Ethanol RIN Waiver Credits:

Improving Outcomes of the Renewable Fuels Standard through a Price Containment Mechanism

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1. Executive Summary

Market-based policies that aim to increase a societal good, such as renewable energy, often employ quantity targets with associated credit markets that allow policy goals to be met at least cost. These credit markets, such as the RIN market under the Renewable Fuels Standard (RFS), can be subject to uncertain and volatile prices when the real world turns out different than policymakers expected. Unexpectedly high prices can lead to significant societal costs and ultimately a failure to meet policy goals.

Since 2013, the ethanol RIN market has experienced high and volatile prices, even though the average ethanol content of motor gasoline in the US has been higher than policymakers thought was necessary to meet their ethanol volume goals when the policy was devised. Actual US transportation fuel consumption has been substantially lower than forecasted when the RFS was written in 2007. This meant that even with the entire country consuming gasoline with approximately 10 percent ethanol, the RFS ethanol volume standards have not been met. Higher ethanol content fuels, such as E15 and E85, could help meet the target, but increasing use of these higher ethanol blends has been held back by infrastructure constraints.

Instead, the RIN deficiency has been met by expanding biodiesel consumption, based on an unintended result of the fuel-type nesting structure of the RFS. Ethanol (D6) RINs have therefore priced off the higher cost biodiesel (D4) RINs. Meanwhile, the US has increased its imports of biodiesel, often from sources with potentially negative environmental impacts. There has also been minimal appreciable increase in ethanol use past the “blend wall,” despite RIN prices being many times greater than their levels prior to 2013.

The RFS policy goals could be met at a more reasonable RIN cost with the implementation of a well-designed price containment mechanism. National biofuel policy discussions have recently turned to such mechanisms. These concepts have proven effective in a variety of other compliance credit markets, such as the Renewable Portfolio Standards and carbon emissions policies in many states and regions. While they may have different names, such as price caps, alternative compliance payments (ACP), or safety valves, they have proven effective policy tools. Their application to the RFS is further supported in academic literature.

Many applications of price containment mechanisms include significant government revenue streams, which in many cases have been effectively targeted at breaking through policy and infrastructure constraints. A price containment mechanism in the RFS could lead to greater ethanol consumption in the long term if it includes redirecting the new government revenue stream to expanding higher ethanol blend fuel consumption.

An ideal mechanism for the RFS will minimize consumer costs while achieving long-term policy goals, such as the use of renewable fuels. Waiver credits could be offered for sale by the EPA as an alternative compliance mechanism for obligated parties. A waiver credit program could consider the following components:

A price that reflects ethanol RIN costs – To minimize compliance costs, the waiver credit price should be as low as possible, without causing displacement of ethanol volumes in normal compliance years. Historical ethanol RIN prices prior to the blend wall, in market conditions similar to current conditions, averaged only a few cents. This was due to oxygenate and octane demand for ethanol driving blending. These other demand drivers still exist, and therefore a waiver credit price of about $0.10 per RIN should effectively relieve the blend wall without displacing ethanol volumes.

A quantity that ensures blend wall relief – If there are not enough waiver credits to clear the blend wall, the program will not provide much value. Given the uncertainty around the volume of credits needed, the program should provide a substantial numbers of credits. If priced above the natural ethanol RIN price, then there would only be demand for waiver credits to displace RIN volumes above the blend wall.

A revenue recycling program aimed at lowering long-term compliance costs – The EPA can expect tens of millions of dollars per year in waiver credit revenues. These could be re-invested in the renewable fuels industry, with the aim of reducing long term compliance costs. A strong candidate for investment is infrastructure for E15 and E85 fuels, which have faced constraints in availability to consumers. With adequate investment in E15 and E85 infrastructure, long term waiver credit demand could decrease, effectively sunsetting the program naturally.

A price containment mechanism for the RFS can benefit from lessons learned from other policies and markets. There are currently a variety of price containment mechanisms within markets that were formed by environmental and energy policies. While a revisiting of the fundamental RFS policy drivers is a reasonable long-term idea, adding a well-designed ethanol waiver credit program could alleviate several of the most pressing issues with the RFS.

2. Introduction

This paper considers the application of a price containment mechanism in the RFS. It covers the following topics, each addressed in separate sections:

- **Issues with the Current RFS Policy Design** – The RFS was designed with ethanol volume goals based on an expectation of ever-increasing motor gasoline consumption. That has not occurred. As a result, the ethanol blend wall has been dictating RIN economics.

  Ethanol RIN prices have been set by the cost to expand biodiesel consumption beyond its RFS-mandated levels. These higher costs have done little to expand ethanol consumption. Nearly the same ethanol volume outcome could have been achieved for a much lower RIN cost. The widespread sale of higher blend ethanol fuels has not increased fast enough despite the high RIN prices.

- **Using a Price Containment Mechanism in the RFS** – The concept of price controls or "safety valves" have existed for as long as there have been compliance markets. They first gained favor in environmental policy-derived markets in the 1980s. The main reasons cited for applying price containment include responding to uncertainty, reducing regulatory burden, decreasing price volatility, and creating a source of revenue that can be used to address policy constraints, thereby improving long-term cost and policy outcomes. All of these are reasons present in the RIN market. We provide an illustration and description of how a price control mechanism would alleviate several RFS issues.

- **A Waiver Credit Solution for the RFS** – An ideal mechanism for the RFS will minimize consumer costs while achieving long-term policy goals, such as the use of renewable fuels. Waiver credits could be offered for sale by the EPA as an alternative compliance mechanism for obligated parties. The waiver credit price should be kept low to minimize compliance costs, but should not lead to significant displacement of ethanol blending. Historical RIN prices suggest that such a price could be as low as a few cents. There should be substantial waiver credits available to ensure that the blend wall is not breached. To improve long-term outcomes, revenues from waiver credits can be invested in relieving infrastructure constraints to higher ethanol blend fuels.

- **Appendices: Case Studies** – A price containment mechanism for the RFS can benefit from lessons learned from other policies and markets. There are currently a variety of price containment mechanisms within markets that were formed by environmental and energy policies. Examples include: many state-level renewable energy programs, the California Low Carbon Fuel Standard, and multiple regional carbon markets, such as that in the Northeast U.S. We examine a few in detail.

While some may point to EPA's waiver authority as an indirect price containment mechanism, it is not used as such and it is limited in its effectiveness. It has not prevented the market distortion caused by ethanol RIN pricing being stuck at biodiesel RIN levels for multiple years. Nor has it created any investment revenues that could be used for improving long-term policy outcomes and blending substantially more ethanol. While it is possible that the waiver authority could be tied to a price containment mechanism, in its current form it does not contain RIN prices.

A well-designed price containment mechanism in the RFS can improve the RIN market. It can deter unnecessary policy costs and can improve long-term outcomes, particularly if waiver credit revenues are used to break through constraints. Ethanol producers can benefit from long-term volume expansion as infrastructure constraints on higher blend fuels are reduced. Obligated parties can benefit from lower compliance costs in years where the price cap is binding. They would also experience reduced price volatility and a reduced risk of losing RIN value to blenders. Finally, and most importantly, consumer costs would decrease as the long-term policy costs decrease.

3. Issues with the Current RFS Design

The RIN mechanism is a quantity-based compliance program, which uses a market mechanism (the RIN market mechanism) to require a certain quantity of ethanol to be used in each period. In simplified terms, the EPA sets the quantity of ethanol to be blended and the tradable RIN mechanism is designed to allow this to happen at least cost.

In the absence of perfect information in setting quantities in advance in such mechanisms, there is a substantial economic literature on the use of quantity versus price-based regulatory mechanisms.[1] If the marginal benefits of compliance greatly exceed the marginal costs, a quantity-based mechanism may be preferable.[2] Nevertheless, the RFS as implemented is a purely quantity-based system with a fixed target, with the inherent scope for unexpected price and policy outcomes if the future turns out differently than expected when the quantities were set.

As we show later in this paper, this is what has happened in the context of the RFS. Originally it was widely thought that, with ever increasing gasoline consumption, it would be relatively easy (and hence require a minimal subsidy, and thus reflecting a low RIN price) to meet the ethanol mandates. However, gasoline consumption has not grown as forecast (a good thing, from an environmental perspective), and infrastructure and other constraints have made it quite difficult to blend higher levels of ethanol to meet RFS requirements. In short, the current RIN market is the result of unintended consequences that a pure quantity-based mechanism lacks the flexibility to address.

This too is a known problem in the economic literature, and various changes to pure quantity-based mechanisms have been proposed in the economic literature (and often implemented in practice) to address the fundamental inflexibility of a pure quantity compliance target.[3] Later in this paper we discuss several case studies of price containment features which have been incorporated into other quantity-based compliance mechanisms to illustrate some practical implementations of these fundamental economic ideas.

We begin with an illustration of current ethanol RIN economics, showing how ethanol (D6) RIN prices have been pricing off of biodiesel (BBD, or D4) RINs. This unexpected outcome was created by the breaching of the ethanol blend wall, which we discuss after the RIN economics illustration. We then show how, despite high RIN prices, higher ethanol blend fuels have not entered the market to relieve the blend wall constraint.

1 Weitzman (1974). Prices versus Quantities. *Review of Economic Studies,* 41(4).

2 Newell, R., W. Pizer and J. Zhang (2003). *Managing Permit Prices to Stabilize Prices*. RFF Discussion Paper RFF DP-0-34

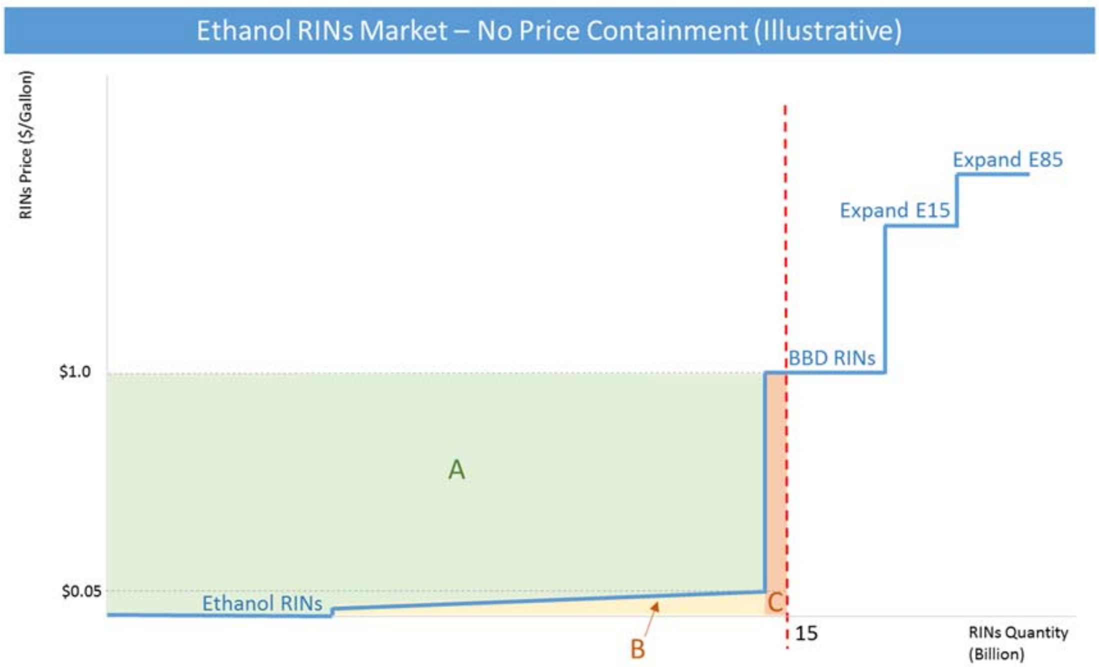
3 See for example, Jacoby, H. and D. Ellerman (2004). The Safety Valve and Climate Policy. *Energy Policy*, 32(4) and Kollenberg, S. and L. Taschimi (2016). Emissions Trading Systems with Cap Adjustments. *Journal of Environmental Economics and Management,* 80.

3.1. Illustration of current RIN economics

The main driver of RIN prices – at least in theory- is the price spread between the conventional fuel and the renewable fuel, adjusted for the lower energy content of the renewable fuel. While there are several constraints on this pricing dynamic being fully realized, historical movements in the conventional-to-renewable fuel spreads have been roughly correlated with RIN price changes.

The following chart is an illustration of the supply and demand curves in the RIN market as it is currently constructed. The prices and quantities roughly match actual outcomes in the past few years, including a RIN price set by BBD RINs. The chart is only meant to illustrate the market, not precisely replicate it.

Figure 1: D6 RIN market illustration, without price containment mechanism



The following describes each of the main elements of the above chart:

- Supply curve – While the illustrative supply curve in a generic market is often represented by a sloping line, the ethanol RINs supply curve is better characterized by a tiered set of steps. These represent the increasing compliance costs of supplying additional RINs, which see the greatest jumps in cost when moving to different fuels for compliance. For example, a significant amount of ethanol would be blended for its oxygenate and octane enhancement characteristics, regardless of the RFS. The associated RINS could be produced even at a zero RIN price, as there is another (non-RFS related) value to using ethanol. These low-cost or no-cost RINs represent the first tier in the supply curve.

  The next tier is the ethanol that requires a RIN price to be blended, which we assume is upward sloping due to different blending economics in different regions of the country and different costs for different producers. Both of the ethanol tiers are primarily driven by the price spread between petroleum feedstock and ethanol and the relative price of ethanol versus other octane enhancement options. In this example, all E10 ethanol RINs are available at under $0.05 per RIN, informed by actual RIN market outcomes when ethanol blending set the RIN price prior to 2013. The ethanol tier ends at the "blend wall," which is the number of RINs that can be achieved by maximizing the amount of ethanol in motor fuels across the country, up to the E10 recommended standard.

RIN market outcomes have demonstrated that the next tier comes from biodiesel-based RINs, which are RINs generated by biodiesel use beyond the D4 volume standard set by the EPA.[4] The nested fuel structure of the RFS allows D4 RINs to count toward fulfilling D6 obligations. The price of these RINs is determined by comparative economics for biodiesel and diesel, with the RIN price theoretically covering the spread adjusted for energy content.

The last two tiers illustrated are for expanding higher ethanol blend fuels. These RIN prices represent the price needed to incentivize the infrastructure investments to expand distribution of the higher blend fuels. The price has not been realized by the market due to the BBD RINs setting a temporary ceiling on D6 RIN prices, so they remain unknown. It is possible that the price level required to incentivize infrastructure investment is extremely high, and therefore could bring high consumer costs if it were ever realized in the RIN market.

- Demand curve – The demand curve is illustrated as a vertical line at the mandated D6 RIN volume. This is a volume that must be met, nearly regardless of RIN price.[5]
- RIN price – The RIN price will be set at the intersection of the supply and demand curves. In the chart, the intersection is on the BBD RIN portion of the supply curve, making the BBD RINs the "marginal RINs" that set the price for all D6 RINs transacted.[6]
- Total market RIN value – In this illustration, the total value of all RINs is $15 billion. This is represented by the areas A, B, and C combined. Had the price been $0.05 per RIN and the quantity remained the same, the total value of all RINs would be $750 million, a difference of $14.25 billion.
- Producer surplus – Producer surplus is the amount that producers of RINs are paid over the amounts for which they would be willing to sell them. In the short term, they would be willing to sell RINs at their cost of producing them. In the long term, they would also include a rate of return. This surplus is achieved due to the concept of a marginal producer setting a single price in a market. In the illustration, it is represented by the area A.[7]

4 Other small tiers exist, such as a tier for banked RINs and tiers for E15 and E85 sold via the existing infrastructure. The banked RIN tier is only an annual phenomenon, and thus they have been excluded in this example. The existing E15 and E85 tiers are assumed to be in the sloping portion of the ethanol RIN tier.

5 At extremely high RIN prices there would be a decrease in demand for motor gasoline and therefore a lower RIN demand, but that extreme effect is not necessary to include in this illustrative example.

6 RINs transacted over a year will change in price based on expectations about the marginal RIN cost (either in the current year, or the next year due to banking). Prices may also vary for participants due to contracts and level of vertical integration. However, in the long term, the marginal supply tier sets the price for all RIN transactions.

7 These surpluses are not entirely held by the producers of RINs (the blenders that separate them). A significant portion is returned through the concept of pass-through in petroleum feedstock prices. Our previous research has shown this pass-through is incomplete, suggesting that some surplus remains with the blenders.

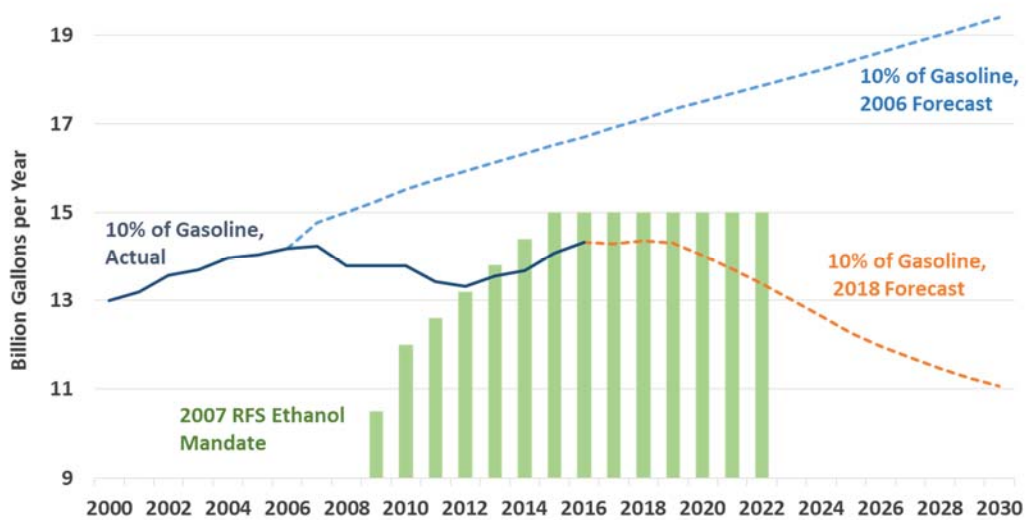
3.2. Issues with breaching the blend wall

The blend wall is breached when the RFS ethanol volume standard is higher than the quantity of ethanol that can be blended as E10, adjusted for higher and lower blend volumes. When the blend wall is exceeded, there is a deficiency of RINs for compliance. There are two main reasons that the blend wall was more easily reached than expected.

1. **Lower U.S. motor gasoline consumption than expected** – This led to a lower amount of ethanol consumed in E10 than expected. The following chart illustrates the discrepancy in forecasted vs. actual E10 ethanol volumes. The light blue line shows the amount of ethanol that would have been blended in E10 if gasoline consumption grew as expected as of 2007. This is well above the green bars, which represent the ethanol quantity mandates from the 2007 RFS2 regulations.

   The dark blue line represents actual ethanol volumes in E10, based on lower motor gasoline consumption. The orange line shows the amount of ethanol in E10 based on recent forecasts of gasoline consumption. Both of these lines are well below the mandated ethanol volumes, thus leaving a gap that must be filled by higher blend fuels or D4 RINs.

   Figure 2: Ethanol potential of E10, forecasted vs. actual vs. mandate (billion gallons)



Sources: EIA AEO 2006, EIA AEO 2018, EPA RFS overview

2. **Lower penetration of higher ethanol blend fuels than expected** - This effectively capped ethanol volumes near 10% of motor gasoline consumption. This is discussed in detail in the next section (Section 3.3).

In the RIN market economics illustration in the previous section, the volume standard of 15 billion ethanol RINs caused a breach of the blend wall. This caused the RIN price to jump from about $0.05 to $1.00 per RIN. While these are illustrative prices, they reflect recent RIN price history. Before the blend wall was breached, RIN prices were far below current levels. In 2012, they averaged under $0.03 per RIN. After the breach in 2013, they priced off of D4 prices, reaching as high as $1.45 per RIN. While there was some price separation in early

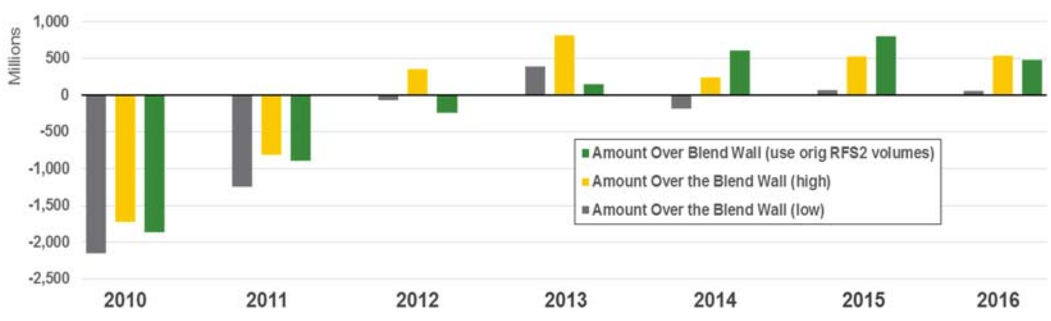
2017, D4 and D6 RIN prices have since converged again. This is shown in the following chart.

Figure 3: Historical RIN prices ($)

Source: RIN data from Oil Price Information Service (OPIS)

The D6 price jump occurred in the same year that the blend wall was breached for the first time. The following chart estimates the quantity, in millions of gallons, by which the blend wall was breached in each year from 2010 to 2016. The amount and timing of the breach is dependent on assumptions about volumes of E0, E15 and E85 consumed. The three bars for each year represent the blend wall breach calculated by various assumptions of higher blend volumes. The green bars represent the breach that would have occurred if the original RFS2 ethanol volume goals were not adjusted. The gray and yellow bars represent breach amounts with high or low assumptions, respectively, about E15 and E85 volumes. Regardless of which is most accurate, it is generally accepted that the blend wall was breached around 2013.

Figure 4: Blend wall "breach" by year



Sources: EPA data, CRA analysis

The blend wall breach occurred without a direct policy response to mitigate its impacts. As a result, there were several issues that arose that threatened the efficient achievement of RFS policy goals. The first set of issues centered on the unintended spike in biodiesel consumption. Because of the ethanol RIN demand for BBD RINs, volumes of biodiesel have significantly exceeded the RFS biodiesel volume standard. In the first year of blend wall breaching, U.S. biodiesel consumption jumped from 21 million barrels (2012) to 34 million barrels (2013).[8]

This had two main consequences. First, D4 prices, which had been on a significant downward trend, jumped nearly 300% in one year. This had impacts on policy costs. Second, there was a significant increase in imported biodiesel and decrease in exports. In the year before the blend wall, the U.S. was a net exporter of biodiesel (2.2 million barrels in 2012). In the first year of the blend wall breach, the U.S. became a net importer (3.5 million barrels in 2013).[9] It also led to increased demand for biodiesel from foreign sources with potentially negative environmental impacts.[10] Given the environmental driver behind the RFS, this was not necessarily in line with policy goals.

The higher prices themselves are an issue. They add uncertainty and volatility as small changes in fuel market factors can have a large impact on RIN prices. The fact that prices can jump between biodiesel and ethanol pricing also impacts uncertainty. This was seen in the past 1.5 years as market participants tried to gauge whether the EPA would maintain volumes that breached the blend wall. The higher prices also increase the potential financial incentives for blenders to retain portions of the RIN value, rather than passing it all through to refiners as the policy intended.

3.3. Failure of high RIN prices to expand higher blend fuels

The blend wall has not been relieved by an expansion of higher blend fuels. There is market evidence that the main cause of the failure to expand E15 and E85 has been insufficient infrastructure investment. If infrastructure were expanded, it is likely that there would be significantly more ethanol blended in transportation fuels at a RIN price well below the RIN prices seen since 2013. These concepts are further explained in this section.

3.3.1. Insufficient penetration of high blend fuels

To drive an increase in higher blend fuels, the fuels must be cost competitive with E10 on an energy content basis,[11] readily available for purchase by final consumers, and have a market of vehicles that can use higher blend fuels. While the pricing issue has seen several challenges with the efficient pass-through of RIN value, the main constraint to all of the above conditions is the lack of adequate infrastructure, and in particular fueling stations that offer E15 and E85. As such, if a primary policy goal is to expand ethanol consumption in transportation fuels beyond the E10 blend wall, any policy options can be substantially judged by whether they effectively confront the E15 and E85 infrastructure challenges.

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8 U.S. Energy Information Administration. (2018). *Monthly Energy Review February 2018: Biodiesel and Other Renewable Fuels Overview.* Retrieved from https://www.eia.gov/totalenergy/data/monthly/pdf/sec10_8.pdf

9 Idem

10 AETS. (2013, February). Assessing the impact of biofuels production on developing countries from the point of view of Policy Coherence for Development. *The European Union's Framework Contract Commission 2011*. European Union. Retrieved from: https://ec.europa.eu/europeaid/sites/devco/files/study-impact-assesment-biofuels-production-on-development-pcd-201302_en_2.pdf

11 E15 has roughly 98% of the energy content of E10, while E85 has roughly 77% of the energy content of E10.

To date, the RFS has not met the challenge of expanding higher blend fuels. There are currently about 1,000 stations selling E15 and about 3,160 stations offering E85.[12] These stations represent 0.8% and 2.6%, respectively, of all public gas stations in the U.S.[13] While E15 and E85 sales volumes are not explicitly tracked, the EPA provided estimates of their volumes in their analysis supporting the 2017 RFS volume standards. They estimated annual sales of 728 million gallons of E15 and 275 million gallons of E85, which represent only 0.5% and 0.2% of all U.S. motor gasoline demand. In order to cover the deficiency of ethanol below the 15 billion gallon RFS goal, there would need to be tens of thousands more stations with either E15, E85 or both.[14]

3.3.2. Lack of infrastructure expansion

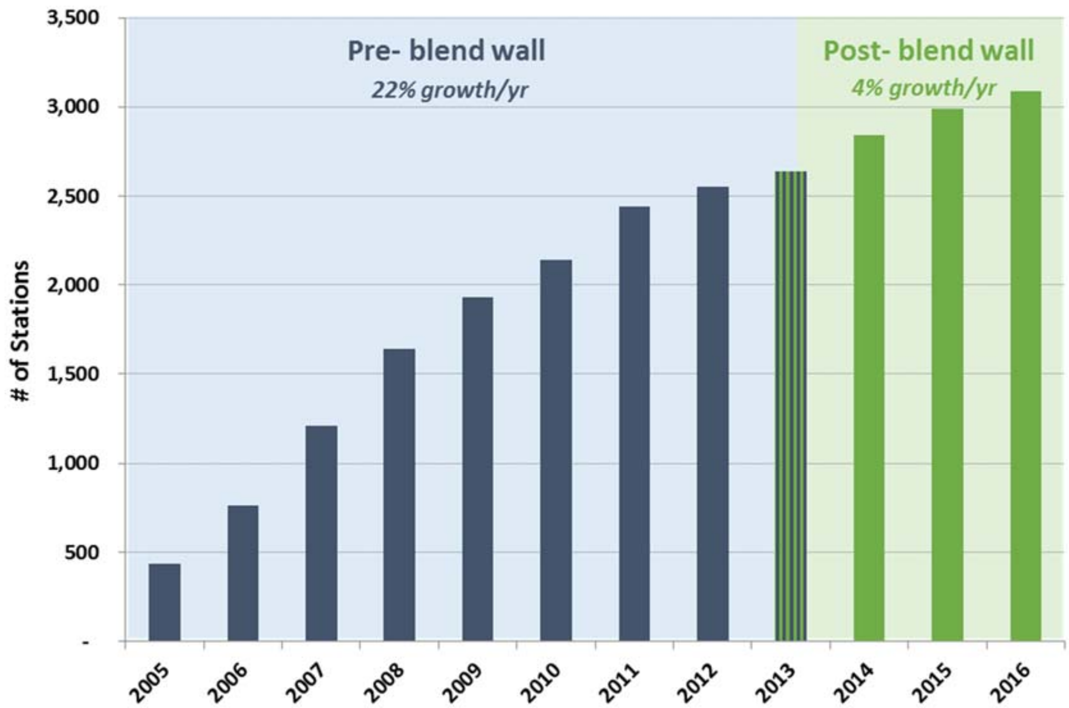
Higher RIN prices have clearly not been enough incentive for the significant infrastructure needed to manage the blend wall. As shown in the figure below, E85 stations were added at a much greater rate prior to the 2013 spike in RIN prices (in blue) versus after the spike (in green). The annual growth rate from 2005 through 2013 was over 22%, while the rate for 2013 through 2016 was only 4%. This plateau occurred despite much higher RIN prices.

12 E15 estimate from Growth Energy's website, as of October 2017. E85 estimate from U.S. DOE's Alternative Fuels Data Center, accessed 2/23/2018. Note that these are not necessarily unique stations, as many E85 stations offer E15 through blending at the station.

13 Total fueling stations from NACS Fuels Report 2016

14 The number of stations could be reduced if each station sold a higher amount of higher blend fuels than the current average.

Figure 5: E85 filling stations, 2005 - 2016



Source: U.S. DOE Alternative Fuels Data Center

3.3.3. The RIN price has been sufficient to blend ethanol

This stall out in infrastructure expansion occurred during a period in which RIN prices were significantly higher than what would theoretically be needed to incentivize the use of higher blend fuels. The needed RIN price is based on ethanol and petroleum feedstock pricing spreads, with adjustments for the energy content penalty for blending ethanol and the blending benefits of oxygenate and octane enhancement.

To understand the RIN price needed to blend ethanol, consider a simple example based on approximate versions of 2013 feedstock prices ($2.50 per gallon RBOB and $2.00 per gallon ethanol) and an assumption of perfectly rational and informed gasoline consumers. Without considering the oxygenate and octane benefits, the maximum RIN price needed for blending ethanol would be about $0.30 per RIN to make up for the energy content difference.[15] However, that is much higher than the needed RIN price since ethanol blending has oxygenate and octane benefits. As seen in 2012, those additional benefits can drive the RIN price near $0 during a period with similar feedstock price spreads.

15 This hypothetical RIN value was calculated based on reaching energy content price parity at the wholesale level. It does not account for the added costs associated with the higher blend fuel supply chains and distortions in retail pricing.

3.3.4. Relief of the infrastructure constraint would drive more ethanol use

The fact that in 2013 prices jumped to well over $1.00 per RIN for a substantial period is a clear indicator that there were infrastructure constraints to expanded ethanol blending. In fact, since the blend wall was breached, RIN prices have remained well over the theoretical amounts needed to incentivize blending E15 and E85 (up to any infrastructure constraints). Relieving these constraints could moderate RIN prices.

This is the conclusion reached in 2014 by Babcock and Pouliot.[16] They performed quantitative analysis to estimate how the consumption of E85 can be increased through the construction of new fueling stations and by changing retail and RIN prices, while maintaining the number of flex-fuel vehicles constant at 2013 levels. In their study, E85 volumes could be expanded to produce 800 million additional ethanol gallons at a price of $0.18/RIN, under the assumption that hundreds of additional fueling stations were added.

A 2015 study by Christensen and Siddiqui has also shown that there is a strong correlation between E85 consumption targets and cost of compliance. They demonstrated that if new initiatives were undertaken to install blender pumps and help deploy an additional 600 million gallons of E85 in 2017, the cost of compliance could be reduced by approximately 50%.[17] According to this study, this would take the form of dampened D5 and D6 RIN prices; D4 RIN prices would largely be unaffected.

It is clear from simple calculations and the academic literature that relieving the infrastructure constraint would lead to a commensurate volume of higher blend fuels added to the market, even at RIN prices less than half their recent levels.

4. Using a Price Containment Mechanism to Address RFS Issues

There are several regulatory options for addressing the issues discussed in the previous section. One option would be to dynamically link the volume standards to market conditions, such as the actual amount of motor gasoline consumed and higher blend fuels in the market. This would only be effective if it kept mandates below the blend wall. Another option would be an expansion of qualifying ethanol RINs, such as allowing unobligated RINs for exports. This white paper focuses on a price containment mechanism.

4.1. How price containment mechanisms work

Well-designed price containment mechanisms can effectively limit the societal costs of environmental and energy policies, while also supporting the attainment of policy goals. The mechanisms are most beneficial in policies based on quantity goals, which have uncertain cost outcomes that need moderation. The mechanisms are also most beneficial in markets where high prices lead to negative impacts on most stakeholders and the prices do not efficiently drive desired policy outcomes. In these markets, higher prices may simply provide surplus income to producers and costs to consumers, while doing nothing for long-term policy

16 Babcock, B., & Pouliot, S. (2014). *Feasibility and Cost of Increasing US Ethanol Consumption Beyond E10.* Ames: Center for Agricultural and Rural Development, Iowa State University.

17 Christensen, A., & Siddiqui, S. (2015). Fuel Price Impacts and Compliance Costs Associated With The Renewable Fuel Standard (RFS). *Energy Policy*, 614-624.

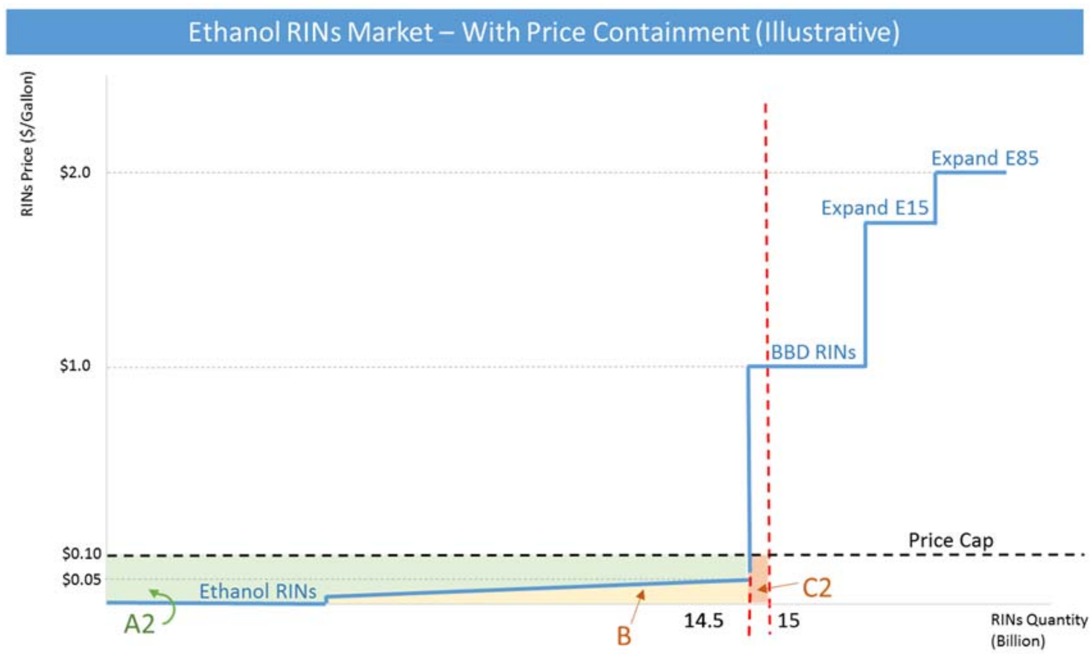
goals. Price containment mechanisms can prevent such unnecessary transfers, while lowering long-term policy costs.

The basic theory of price containment mechanisms is quite simple. An administrative mechanism is put in place that prevents the price of a compliance credit from exceeding a set level. The mechanism usually involves the administrator, often a government entity, selling compliance credits at a specified price to prevent prices from going higher in the market. This price cap can help contain the overall cost of compliance with a mandate.

Price caps are popular among policymakers for many reasons. They can make new regulations more palatable for many stakeholders by reducing the risk of high costs of compliance, which can both impact obligated parties as well as consumers downstream from the compliance market. In the long-term, this benefit can allow the policymakers to be more ambitious with targets. Philibert argues that a safety valve (another term for a price cap) allows for a more ambitious target in the face of uncertainty about costs because it prevents costs in excess of acceptable levels.[18] This can also extend the life of a policy, since a clear threat to policy longevity would be stakeholder backlash from extreme compliance costs.

Figure 6 shows how a simple price containment mechanism would work in the RFS. It begins with the same RIN supply curve and quantity mandate as in Figure 1, with a price cap added at $0.10 per compliance credit.

Figure 6: D6 RIN market illustration, including price containment [19]



The following describes each of the main elements of the above chart:

- Supply curve – The supply curve is the same as the example without a price cap.

18 Philibert, C. (2006). *Certainty versus Ambition: Economic Efficiency in Mitigating Climate Change.* Paris: International Energy Agency Working Paper Series. Report Number LTO/2006/03.

19 As mentioned in the text, this chart is illustrative and not a policy recommendation for a particular price cap level.

- Demand curve – The demand curve is the same as the example without a price cap, a vertical line at 15 billion RINs.
- Price cap – This purely illustrative example includes a price cap of $0.10 per compliance credit.
- RIN price – In this example, the price cap is reached before the volume standard is reached, and therefore the RIN price is set by the cap at $0.10 per RIN. If the volume standard were less than 14.5 billion gallons, the RIN price would have been set off the ethanol RIN supply curve and the price cap would not be used.
- Total market RIN value – The price of RINs fell from $1.00 per RIN to $0.10 per RIN. This $0.90 per RIN reduction results in a $13.5 billion reduction in the total value of all D6 RINs, including those purchased at the cap. In a market where most RINs are transacted, this is a major reduction in the total value of market transactions.
- Government revenue – Assuming the price cap is administered by the sale of compliance credits, the chart shows 500 million credits sold at the price cap level of $0.10 per credit. This results in $50 million of proceeds from the sale, represented by area C2 in the chart. If the volume standard was set below 14.5 billion RINs, there would be no proceeds from the sale of additional credits.
- BBD RINs - There are no BBD RINs used for compliance with the D6 mandate. This is a reduction of about 330 million gallons of biodiesel (since they receive 1.5 RINs per gallon blended). In addition, the D4 RIN market could see lower RIN prices, since they were previously being set by the marginal BBD RINs used for D6 compliance.

4.2. Infrastructure investment benefit

The chart in the previous section illustrated a RIN market outcome for a hypothetical year. Over time, dedicated policies can change the RIN supply curve significantly. An example from the biodiesel market is the blender tax credit, which causes a downward shift in the supply curve and therefore lower RIN prices when in effect. A price containment mechanism can have the same directional shift in the supply curve over time if it is designed to address RIN supply constraints. One possible way to do so is through strategic investment of the proceeds from the additional RIN sales associated with the price cap.

There are precedents for such “revenue recycling” programs in other markets. In Section 5.3.2, we discuss the program associated with the Northeast’s Regional Greenhouse Gas Initiative (RGGI). Such programs are commonly proposed for national carbon policies, with support such as the following from Resources for the Future, “Scholarly research suggests that an alternative payment mechanism linked to investment can be designed to meet and exceed environmental goals and produce more rapid investment in innovative technologies, and improve environmental outcomes at a lower cost…”[20]

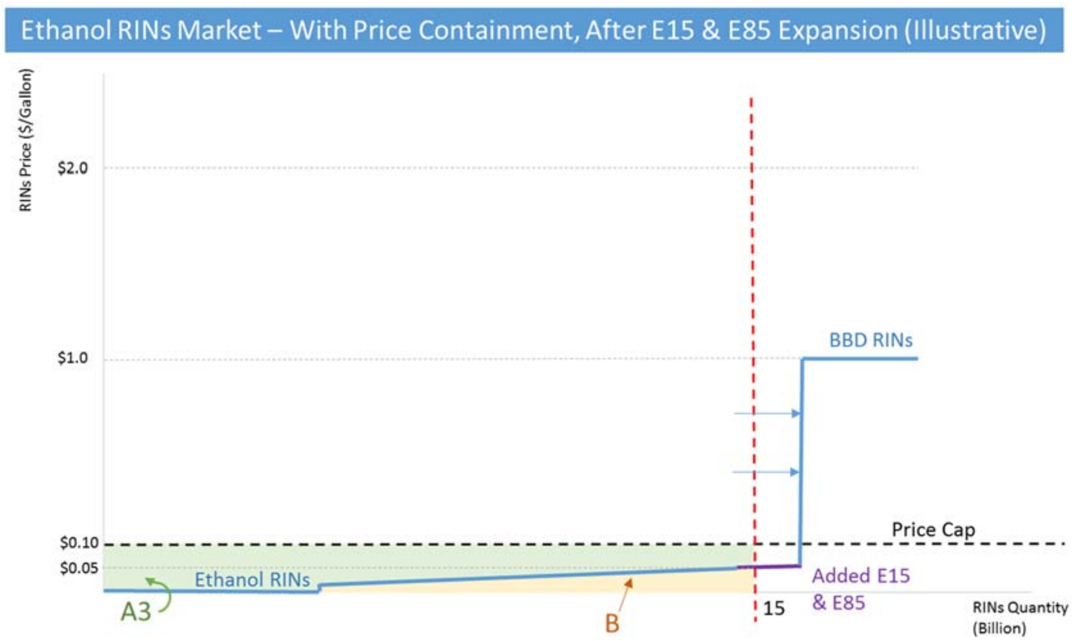
There can be significant sums of money brought in through a price containment mechanism in the RFS. In the example in the previous section, a mechanism that simply covered the hypothetical number of RINs beyond the blend wall led to $50 million in annual revenue. That

20 Burtraw, D., & Palmer, K. (2014, November 12). *Resources for the Future: Alternative Compliance Payments under the Clean Power Plan*. Retrieved 2 22, 2018. (See Patino, Echeverri et al. 2012, *Journal of Regulatory Economics*)

number could be much higher if the price cap was set at a level below a portion of the ethanol RIN step of the supply curve, thus leading to a greater number of RINs sold.

If a large share of that revenue was directed to relieving constraints to higher blend fuels, the policy could lead to lower priced RINs associated with more E15 and E85 consumption. In the long term, RIN prices could fall below the price cap, as shown in Figure 7 below. In this example, there are additional low cost RINs added to the supply curve, thus shifting the BBD RINs step out to the right. The new E15 and E85 RINs are plentiful enough to keep the RIN price below the price cap.

Figure 7: D6 RIN market illustration, including price containment & post-reinvestment



There are many positive outcomes in the above example. First, the price cap is no longer needed unless there are significant commodity price shifts that disadvantage ethanol against petroleum feedstocks. Second, the RFS volume standards are entirely met with ethanol, versus relying on biodiesel volumes indefinitely, as seems to be the current situation. Finally, note that the entire RIN value ($750 million) is far lower than in the first example with no price cap ($15 billion).

5. Designing a Mechanism for the RFS

As illustrated throughout this paper, the RFS could greatly benefit from a well-designed price containment mechanism. To be well-designed, the mechanism should adhere to a set of economic principles that support overall policy goals. It should also integrate the price containment experiences in other similar markets. Given these requirements, an ethanol RIN waiver credit program with certain design features could meet the goals of the RFS more effectively than the current RFS without a price containment mechanism.

5.1. Economic considerations

The following are some of the key economic considerations for policymakers when evaluating a price containment mechanism for the RFS. The list is not comprehensive, but rather highlights considerations based on the RFS issues and goals discussed in previous sections.

- Minimize overall compliance costs
- Avoid the unintended use of nested fuel tiers as long-term backstops for parent tiers
- Incentivize investment to relieve constraints, such as infrastructure expansion or new technology development
- Reduce volatility and RIN cost uncertainty

5.2. Lessons from price containment in other markets

When considering a price containment mechanism for the RFS, policymakers can benefit from the experiences in other similar markets. Price containment mechanisms have proven effective in a variety of markets, such as the Renewable Portfolio Standards and carbon emissions policies in many states and regions (such as the Regional Greenhouse Gas Initiative and California's Low Carbon Fuel Standard). There is even a price containment mechanism within the RFS already, in the form of the cellulosic (D3) waiver credit program.

All of the existing mechanisms were put in place to avoid potential issues in their respective policies, and those issues are in many cases the ones highlighted in this paper as currently plaguing the RFS. The issues most mentioned by policymakers include minimizing consumer costs, ensuring longevity of the policies by avoiding overly-burdensome outcomes, and reducing uncertainties of costs to comply with quantity-based policies.

We describe the mechanisms for several policies in Appendices A-C. We highlight key features of three different policies and the RFS' D3 waiver credits in the table below:

Table 1: Comparing Price Control Mechanisms in Similar Markets

	Renewable Portfolio Standards (RPS)	Regional Greenhouse Gas Initiative (RGGI)	Low Carbon Fuel Standard (LCFS)	Cellulosic Waiver Credits (CWC)
Region	USA (29 states)	Northeast, Mid-Atlantic USA	California	USA
Policy Mandate	Percentage or amount of utilities' electricity sales that must come from renewables	Carbon emissions caps for electric sector	Carbon emissions caps for transportation sector	Sale of waiver credits for compliance with RFS cellulosic mandates
Obligated Parties	Load serving entities (utilities)	Fossil-fuel-based electric power generators	Producers of petroleum-based fuels	Refiners and importers of conventional fuels
Compliance Options	Alternative compliance payments, financial penalties	Acquiring allowances issued by RGGI, traded among participants	Acquiring credits to offset carbon deficits from other participants	Purchasing waiver credits from the EPA at pre-set prices
Credits	Renewable Energy Certificates (REC)	RGGI Allowances	LCFS Credits	Cellulosic Waiver Credits
Price Control Mechanism	Alternative Compliance Payments (ACP), caps on rate impact, caps on contract prices or funds	Cost Containment Reserve (CCR)	Credit Clearance Market (CCM)	Price floor and price ceiling
Government Revenues Generated?	Yes	Yes	No, credits sold by other parties	Yes
Revenue Recycling Methods	Funding Public Benefit Funds (PBF)	Funding emissions reduction programs, assisting ratepayers	Kept within the clean-fuel market place, reallocated among participants	N/A

5.3. Waiver credit program design features

Based on the proposed set of principles and goals, and considering experiences with price containment mechanisms in other markets, we provide a set of design recommendations. We focus on the design aspects of an ethanol RIN waiver credit program for the RFS. While this paper does not advocate a particular price containment mechanism, there are clear strengths to the waiver credit approach compared to other options. It is a natural fit for the RFS.

The basic form of an ethanol RIN waiver credit program is straight-forward. The US government, through the EPA, offers waiver credits for sale at a set price to obligated parties. Obligated parties can comply with the RFS by: 1) submitting/retiring RINs that were separated during ethanol blending, similar to the current approach, 2) submitting waiver credits, or 3) submitting/retiring a combination of RINs and waiver credits.

Beyond the basic form, there are several design components critical to the mechanism:

- **Setting the initial waiver credit price** – Setting a price too high will lead to underutilization of the waiver credits and likely a continued breaching of the blend wall. This would defeat the cost minimization goal of the mechanism. The price should be set as low as possible without driving out significant ethanol volumes.

  In many markets there is also concern over setting the price too low, which could defeat environmental or other policy goals. For example, in the Renewable Portfolio Standards, an ACP that is too low could result in no construction of solar power facilities. Fortunately, this is not a significant concern in the RFS. There is recent history to demonstrate that the cost of ethanol RINs for volumes below the blend wall is extremely low under market conditions similar to the current conditions. It is possibly as low as $0 per RIN.

  In 2012, the average RIN price was $0.029 cents per RIN with an ethanol RIN quantity mandate just below the blend wall. Importantly, these prices were seen while the fundamental drivers of RIN costs were similar to their current levels. For example, in the last six months before the blend wall was breached, the average national feedstock spread (ethanol vs. RBOB), adjusted for energy content, was $0.55 per gallon. Over the first six months of 2017, the same spread averaged $0.53 per gallon. This would suggest very similar economics, and therefore similar ethanol RIN costs.

  This would suggest a recent proposal of a $0.10 per RIN waiver credit price would only be used for replacing RINs required beyond the blend wall, since obligated parties would find lower cost compliance from purchasing RINs from blenders (or blending the ethanol themselves if vertically integrated).

- **Predictable long-term price path with infrequent adjustments** – There must be a balance between setting a clear long-term waiver credit price path and having the mechanism adjust to significant changes in the market. The mechanism is most valuable if it removes long-term uncertainty. If the mechanism expires after a short period of time, the program will jump right back into a period of speculation and volatile RIN prices. That speculation would actually arrive in RIN prices before the mechanism expires due to RIN banking.

- **Ample waiver credits available to ensure the blend wall is not breached** – The precise volume of credits needed to prevent reliance on BBD RINs is not known in advance of a compliance year. While we can view historical biodiesel volumes to see how far they exceeded their D4 mandate, the presence of banking clouds that picture and the story can change year to year.

  In addition, the blend wall level can move significantly year-to-year, particularly during large economic downturns in the economy. For example, from both 2007-to-2008 and

2010-to-2011, there were drops in motor gasoline demand of about 3% in individual years. Applied to a blend wall of about 14 billion gallons, such a drop would remove about 450 million ethanol RINs. It is precisely during these times that the waiver credits could prove most valuable, and therefore they need to be available in sufficient quantities.

Given that this outcome is critical to the benefits of a price containment mechanism, the volume of waiver credits should substantially exceed the quantity estimated as necessary to avoid the blend wall. This is particularly true if there is a set volume of credits that is not responsive to economic shifts year-to-year.

Some stakeholders may have concern that a large volume of waiver credits would displace ethanol blending. However, given that ethanol RIN costs below the blend wall constraint are assumed to be extremely low, there is little risk of obligated parties overly relying on waiver credits regardless of the quantity available.

- **Recycling revenues into constraint-relieving investments** – The selling of waiver credits could lead to tens of millions of dollars in revenues per year. These revenues can be used to reduce long-term compliance costs by supporting initiatives to break through constraints. The most clear constraint deserving attention is the infrastructure constraint to higher ethanol blend fuel expansion. There are multiple examples of government programs that have expanded the number of fueling stations selling E85, but the funding for those programs has been insufficient without dedicated revenue streams like those available through a waiver credit program.[21]

21 *USDA announces grants to expand E15, E85 infrastructure* (2015, September 10). Retrieved from Ethanol Producer Magazine: http://ethanolproducer.com/articles/12612/usda-announces-grants-to-expand-e15-e85-infrastructure

Appendix A: Case Study: Renewable Portfolio Standards

A Renewable Portfolio Standard (RPS) is a regulation set by a state, region or nation that requires increasing percentages or amounts of electricity provided to retail customers be generated by eligible renewable sources. As of 2018, twenty-nine states have implemented an RPS, while eight others have adopted Renewable Energy Goals. The existing RPS programs vary in their design, targets, reporting and compliance enforcement methods.

The RPS-eligible sources vary by program, but generally include wind, solar, biomass and other generating technologies. In many cases, there are separate tiers for different sources, such as a solar “carve out,” with specific targets nested within the overall target. This is similar to the biofuel tiers in the Renewable Fuels Standard (RFS). The obligated parties are Load Serving Entities (LSEs), commonly thought of as the utilities that provide electricity to end-use consumers. This is dissimilar to the RFS, since the RFS places the obligation on refiners, not the entities that directly serve end consumers of fuels.

In most RPS programs, the obligated parties can either directly procure or produce renewable electricity, or they can purchase compliance credits, known as Renewable Energy Certificates (REC), from the generators of renewable electricity. The RECs in RPS programs are similar to the RINs used in the RFS. A key difference, however, is that most RPS programs recognize the significant uncertainty in renewable energy technology development and cost competitiveness, and therefore many programs explicitly include price containment mechanisms. As of 2014, at least 24 of 30 states with renewable energy programs included a cost containment mechanism in their regulations.[22]

The price containment mechanisms found in RPS programs include, but are not restricted to the following:[23]

- **Alternative Compliance Payment (ACP)** – An RPS regulation may allow LSEs to pay an ACP for each megawatt-hour (MWh) of renewable electricity that the LSE is short of its compliance obligation, by failing to obtain sufficient RECs. The ACP rates are generally set administratively based on economic principles and expected technology costs over time. ACPs are discussed in more detail below.
- **Caps on rate impacts or revenue requirements** - Some states have created ceilings that limit how much a renewable energy policy can increase electricity rates for customers. They are often implemented in the form of set percentages of the utilities’ annual retail revenue requirement to be spent on compliance with RPS. Thus, utilities that have spent the specified percentage on renewables may be considered compliant even if they have not met the annual RPS targets.[24]
- **Renewable energy contract price caps** - These caps limit the amount that a renewable energy generator can charge a utility for a renewable energy or REC purchase, which indirectly caps prices.

22 Heeter, J., Barbose, G., Bird, L., Weaver, S., Flores-Espino, F., Kuskova-Burns, K., & Wise, R. (2014). *A Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards.* National Renewable Energy Laboratory.

23 Barbose, G. (2017). *U.S. Renewables Portfolio Standards 2017 Annual Status Report.* Lawrence Berkeley National Laboratory.

24 Stockmayer, G., Finch, V., Komor, P., & Mignogna, R. (2012). Limiting the costs of renewable portfolio standards: A review and critique of current methods. *Energy Policy*, 155-163

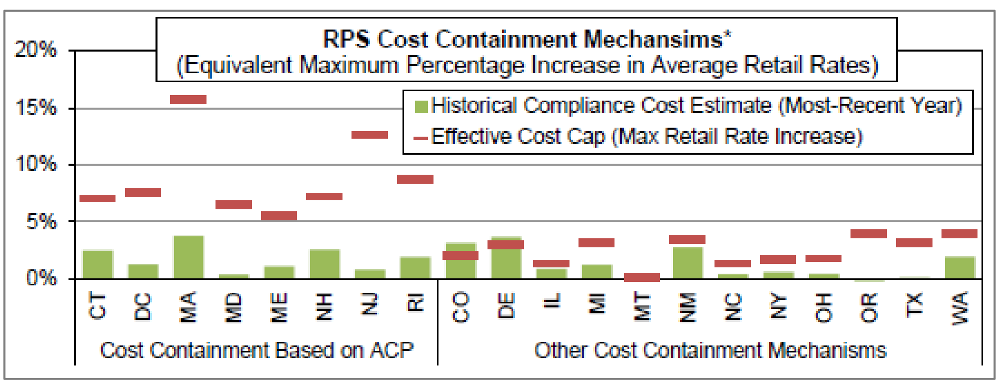
- **Renewable energy fund caps** – Some states, such as New York, have established specific programs for the purpose of a central RPS procurement. These caps limit the amount of funding that can be made available to cover the program's budget.
- **Financial penalties** - Similarly to ACPs, penalties can be imposed on LSEs who are not able to meet their RPS requirements for the year. They differ from ACPs insofar as they cannot be passed through to ratepayers and/or the penalty rate is not pre-specified.[25]

Among these mechanisms, ACPs and caps on rate impacts are the most common.[26] The latter are less relevant to the Renewable Fuels Standard since gasoline prices are not regulated to the same extent as electricity prices and the RFS obligated parties, as currently designated, would have no way to administer such caps. It is therefore more applicable to the RFS to consider the design and implementation of ACPs.

The design and price of ACPs vary by state. The total ACP cost is calculated as the state-determined ACP rate multiplied by the LSE's deficient kilowatt-hours. In some states, ACPs are required and thus they constitute the cost of RPS compliance. In Illinois, for example, alternative electricity suppliers must fulfill half of their RPS requirement by purchasing ACPs. In most other states, however, ACPs are optional. LSEs therefore pick the option that allows them to fulfill their RPS requirement at the least cost: if the ACP rate is higher than purchasing RECs or renewable energy, they will opt for this method of compliance. In this way the ACP effectively sets a ceiling on the REC and renewable procurement costs.

Typically, ACP costs have proven higher than the cost of meeting the requirement by generating renewable energy or purchasing RECs, but they have been critical in salvaging several RPS programs when costs may have otherwise have risen unsustainably. A 2014 study has shown that in almost all states the historical cost of complying with RPS has been lower than the effective cost cap (Figure 8). This means that the ACP has not been binding.

Figure 8. RPS cost caps compared to estimated recent historical cost [27]



Source: Heeter, et al., 2014

25 Heeter, et al, 2014

26 Pierpont, B. (2012, December). *Renewable portfolio standards – the high cost of insuring against high costs*. Retrieved February 07, 2018, from Climate Policy Initiative: https://climatepolicyinitiative.org/2012/12/17/renewable-portfolio-standards-the-high-cost-of-insuring-against-high-costs/

27 Further note on the chart: "For states with multiple cost containment mechanisms, the cap shown here is based on the most-binding mechanism." Heeter, et al., 2014.

The revenue from ACPs is generally used to fund a public benefits fund that supports renewable development, demand-side energy efficiency programs, low-income assistance and weatherization programs in the state.[28] These funds are often managed by governmental entities and in fewer cases by non-profit organizations or corporations created specifically to manage the fund. In some cases, separate sub-funds are created for specific technologies. For instance Maryland and Massachusetts set aside the revenue from ACPs collected from the solar carve-out obligation to fund more solar deployment. These funds can benefit communities in a wide variety of ways, including environmental health improvements, energy costs reductions achieved through energy efficiency, financial assistance to low-income customers and support to home-owners for home improvement initiatives.

28 Stockmayer, et al., 2012; U.S. Department of Energy. (2010). *Public Benefit Funds: Increasing Renewable Energy & Industrial Energy Efficiency Opportunities.* U.S. Department of Energy.

Appendix B: Case Study: Various Carbon Policies

Many countries around the world and states within the United States have set goals on limiting carbon emissions from fossil fuel combustion. To achieve these goals, many governments have formed carbon policies that limit emissions in single or multiple sectors of their economies, either directly through emissions caps or carbon pricing, or indirectly through regulated mandates on technologies or emissions controls. Quantity targets generally involve market mechanisms through cap-and-trade systems, whereby entities can buy and sell emissions permits in order to comply with emission limits. Price targets are often implemented in the form of a carbon tax: parties that emit carbon dioxide (CO_2) pay the government a set amount per ton of CO_2 emitted. Hybrid systems include imposing upper limits on the price for emissions permits by making additional permits available at a predetermined price. These policies can often be more efficient than pure price or pure quantity-based policies, because they are better equipped to deal with market uncertainty.[29]

A key difference from the RFS is that carbon policies are designed to reduce emissions, not to provide direct incentives for increasing a certain activity (like blending renewable fuels). Therefore, carbon allowances are generally not created by market participants, but rather auctioned by the government or freely allocated. Similar to the RFS, however, these credits are tradable and they are submitted by obligated parties to cover their annual emissions.

Successful carbon cap-and-trade programs have been implemented in Europe, New Zealand, Australia, North America, and recently in China. Several countries across Africa, Asia, Europe, Central and South America currently have a carbon tax in place.[30] There exists an expansive literature on the possible design and implementation of a carbon policy in the United States, although no such policy has been approved at the federal level. Instead, there are regional policies, such as the Regional Greenhouse Gas Initiative (RGGI) in the Northeast U.S. and the AB 32 program in California, which is in the process of expanding.

Price containment mechanisms feature prominently in both the existing carbon policies and the many proposals at the U.S. federal level. They are often referred to as “safety valves” in the carbon policy context. The most common form involves the government releasing additional allowances into the market if a set carbon price is reached. This additional supply of allowances moderates the price. The added allowances are either newly created or borrowed from future years. An example of such a program is the Cost Containment Reserve (CCR) in the RGGI program, described in the next section.

5.3.1. Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) was the first mandatory cap-and-trade program to limit CO_2 emissions from the power sector in the U.S. The participating states are all located in the Northeast and Mid-Atlantic regions and include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

29 Aldy, J., Hafstead, M., Metcalf, G., Murray, B., Pizer, W., Reichert, C., & Williams, R. (2017). *Resolving the Inherent Uncertainty of Carbon Taxes.* Harvard Environmental Law Review.

30 The World Bank. (2017, December 01). *Carbon Pricing Dashboard*. Retrieved February 09, 2018, from http://carbonpricingdashboard.worldbank.org/map_data

CO_2 emissions are regulated through CO_2 Budget Trading Programs that vary by state, but are all aligned with the RGGI Model Rule.[31] The overarching RGGI regulation requires fossil-fuel-based electric power generators above a certain size to obtain allowances equal to their CO_2 emissions over a three-year control period. Each allowance corresponds to the permission to emit one short ton of CO_2 and can be traded between different regulated parties. Allowances are issued by the states' Budget Trading Programs, which also establish participation in regional allowance auctions. There is a cap to the maximum amount of allowances that can be issued, which is set yearly by the RGGI and decreases over time.

RGGI includes a Cost Containment Reserve (CCR). The CCR consists of additional allowances on top of the caps, which are made available only when the allowance prices exceed a predefined threshold. The goal is to protect participants from exceedingly high emissions reduction costs. Both the threshold price at which the CCR is triggered and the size of the reserve is set to change every year: the former increases, while the latter decreases over time.

All 15 million CCR allowances were sold in 2014 to 2015, but the reserve was not triggered in 2016. Those 15 million allowances represent 2.5% of all allowances expected in RGGI from 2014 to 2020.[32] The independent market monitor for RGGI, Potomac Economics, emphasizes the value of the CCR, stating that "Since the program changes announced in February 2013, the CCR has been a significant factor in reducing the volatility of allowance prices."[33] Adding that the CCR "...may have helped to limit price volatility: (a) directly by providing for the sale of ten million additional allowances during 2015 and (b) indirectly since the potential for CCR allowances to be sold in future auctions limits upward speculative pressure on prices.[34]

The nine RGGI states receive significant revenues from the initial auctions of allowances and the CCRs. Through 2015, they had generated $1.7 billion, most of which has been invested in initiatives that further reduce emissions or assist ratepayers with the added cost on their electricity bills. The investment categories are summarized in the table below:[35]

Spending Category	**Percentage of 2015 RGGI investment**	**Outcome**
Energy Efficiency	64%	$1.3b lifetime energy bill savings to over 141,000 households and 5,700 businesses
Clean and Renewable Energy	16%	$785.8m lifetime energy bill savings to 19,600 households and 122 businesses

31 The Regional Greenhouse Gas Initiative. (2018). *Program Overview and Design: Elements of RGGI*. Retrieved 02 21, 2018, from https://www.rggi.org/program-overview-and-design/elements

32 Potomac Economics. (2017). *Annual Report On The Market For RGGI CO2 Allowances: 2016.* Potomac Economics. Retrieved February 22, 2018 from https://www.rggi.org/sites/default/files/Uploads/Market-Monitor/Annual-Reports/MM_2016_Annual_Report.pdf

33 Idem

34 Potomac Economics. (2016). *Annual Report On The Market For RGGI CO2 Allowances: 2015.* Potomac Economics. Retrieved February 22, 2018 from https://www.rggi.org/sites/default/files/Uploads/Market-Monitor/Annual-Reports/MM_2015_Annual_Report.pdf

35 The Regional Greenhouse Gas Initiative. (2017). *The Investment of RGGI Proceeds in 2015.* RGGI, Inc.

Greenhouse Gas Abatement	4%	Avoided release of 636,000 short tons of CO_2
Direct Bill Assistance	10%	$40.4m returned in bill credits and assistance to consumers

5.3.2. Revenue Recycling

As just discussed, carbon polices with both initial emissions auctions and allowance-based reserve systems can bring in substantial amounts of money. Therefore, an important aspect of carbon policy design is determining how the revenues collected are to be returned to the economy. This is often referred to as “revenue recycling” and is covered in a large amount of academic literature.

One option is to use some of the revenues to pay for emissions reductions in sectors not covered by the carbon regulation, in the case where emissions targets have not yet been met.[36] Alternatively, the revenues could be used to invest in energy efficiency, renewable and other low-carbon technologies. Another option is to reinvest the revenues in other initiatives that touch the economy at large, such as income tax cuts or infrastructure spending.[37] For example, returning the revenues to individuals and businesses through lump-sum rebates can significantly lower the cost of a carbon tax. This cost offsetting idea has been popular in recent proposals that seek to achieve a carbon policy with minimal regulatory burden.

36 Murray, B., Pizer, W., & Reichert, C. (2017). *Increasing Emissions Certainty Under a Carbon Tax.* Harvard Environmental Law Review.

37 Goulder, L., & Hafstead, M. (2013). *Tax Reform and Environmental Policy.* Washington: Resources For the Future; Metcalf, G. (2017). *Implementing a Carbon Tax.* Washington: Resources For the Future.

Appendix C: Case Study: California's Low Carbon Fuel Standard

California's Low Carbon Fuel Standard (LCFS) is administered by the California Air Resources Board (ARB). Implemented in 2011, its goal is to reduce the carbon intensity of the transportation fuel consumed in California by at least 10% by 2020.[38] Unlike the RFS, it does not specify which fuels or what volumes of each are necessary to satisfy the requirement, letting the market determine the mix of fuels needed. Instead, it assigns to each fuel type a carbon intensity rating, measured in CO2 equivalent, which can be above or below the standard. LCFS deficits and credits are then defined as the difference between the fuel's rating and the standard (positive for deficits, negative for credits). Obligated parties must maintain compliance by purchasing or generating enough credits to offset the deficits they have produced in a calendar year.

The LCFS includes a price cap in the form of a Credit Clearance Market (CCM). It was developed with the following goals:[39]

- Allow compliance even if a credit shortfall occurs
- Strengthen incentives to invest in low carbon intensity fuels
- Increase certainty regarding the maximum cost of compliance
- Prevent extreme market volatility
- Ensure that willing credit generators can sell available credits

The CCM works as follows: If the obligated parties fail to offset their annual deficit, they must purchase their pro-rata share of credits in the CCM. Other parties that hold available credits for that year offer them for sale in this market at a set price of $200 per metric ton, adjusted annually for inflation. The LCFS Credit Prices have never come close to this ceiling, having traded at their highest point just above $120 per metric ton.

Prior to selecting the CCM option, the ARB staff had also considered a credit window option, which was closer in design to the price caps in RGGI and many RPS programs. One of the major differences between these two mechanisms is the way in which the revenues collected are reinvested. In the clearance market process, the proceeds are kept within the clean fuels marketplace: the money flows from parties that have not been able to offset their deficits to those that hold credits. In the credit window process instead, proceeds are distributed to low-carbon intensive fuel producers or used for other greenhouse gas reductions to mitigate the loss in LCFS benefits.[40]

With such cost-containment mechanisms in place, the LCFS achieved 98% compliance in 2015. Given that one party was short after the deadline, a CCM was held in 2016, which enabled them to cover their remaining 2015 obligation.[41] In 2017, the CCM for 2016 did not occur since all obligated parties with deficits were able to meet their compliance obligation.

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38 California Air Resource Board. (2016, May 10). *LCFS Basics*. Retrieved February 08, 2018, from https://www.arb.ca.gov/fuels/lcfs/background/basics.htm

39 Idem.

40 Wade, S. (2016). *California Low Carbon Fuel Standard Cost Containment Provisions.* California Air Resources Board.

41 Wade, 2016

References

Aldy, J., Hafstead, M., Metcalf, G., Murray, B., Pizer, W., Reichert, C., & Williams, R. (2017). *Resolving the Inherent Uncertainty of Carbon Taxes.* Harvard Environmental Law Review.

AETS. (2013, February). Assessing the impact of biofuels production on developing countries from the point of view of Policy Coherence for Development. *The European Union's Framework Contract Commission 2011*. European Union. Retrieved from: https://ec.europa.eu/europeaid/sites/devco/files/study-impact-assesment-biofuels-production-on-development-pcd-201302_en_2.pdf

Babcock, B., & Pouliot, S. (2014). *Feasibility and Cost of Increasing US Ethanol Consumption Beyond E10.* Ames: Center for Agricultural and Rural Development, Iowa State University.

Barbose, G. (2017). *U.S. Renewables Portfolio Standards 2017 Annual Status Report.* Lawrence Berkeley National Laboratory.

Burtraw, D., & Palmer, K. (2014, November 12). *Resources For the Future: Alternative Compliance Payments under the Clean Power Plan*. Retrieved 2 22, 2018, from http://www.rff.org/blog/2014/alternative-compliance-payments-under-clean-power-plan#top

Burtraw, D., Palmer, K., & Kahn, D. (2009). *A Symmetric Safety Valve.* Washington: Resources For the Future. Retrieved from http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-09-06.pdf

California Air Resource Board. (2016, May 10). *LCFS Basics*. Retrieved February 08, 2018, from https://www.arb.ca.gov/fuels/lcfs/background/basics.htm

Christensen, A., & Siddiqui, S. (2015). Fuel Price Impacts and Compliance Costs Associated With The Renewable Fuel Standard (RFS). *Energy Policy*, 614-624.

Goulder, L., & Hafstead, M. (2013). *Tax Reform and Environmental Policy.* Washington: Resources For the Future.

Haitao, Y., & Nicholas, P. (2009). Do state renewable portfolio standards promote in-state renewable. *Energy Policy*, 1140-1149.

Heeter, J., Barbose, G., Bird, L., Weaver, S., Flores-Espino, F., Kuskova-Burns, K., & Wise, R. (2014). *A Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards.* National Renewable Energy Laboratory.

Jacoby, H. and D. Ellerman (2004). The Safety Valve and Climate Policy. *Energy Policy*, 32(4)

Kollenberg, S. and L. Taschimi (2016). Emissions Trading Systems with Cap Adjustments. *Journal of Environmental Economics and Management,* 80.

Liu, C., & Greene, D. (2013). *Modeling the Demand for E85 in the United States.* Oak Ridge National Laboratory.

Metcalf, G. (2017). *Implementing a Carbon Tax.* Washington: Resources For the Future.

Murray, B., Pizer, W., & Reichert, C. (2017). *Increasing Emissions Certainty Under a Carbon Tax.* Harvard Environmental Law Review.

New Jersey's Clean Energy Program. (n.d.). *SREC Pricing Archive*. Retrieved February 22, 2018, from http://www.njcleanenergy.com/renewable-energy/project-activity-reports/srec-pricing/srec-pricing/archive

Newell, R., W. Pizer and J. Zhang (2003). *Managing Permit Prices to Stabilize Prices*. RFF Discussion Paper RFF DP-0-34

Philibert, C. (2006). *Certainty versus Ambition: Economic Efficiency in Mitigating Climate Change.* Paris: International Energy Agency Working Paper Series. Report Number LTO/2006/03.

Pierpont, B. (2012). *Limiting the Cost of Renewables: Lessons for California.* San Francisco: Climate Policy Initiative. Retrieved from https://climatepolicyinitiative.org/wp-content/uploads/2012/06/Limiting-the-Cost-of-Renewables-Lessons-for-California.pdf

Pierpont, B. (2012, December). *Renewable portfolio standards – the high cost of insuring against high costs*. Retrieved February 07, 2018, from Climate Policy Initiative: https://climatepolicyinitiative.org/2012/12/17/renewable-portfolio-standards-the-high-cost-of-insuring-against-high-costs/

Potomac Economics. (2017). *Annual Report On The Market For RGGI CO2 Allowances: 2016.* Potomac Economics. Retrieved from https://www.rggi.org/sites/default/files/Uploads/Market-Monitor/Annual-Reports/MM_2016_Annual_Report.pdf

Shrimali, G., Jenner, S., Groba, F., Chan, G., & Indvik, J. (2012, October 25). Have State Renewable Portfolio Standards Really Worked? Synthesizing past policy assessments to build an integrated econometric analysis of. *USAEE Working Paper No. 12-099; DIW Berlin Discussion Paper No. 1258*.

Stockmayer, G., Finch, V., Komor, P., & Mignogna, R. (2012). Limiting the costs of renewable portfolio standards: A review and critique of current methods. *Energy Policy*, 155-163.

The Regional Greenhouse Gas Initiative. (2017). *The Investment of RGGI Proceeds in 2015.* RGGI, Inc.

The Regional Greenhouse Gas Initiative. (2018). *Program Overview and Design: Elements of RGGI*. Retrieved 02 21, 2018, from https://www.rggi.org/program-overview-and-design/elements

The World Bank. (2017, December 01). *Carbon Pricing Dashboard*. Retrieved February 09, 2018, from http://carbonpricingdashboard.worldbank.org/map_data

USDA announces grants to expand E15, E85 infrastructure (2015, September 10). Retrieved from Ethanol Producer Magazine: http://ethanolproducer.com/articles/12612/usda-announces-grants-to-expand-e15-e85-infrastructure

U.S. Department of Energy. (2010). *Public Benefit Funds: Increasing Renewable Energy & Industrial Energy Efficiency Opportunities.* U.S. Department of Energy.

U.S. Energy Information Administration. (2015). *Renewable & Alternative Fuels: Alternative Fuel Vehicle Data*. Retrieved 02 22, 2018, from https://www.eia.gov/renewable/afv/users.php?fs=a&ufueltype=E85

U.S. Energy Information Administration. (2018). *Monthly Energy Review February 2018: Biodiesel and Other Renewable Fuels Overview.* Retrieved from https://www.eia.gov/totalenergy/data/monthly/pdf/sec10_8.pdf

Weitzman (1974). Prices versus Quantities. *Review of Economic Studies,* 41(4).

Wade, S. (2016). *California Low Carbon Fuel Standard Cost Containment Provisions.* California Air Resources Board.