15 will likely require price discounts below E10 on an energy parity basis. At current prices, E15 must be priced 4.3 cents per gallon lower than E10 to make it equal on a GGE basis. In Figure 2, this would require a $0.47 RIN price.

Distribution of E15 Fueling Stations: Although motorists may be willing to fuel with E15, its distribution is limited by the number of retail stations which sell the fuel. Many fuel stations do not have equipment (pumps, distribution lines, tanks) rated for E15. In the short run, constraints on the distribution of E15 would limit its distribution and hence its consumption even if E15 were granted an RVP waiver. In the long run, distribution of E15 will increase only if fuel distributors have the incentive to upgrade their equipment to sell E15, i.e., only if fuel station owners foresee a large potential market for the fuel. If RIN prices are capped at $0.10/gal, there will be little incentive to increase offering of E15 because its price will be nearly the same as E10 (see Figure 2).

RVP Waivers, RIN price caps, and E15/E85 demand

The tradeoffs between allowing an RVP waiver for E15 and setting a price cap for RINs are by now hopefully clear. An E15 RVP waiver will increase the fuels' availability throughout the year. However, demand for the fuel and the incentive to invest in retail distribution capacity will depend on its price relative to E10, which is directly related to RIN prices. If Congress or the EPA cap RIN prices, they also cap the discount for E15. In this section, we discuss the required RIN prices to achieve various (E15-E10) discounts. We then discuss how markets adjust to offering E15 under different assumptions about the implementation of the RFS waivers and the feasibility of expanding E15 sales.

E15-E10 discounts and RIN prices

A motorist who cares only about the cost per mile will require a 1.75% E15 discount relative to E10. Table 1(a) presents the RIN price needed to meet this discount as a function of gasoline and ethanol prices. The calculations assume a $0.75/gal wholesale-to-retail markup. For example, with today's prices, a $0.47 RIN price is necessary for E15 prices to be equivalent to E10 on a cost per mile basis. When wholesale ethanol prices are low relative to gasoline, E15 prices will already be below energy parity with E10 because of its higher ethanol content. However, higher relative ethanol costs require higher RIN prices to make E15 competitive with E10. The grey cells highlight scenarios that require a RIN price greater than $0.10/RIN to achieve energy parity and the orange cells highlight scenarios that require a RIN price greater than $0.20/RIN.

It seems likely that increased market penetration of E15 will require E15 to be priced even lower than energy parity. For example, motorists may need larger E15-E10 discounts before they switch fuels because E15 is unfamiliar or because car manufacturers do not recommend using E15. Table 1(b) explores the required RIN prices to make E15 5% cheaper than E10 at the same wholesale gasoline and ethanol prices as in Table 1(a). The required RIN prices are much larger than those in Table 1(a) because the difference in ethanol content between E10 and E15 is small. Thus, consumer reluctance to purchase E15 would require much higher RIN prices.

Table 1(a): Required RIN price for wholesale E15 to be equal to retail E10 price on a cost per mile basis

Ethanol Price ($/gal)	Gasoline Price ($/gal): 1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80
1.00	0.26	0.19	0.13	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.10	0.36	0.29	0.23	0.16	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.20	0.46	0.39	0.33	0.26	0.20	0.13	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.30	0.56	0.49	0.43	0.36	0.30	0.23	0.16	0.10	0.03	0.00	0.00	0.00	0.00	0.00
1.40	0.66	0.59	0.53	0.46	0.40	0.33	0.26	0.20	0.13	0.07	0.00	0.00	0.00	0.00
1.50	0.76	0.69	0.63	0.56	0.50	0.43	0.36	0.30	0.23	0.17	0.10	0.03	0.00	0.00
1.60	0.86	0.79	0.73	0.66	0.60	0.53	0.46	0.40	0.33	0.27	0.20	0.13	0.07	0.00
1.70	0.96	0.89	0.83	0.76	0.70	0.63	0.56	0.50	0.43	0.37	0.30	0.23	0.17	0.10
1.80	1.06	0.99	0.93	0.86	0.80	0.73	0.66	0.60	0.53	0.47	0.40	0.33	0.27	0.20
1.90	1.16	1.09	1.03	0.96	0.90	0.83	0.76	0.70	0.63	0.57	0.50	0.43	0.37	0.30
2.00	1.26	1.19	1.13	1.06	1.00	0.93	0.86	0.80	0.73	0.67	0.60	0.53	0.47	0.40
2.10	1.36	1.29	1.23	1.16	1.10	1.03	0.96	0.90	0.83	0.77	0.70	0.63	0.57	0.50
2.20	1.46	1.39	1.33	1.26	1.20	1.13	1.06	1.00	0.93	0.87	0.80	0.73	0.67	0.60
2.30	1.56	1.49	1.43	1.36	1.30	1.23	1.16	1.10	1.03	0.97	0.90	0.83	0.77	0.70

Table 1(b): Required RIN price for wholesale E15 to be 5% below retail E10 price

Source: Authors' calculations

Ethanol Price ($/gal)	Gasoline Price ($/gal): 1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80
1.00	1.55	1.54	1.53	1.52	1.51	1.50	1.49	1.48	1.47	1.46	1.45	1.45	1.44	1.43
1.10	1.65	1.64	1.63	1.62	1.61	1.60	1.59	1.58	1.57	1.56	1.55	1.55	1.54	1.53
1.20	1.75	1.74	1.73	1.72	1.71	1.70	1.69	1.68	1.67	1.66	1.65	1.65	1.64	1.63
1.30	1.85	1.84	1.83	1.82	1.81	1.80	1.79	1.78	1.77	1.76	1.75	1.75	1.74	1.73
1.40	1.95	1.94	1.93	1.92	1.91	1.90	1.89	1.88	1.87	1.86	1.85	1.85	1.84	1.83
1.50	2.05	2.04	2.03	2.02	2.01	2.00	1.99	1.98	1.97	1.96	1.95	1.95	1.94	1.93
1.60	2.15	2.14	2.13	2.12	2.11	2.10	2.09	2.08	2.07	2.06	2.05	2.05	2.04	2.03
1.70	2.25	2.24	2.23	2.22	2.21	2.20	2.19	2.18	2.17	2.16	2.15	2.15	2.14	2.13
1.80	2.35	2.34	2.33	2.32	2.31	2.30	2.29	2.28	2.27	2.26	2.25	2.25	2.24	2.23
1.90	2.45	2.44	2.43	2.42	2.41	2.40	2.39	2.38	2.37	2.36	2.35	2.35	2.34	2.33
2.00	2.55	2.54	2.53	2.52	2.51	2.50	2.49	2.48	2.47	2.46	2.45	2.45	2.44	2.43
2.10	2.65	2.64	2.63	2.62	2.61	2.60	2.59	2.58	2.57	2.56	2.55	2.55	2.54	2.53
2.20	2.75	2.74	2.73	2.72	2.71	2.70	2.69	2.68	2.67	2.66	2.65	2.65	2.64	2.63
2.30	2.85	2.84	2.83	2.82	2.81	2.80	2.79	2.78	2.77	2.76	2.75	2.75	2.74	2.73

Market impacts of an RVP waiver: All E10 fuel is converted to E15

We begin with a relatively extreme case by considering a scenario where E15 becomes the default fuel offered by all stations. The scenario naturally ignores all distribution and vehicle technical constraints to using E15 and therefore is most relevant in the long run. Nonetheless, the scenario is useful in establishing the maximum impact of an E15 RVP waiver.

Consumption of retail gasoline in 2017 was around 143 billion gallons of which 14.4 billion gallons (10.08%) was ethanol.[xvi] On a per gallon basis, ethanol is currently less expensive than gasoline. Suppose that this would remain true under an RVP waiver for E15 and that the industry faces no production constraints. In this case, total ethanol consumption would increase to 21.4 billion gallons, substantially more than the 15.84 billion gallons of ethanol produced in 2017. Thus, in this (unrealistic) scenario, an RVP waiver and E15 adoption nation-wide could substantively increase ethanol use in the United States.

The conversion of all E10 to E11 would be a more realistic proposal as it would likely not be affected by the same technical constraints as E15. Based on gasoline sales of 143 billion gallons in 2017, ethanol volumes with nationwide adoption of E11 would be about 15.7 billion gallons. This policy would drive the price of RINs down near zero, reduce sales of E85 near zero and eliminate almost all U.S. exports of ethanol.

Market impacts of an RVP waiver: Limited E15 offering, consumers require fuel discounts

For our second case, we consider a scenario where: (i) not all fuel stations offer E15; (ii) not all motorists purchase E15; and (iii) those consumers that do purchase E15 do so only if it is discounted compared to E10 on an energy-equivalent basis.

First, consider the impact of a cap on RIN prices in the absence of an RVP waiver. Figure 5 illustrates the market impacts of a cap on RIN prices. A mandate at level M requires a $1 RIN price in this example. The quantity of ethanol that corresponds to a RIN price $0.10/gal is given by M_{10}. To obligated parties, the least costly compliance path is to blend an amount of ethanol equal to M_{10} and then purchase (M-M_{10}) RINs from the EPA. Thus, a RIN price cap reduces ethanol blending from M to M_{10}. Without the price cap, the amount of ethanol given by (M-M_{10}) would likely be sold in high ethanol blends such as E15 and E85. Thus, a price cap effectively eliminates sales of E15 and E85 in this scenario.

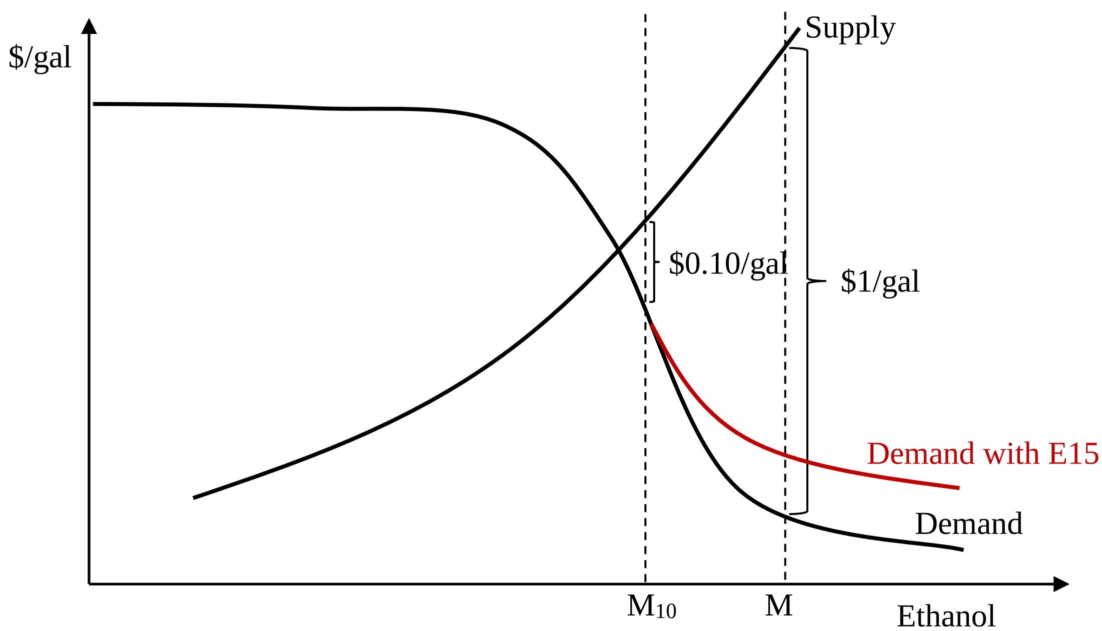

Figure 5: Market impacts of a cap on RIN prices and motorists value fuel on a cost per mile basis

An E15 RVP waiver increases demand for ethanol, illustrated by the red curve in Figure 5. As Tables 1(a) and 1(b) show, the retail discount necessary to make E15 attractive to motorists likely requires a RIN price above 10 cents under current market conditions. Therefore, if the necessary E15 discount requires a RIN price greater than $0.10/RIN, the RVP waiver with a RIN price cap will not expand E15 demand relative to a scenario with no RVP waiver and no RIN cap.

Market impacts of an RVP waiver: E15 sales are limited, consumers care only about fuel price

The difference in energy content between E10 and E15 is small (1.75%). If consumers ignore this difference, an RVP waiver may increase E15 demand more than we illustrate in Figure 5. Figure 6 graphs ethanol demand in a scenario in which motorists ignore the difference in energy content between E10 and E15. Compared to Figure 5, the RVP waiver shifts the demand for ethanol even when the RIN price is zero. Thus, provided that the wholesale ethanol price is lower than the wholesale gasoline price, the RVP waiver increases demand for ethanol at all RIN prices. However, the increase is likely modest given limited E15 distribution capacity. Even if demand for ethanol increases with the RVP waiver, a binding cap on RIN prices still reduce ethanol demand. The effective mandate would be $M_{15}>M_{10}$, which is lower than the statutory mandate at M.

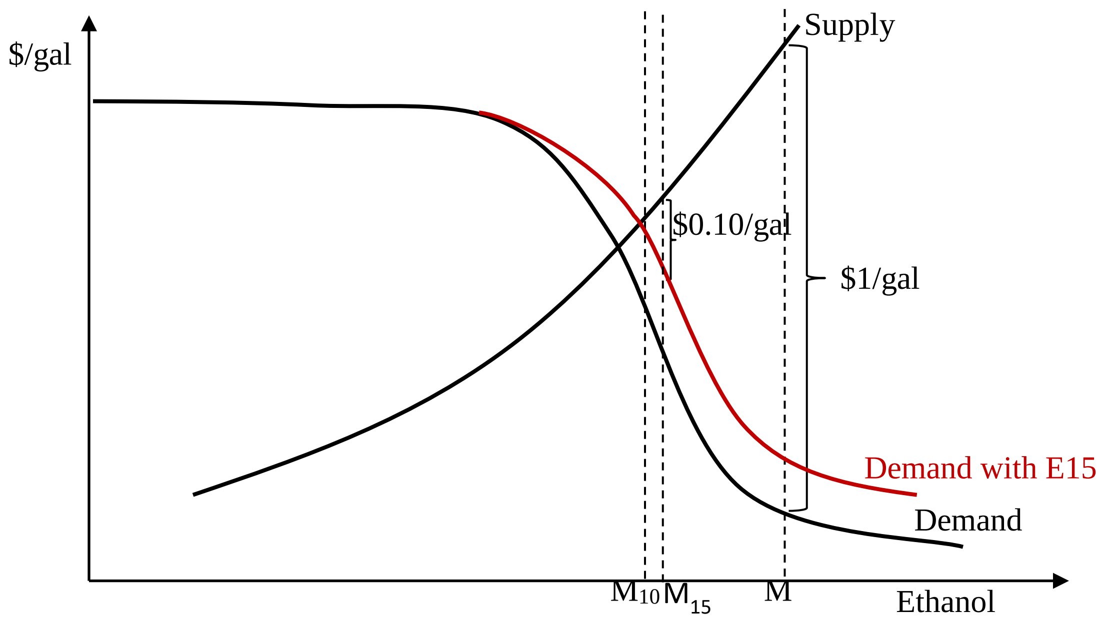

Figure 6: Market impacts of a cap on RIN prices and motorists care only about fuel price

CONCLUSIONS

The proposed RFS compromise of a cap on RIN prices in exchange for an RVP waiver that would allow year-round sales of E15 seemingly has benefits both for those who advocate for a reduction in RFS compliance costs and for those who want to see expanded sales of high ethanol fuels. Whether both sides would benefit from such a deal depends on whether the cap on RIN prices is set high enough to continue to incentivize sales of E15 and E85.

Two attributes of E15 determine how high RIN prices need to be to incentivize sales. On the one hand, E15 contains more ethanol than E10, so it has about 1.75% lower fuel efficiency. To offset this lower efficiency requires a RIN price of about 50 cents at current gasoline and ethanol prices. A further disadvantage of E15 is that some car manufacturers have, until recently, labeled their cars as not being compatible with E15. Offsetting these disadvantages to some extent is E15's one-point octane advantage over E10.

The lack of an RVP waiver for E15 restricts most sales to non-summer months. This restriction has likely kept some retailers from installing the E15 fueling equipment despite high RIN prices. Thus, granting E15 an RVP waiver would increase the likelihood that retailers would make the required investments to sell E15. However, these investments will only be made with a waiver if RIN prices are high enough to make E15 an attractive fuel.

The proposed cap on RIN prices of 10 cents per gallon, or even 20 cents per gallon, would not offset E15's lower energy content relative to E10 at current market prices. Thus, under a capped RIN prices, the cost of driving using E15 would increase relative to E10. This means that demand for E15 under capped RIN prices would have to rely on the one-point octane advantage of E15. There are high-performance cars that require 91 octane fuels, and perhaps some that specify 89 octane. However almost all cars on the road only require 87 octane fuel, and the majority of these cars will not differ in performance if 88 octane fuel is used. Thus, octane alone is unlikely to maintain, much less increase, current E15 demand.

Will major retailers be willing to invest in pumps and tanks to market a fuel that increases driving costs and that does not enhance engine performance? Not having done the necessary market research, we cannot answer this question definitively. However, our research on E85 demand shows that most drivers require a large financial incentive to switch from E10 to E85. If this result also holds for E15 demand, capping RIN prices at low levels makes it implausible that retailers would invest in E15 even with the assurance that they could sell the fuel throughout the year. Under the proposed compromise, therefore, compliance costs will fall dramatically, but E15 and E85 sales will also decrease. The result would be lower compliance cost and a lower effective blending mandate.

We cannot say with certainty what would happen to the demand for corn under the proposed compromise. A lower effective corn ethanol mandate would decrease the demand for corn which would lower the price of corn. It is likely that lower domestic demand for ethanol would increase exports which would offset some part of the impacts. A lower bound on the corn price impact from capping RIN prices would occur if ethanol exports completely offset lower domestic blending. In this case, corn prices would remain the same. An upper bound on the corn price impact is if blending is reduced by a billion gallons, which is the difference between the current 15 billion gallon mandate and 14.3 billion gallons of blending that could occur under capped RIN prices. Corn prices under this scenario would drop, in the short-run, by around 25 cents per bushel.

ENDNOTES

[i] See https://www.eia.gov/todayinenergy/detail.php?id=26092.

[ii] See https://www.reuters.com/article/us-philadelphia-energy-solutions-bankrup/u-s-refiner-pes-pins-bankruptcy-plan-hopes-on-biofuel-costs-idUSKBN1FB26M.

[iii] There are currently many other proposals for RFS reform, and the debate on policy options has and will continue to evolve. However, expanding markets for E15 and limiting RIN prices is a common component of many reform proposals. For a broader discussion on RFS reform proposals, see http://energypolicy.columbia.edu/research/report/reforming-renewable-fuel-standard.

[iv] There are questions over whether EPA has authority to implement these changes to the program. Many current RFS reform proposals will likely require a congressional act. For a discussion on limits to EPA authority, we refer the reader to a series of articles from the University of Illinois farmdocDaily:

(1) http://farmdocdaily.illinois.edu/2017/10/three-little-words-all-over-again-epa-revisits.html
(2) http://farmdocdaily.illinois.edu/2017/10/general-waiver-rfs-and-severe-economic-harm.html
(3) http://farmdocdaily.illinois.edu/2017/10/the-biodiesel-waiver-provision-in-the-rfs.html
(4) http://farmdocdaily.illinois.edu/2017/12/still-another-wrinkle-in-the-rfs-rins-price-cap.html

[v] See https://www.epa.gov/renewable-fuel-standard-program/cellulosic-waiver-credits-under-renewable-fuel-standard-program.

[vi] For more discussion of the merits of RIN price caps, see https://academic.oup.com/ajae/article/100/2/585/4801228 and

[vii] See https://www.epa.gov/gasoline-standards/gasoline-reid-vapor-pressure and https://fas.org/sgp/crs/misc/IN10703.pdf.

[viii] Several densely populated states and most major metropolitan areas have lower RVP limits in the summertime. For more information on RVP limitations and the impact of ethanol blending on RVP, see https://fas.org/sgp/crs/misc/IN10703.pdf and http://www.ethanolrfa.org/wp-content/uploads/2015/09/RVP-Effects-Memo_03_26_12_Final.pdf.

[ix] The RFS is a *domestic* biofuel mandate. Thus, refiners can only use separated RINs for compliance. When domestically produced biofuels is exported abroad, RINs are 'retired' or removed from the pool of eligible RINs that refiners can use towards compliance. Another reform proposal that has been discussed is allowing refiners to use RINs generated by exported fuel to count towards compliance. While not the focus of this report, the proposal would substantially decrease RINs prices. The U.S. exported over 1.3 bgals of ethanol in 2017. Therefore, making RINs that were historically retired eligible for compliance use would increase the supply of RINs by roughly 1.3 billion – more than enough to bridge the blend-wall. However, it is unlikely that such a proposal would satisfy the intent of the Energy Independence and Security Act, and the proposal would likely be challenged by importing countries through the World Trade Organization. For more information on U.S. ethanol exports see http://www.ethanolrfa.org/wp-content/uploads/2018/02/2017-U.S.-Ethanol-Trade-Statistics-Summary_CORRECTED2.pdf.

[x] Corn ethanol is relatively cheap, and therefore their costs are not a large driver of RIN prices. However, with the blend wall, expanding corn ethanol use requires increasing demand for E15 and E85 which, as we discuss in the report, requires potentially high discounts relative to E10 and, therefore, high RIN prices. Thus, ethanol related RIN price drivers primarily are related to demand-side factors. In contrast, biodiesel

has much higher production costs relative to diesel, but it is relatively easy to increase blends of biodiesel. Thus, biodiesel related RIN price drivers are primarily related to supply-side factors.

[xi] The wholesale prices are settlement prices on Chicago Platts futures for ethanol and CBOB from March 2, 2018.

[xii] We calculate retail fuel prices as

$$P^{Retail} = 0.75 + B^{Eth}(P^{Eth} - P^{RIN}) + (1 - B^{Eth})(P^{Gas} + 0.1P^{RIN})$$

where P^{Retail} is the retail fuel price, B^{Eth} is the blend rate of ethanol in the fuel,$(P^{Eth} - P^{RIN})$ is the wholesale ethanol cost less the RIN subsidy, and $(P^{Gas} + 0.1P^{RIN})$ is the wholesale gasoline cost plus the RIN tax. We set B^{Eth} equal to 0, 0.1, 0.15, and 0.75 for E0, E10, E15, and E85, respectively.

[xiii] Ungated versions available at https://www.card.iastate.edu/products/publications/pdf/14pb17.pdf and https://www.card.iastate.edu/products/publications/synopsis/?p=1242.

[xiv] See https://www.eia.gov/tools/faqs/faq.php?id=27&t=10.

[xv] See https://www.eia.gov/todayinenergy/detail.php?id=31732.

[xvi] See http://energy.agwired.com/2018/03/05/final-2017-numbers-show-record-ethanol-production/.