<u>Exhibit List</u>

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit Number	Title of Exhibit
1	Stillwater Associates LLC, *Analysis of Requests for RFS Severe-Harm Waivers for 2019 and 2020* (Feb. 18, 2021)
2	Stillwater Associates LLC, *The RFS Reset: A Look at Corn Land Use and Conventional Ethanol Production* (Aug. 30, 2019)
3	Ramboll, *The RFS and Ethanol Production: Lack of Proven Impacts to Land and Water* (Aug. 18, 2019)
4	Melissa J. Scully et al., *Carbon Intensity of Corn Ethanol in the United States: State of the Science*, ENV'T RSCH. LETTERS (forthcoming 2021)
5	Air Improvement Resource, *EPA Proposed Renewable Fuel Standards for 2018: Estimated Increase in National GHG Emissions if EPA Reduces the Conventional Fuel Volume* (Aug. 31, 2017)
6	Air Improvement Resource, *Emissions Reductions from Current Natural Gas Corn Ethanol Plants* (July 27, 2015)
7	Alberto Salvo et al., *Reduced Ultrafine Particle Levels in São Paulo's Atmosphere during Shifts from Gasoline to Ethanol Use*, 8 NATURE COMMS. 77 (2017)
8	John M.E. Storey et al., *Ethanol Blend Effects On Direct Injection Spark-Ignition Gasoline Vehicle Particulate Matter Emissions*, SAE Technical Paper 2010-01-2129 (2010)
9	M. Matti Maricq et al., *The Impact of Ethanol Fuel Blends on PM Emissions from a Light-Duty GDI Vehicle*, 46 AEROSOL SCI. & TECH. 576 (2012)
10	Marc Chupka et al., *Blending In: The Role of Renewable Fuel in Achieving Energy Policy Goals - 2018 Updated Edition* (Aug. 17, 2018)
11	*Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2019 and Biomass-Based Diesel Volume for 2020* (Aug. 17, 2018), EPA-HQ-OAR-2018-0167
12	*Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019* (Aug. 31, 2017), EPA-HQ-OAR-2017-0091
13	*Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017* (July 27, 2015), EPA-HQ-OAR-2015-0111
14	Edgeworth Economics, *The Impact of an RFS Waiver on the Ethanol Industry and Broader Economy in 2016* (July 27, 2015)

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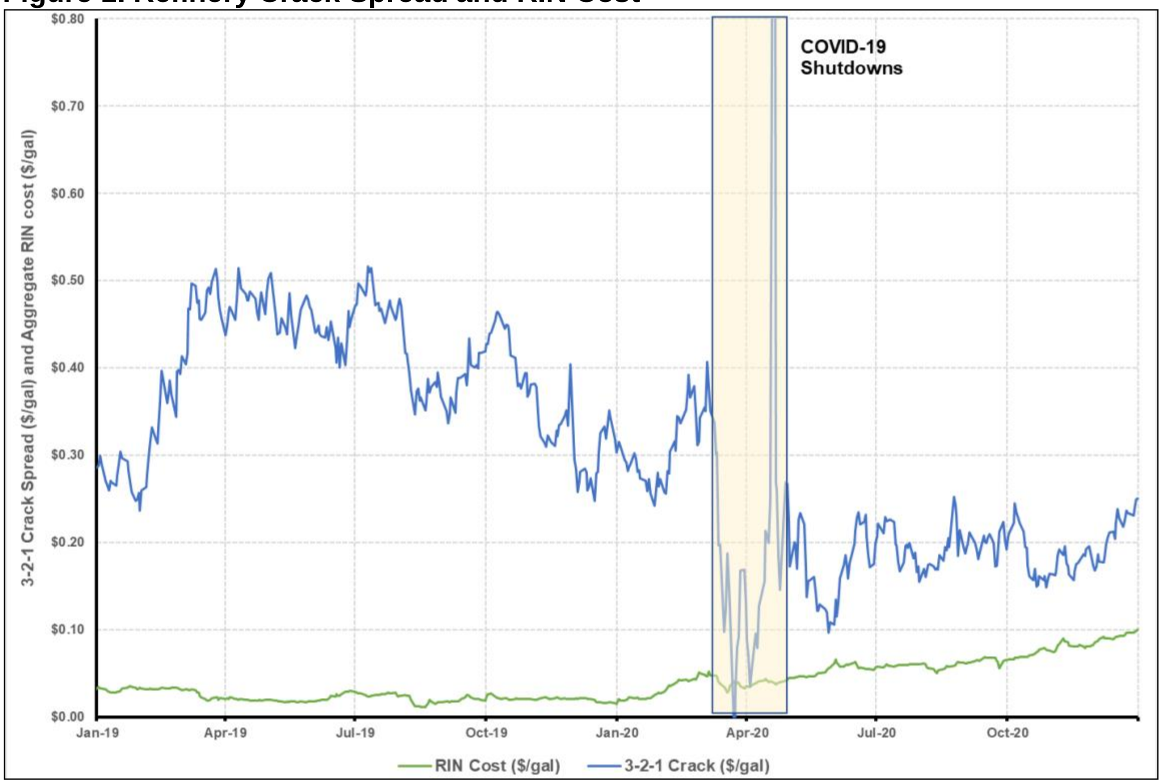
Exhibit 1

Stillwater Analysis of Requests for RFS Severe-Harm Waivers for 2019 and 2020

1. **Refineries do not pay RIN costs; instead, they are generally included in the spot market price the refinery receives for fuels. As such, consumers ultimately pay for the RFS program. Over the 2019-2020 time period, however, consumers saved an average of 2.85 cents per gallon due to the RFS. Therefore, the RFS caused no economic harm to consumers or to refineries.**

   In 2015, on behalf of EPA, Dallas Burkholder completed a thorough analysis of the RFS RIN system. Burkholder's analysis "suggest(s) that obligated parties are generally recovering their RIN costs in the price of the petroleum fuels they produce."[1] Following this report, James Stock et al. found there was almost complete passthrough of RIN prices from the refinery to the retail marketplace with the exception of E85.[2] More recently, in 2019, Burkhardt found "RIN costs are fully passed-through to gasoline and diesel rack prices."[3] As such, there is no basis for EPA to grant severe-harm RFS waivers due to RIN prices.

Figure 1. Refinery Crack Spread and RIN Cost



Sources: *OPIS, Stillwater analysis*

[1] Burkholder, Dallas. 2015. A preliminary assessment of RIN market dynamics, RIN prices, and their effects. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2015-0111-0062

[2] Stock, James H., et al. The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard. June 2015. https://scholar.harvard.edu/files/stock/files/pass-through_of_rin_prices_1.pdf

[3] Burkhardt, Jesse. The impact of the Renewable Fuel Standard on US oil refineries. April 2019. https://doi.org/10.1016/j.enpol.2019.03.058

Figure 1, above, displays a comparison of refinery gross margins (represented by the 3-2-1 crack spread for years 2019 and 2020[4]) to the aggregate cost per gallon of gasoline and diesel of meeting the refiner's obligation for all four RIN categories. In 2019, refinery gross margins were strong, and the cost of RINs were stable and small compared to the gross margin. In 2020, refinery gross margins did come down with the onset of COVID-related shutdowns, but slowly recovered over the course of the year; RIN costs increased over the course of the year, but more slowly than the recovery in refining margins. This indicates that refiners passed along the increase in RIN costs which they incurred over the time period.

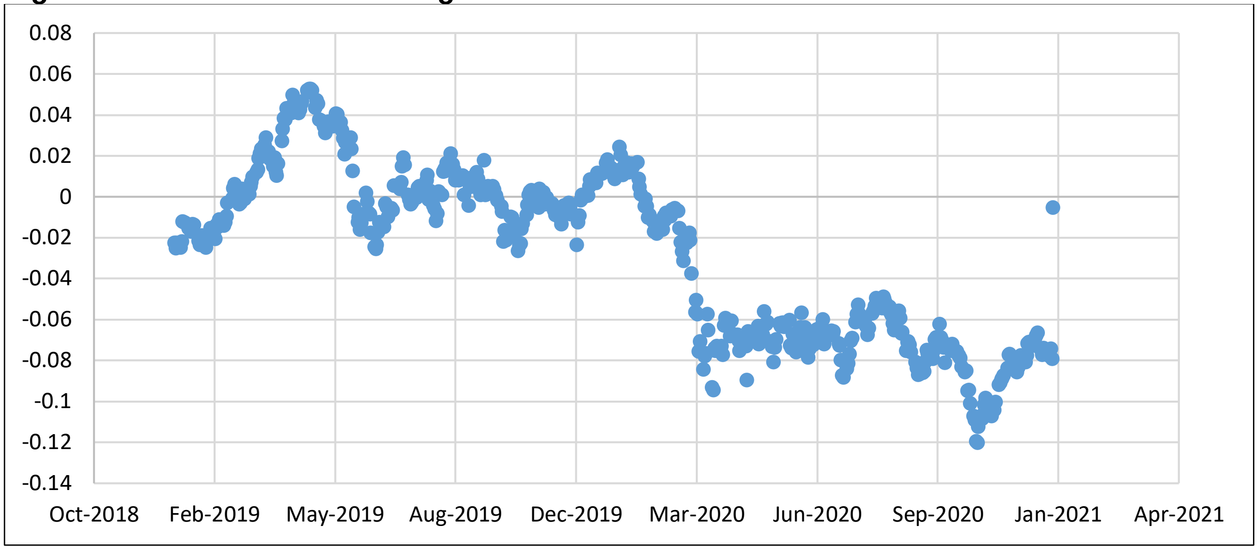
Since, as described above, refineries pass their RIN costs along to the downstream market and eventually to the consumer, the real question in terms of economic harm is whether RFS compliance causes economic harm to the consumer. In order to determine whether the ethanol-blending requirement of the RFS caused economic harm to consumers of E10 gasoline, we look at the price differential between a gallon of E10 blended in order to comply with the RFS compared to a theoretical gallon of ethanol-free gasoline (E0) which may have been sold absent an RFS-style program. As shown in Figure 2 below, for 2019 and most of 2020 regular gasoline was priced close to the price of ethanol, adjusted for the price of the associated D6 RIN[5]. The price of ethanol needs to be adjusted by subtracting the D6 RIN value because until it is blended this ethanol also has a D6 RIN attached (virtually) to it. For 2019 through January 2021, the gasoline-to-ethanol spread (less the D6 RIN) ranged from a high of almost 6 cpg to a low of -12 cpg. The average over these two years was -2.85 cpg, indicating that, on average over the 2019-2020 time period, the consumer saved 2.85 cpg with the RFS in place as compared to a world in which there was no RFS. Thus, rather than causing economic harm, the RFS program saved the consumer money on average over this time period.

In summary, for the period in question, the RFS caused no economic harm to either refineries or consumers.

[4] The 3-2-1 Crack Spread, calculated as the price of two gallons of gasoline plus one gallon of diesel minus the price of one gallon of crude oil all divided by 3, is a widely used metric of refinery gross margins as it approximates the typical U.S. refinery product mix and feedstock cost on a per gallon of output basis.

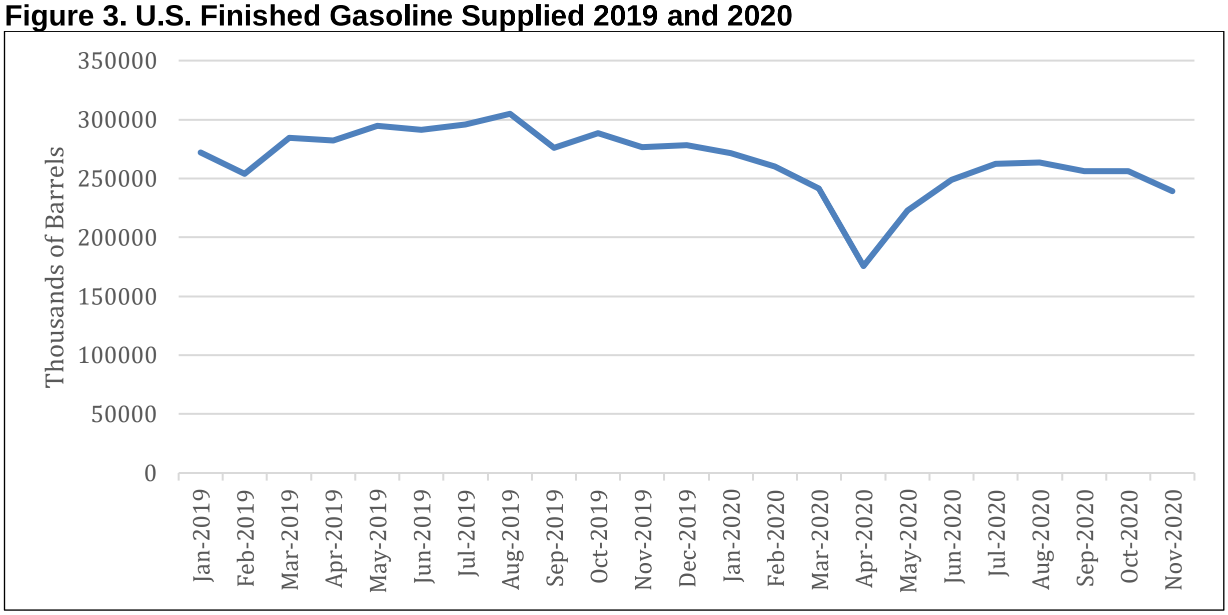
[5] Ethanol is commonly traded with the RIN "attached." Accordingly, the quoted price of ethanol includes both the physical gallon and the RIN. The party blending that ethanol with gasoline is entitled to separate that RIN and either sell it or use it to meet their RFS obligations. Thus, the effective price of ethanol is the quoted price less the value of the attached RIN.

Figure 2. 10% of the Cost of Regular Gasoline Less Ethanol Net of D6 RIN Value[6]



2. **Retroactively waiving the RFS requirements for 2019 and 2020 makes little sense.** No action taken in 2021 can change what already occurred in 2019 or 2020. First, the COVID-19 pandemic, whose effects on gasoline production hit the U.S. beginning in April 2020, as seen in Figure 3 below, occurred after 2019 compliance was completed in March 2020. The decline seen in Figure 3 in gasoline supplied from December 2019 through February 2020 is normal seasonal variability. It was not until mid-March 2020 that non-seasonal demand destruction began to occur. As such, the pandemic could not have impacted 2019 operations or profitability.

Figure 3. U.S. Finished Gasoline Supplied 2019 and 2020



Source: *[EIA's U.S. Product Supplied of Finished Motor Gasoline]*

[6] This formula was developed as follows: Subtracting the RIN-adjusted price of ethanol from the price of regular gasoline yields the ethanol cost advantage over gasoline. Since there is 10% ethanol in regular gasoline, multiplying ethanol cost advantage over gasoline by 10% yields the ethanol cost advantage of a gallon of blended gasoline.

Second, even apart from the pandemic, there is no basis for granting a severe-harm waiver for a year in which compliance was already achieved without causing severe harm.

Waiving past requirements simply results in a potential windfall for refineries in 2021. For EPA to provide the refineries with individually targeted waivers of the kind the small refineries propose would result in additional profits which would upset the level refinery playing field that EPA should be supporting. In 2019, refineries made their decisions on how much gasoline and diesel fuel to produce based on the spot market prices and RIN prices at the time of production. By the end of March 2020, all of 2019's gasoline and diesel production and supply decisions had been made, and all refinery RFS compliance activity was finalized. Financial results had been reported to the public and stockholders. Our strong view is that EPA cannot grant individually targeted waivers consistent with the statute.

Each refiner, blender, or importer is required to comply with the RFS by securing sufficient RINs to cover their obligation, which is a percentage of the fuel that party produced, blended, or imported. Waiving any RFS 2019 requirement in 2021 cannot change the production, blending, or import of gasoline, diesel fuel, and renewable fuels that has already occurred. Refiners, renewable fuel producers, marketers, and retailers have already made and acted upon their production and supply decisions for 2019. The financial results of these decisions have already been accounted for, and the stock market has already adjusted the stock value for these refiners and renewable fuel producers to reflect those financial results. Waiving the RFS requirements for 2019 in 2021 based on a claim that compliance achieved long ago would cause severe economic harm is thus not only dubious but would not undo the supposed economic harm. Giving back to the refineries the RINs that they used for 2019 cannot change any of the circumstances that occurred in 2019.

Since refineries have already closed their financial accounts for 2019 and have already acquired the vast majority of RINs needed for 2020 compliance (unless the refineries chose not to acquire RINs ratably), there is very little time left for the 2020 activities of refineries to impact state or national economies. Any benefit that EPA grants these refineries as part of granting any of these RFS waiver requests results in a windfall profit for 2021.

3. **RFS compliance requirements declined along with pandemic-related demand destruction.**
   In formulating the annual volume requirements for each of the four nested renewable fuel categories, EPA considers the statutory volume requirements and potential application of their Cellulosic and General waiver authorities in concert with projected annual demand for gasoline and diesel fuel as determined by the Department of Energy (DOE). This assessment of market volume is important at the stage of the regulatory process, during which EPA considers feasibility of the proposed standards, as the large majority of ethanol of all types (Conventional, Advanced and Cellulosic) is expected to be consumed as E10. The resultant annual rulemaking then sets both annual volumes for each of the four nested renewable fuel categories and percentage requirements. The annual volume requirements assume that actual gasoline and diesel consumption in the U.S. will equal that projected by DOE at the time of the rulemaking. The conversion of these four annual volume requirements to four percentage standards is designed to accomplish two critical objectives: first, to adjust the requirements dynamically to reflect variation of actual U.S. gasoline and diesel demand from DOE's forecast,[7] and, secondly, to enable the proration of the total national volume requirements to specific requirements for each obligated party (whose production and market share will vary year-to-year independent of the national market volumes).

[7] In other words, if the U.S. consumes more gasoline and diesel in a given year than the DOE forecast, the mandated volumes automatically increase and, if the U.S. consumes less gasoline and diesel in a given year than the DOE forecast, the mandated volumes are automatically decreased.

Thus, while the RFS has annual volumetric requirements for each of the four nested renewable fuel categories, which are defined in the statute and sometimes modified through waivers that EPA exercises in its annual rulemaking, those volumetric requirements are not the requirements that bind obligated parties. Rather, the binding obligations are the percentage standards for each of the renewable fuel categories, which are finalized each year in the rulemaking process described above. Each obligated party's actual annual compliance requirement for each of the four renewable fuel categories in a given year is determined by multiplying each of the four percentage standards by the sum of that party's *actual* gasoline and diesel production for the U.S. market during the compliance year. As a result, an obligated party's obligations are automatically scaled to their *actual* production during the compliance year. Thus, with the drop in 2020 product sales, every refiner's 2020 RFS obligations automatically dropped proportionally to their actual decrease in gasoline and diesel production for the U.S. market. Accordingly, every refiner, importer, and blender supplying covered fuels to the U.S. market in 2020 has already had their annual RFS obligation scaled down in proportion to their reduced volume of gasoline and diesel production. Thus, the petitioners' request to reduce the requirements "by an amount commensurate with the current projected shortfall in national gasoline and diesel consumption"[8] was already implemented by virtue of the fact that an obligated party's obligations are already calculated as a percentage of their actual production. No further relief from their RFS obligations is warranted.

4. **A majority of the RFS requirements are met with ethanol, which positively impacts refinery profitability.**

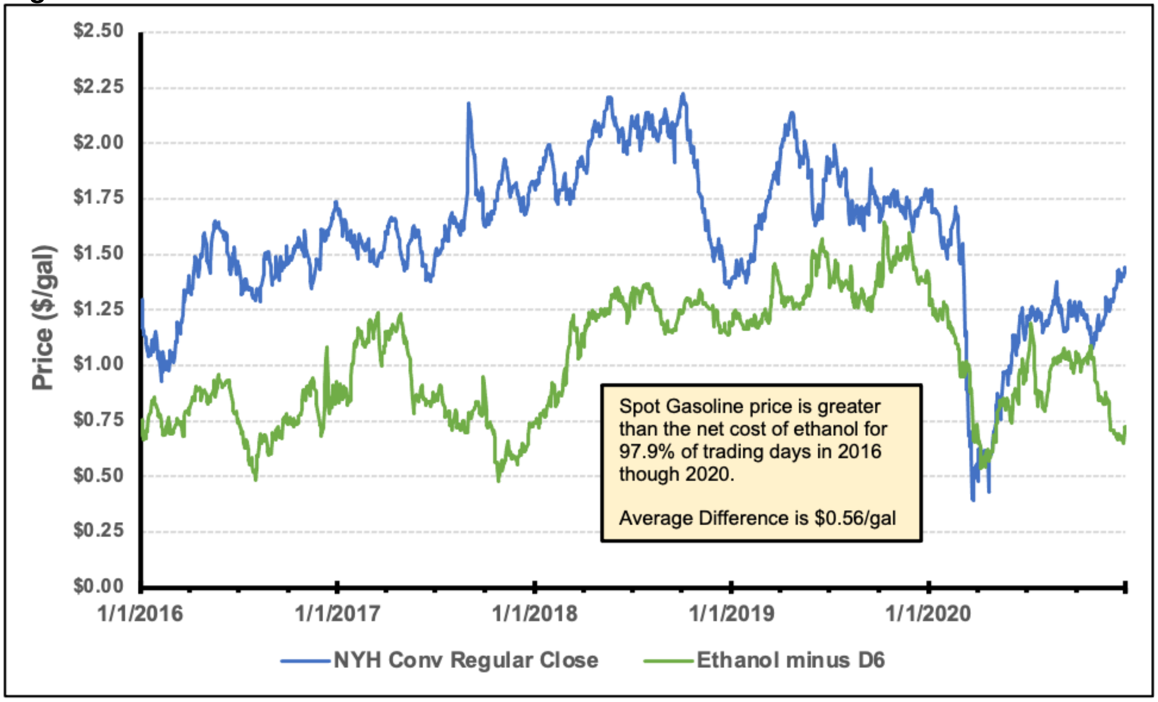
Refiners who comply with the RFS by purchasing RINs in the spot market are able to pass along that cost as established in item 1 above. Refiners who comply with the RFS by blending biofuels such as ethanol are generally able to do so at a profit. As the spot market price of ethanol includes an attached D6 RIN, the net cost of ethanol to a gasoline-ethanol blender is actually the spot price minus the current value of a D6 RIN. This cost can be compared to the spot price of gasoline for a given market. In general, this comparison will show that the net cost of ethanol is consistently below that of gasoline on a per gallon basis. Accordingly, blending ethanol reduces the cost of production of finished gasoline, even without accounting for its octane value, and thus increases refiner profitability. This occurs because the refiner is generally able to acquire ethanol at a price below that of gasoline and blend it with an 84 octane blendstock (BOB, blendstock for oxygenate blending), which costs less to produce than 87 octane gasoline, and sell the resultant blend at the price of 87 octane gasoline. So while the cost of the RIN gets passed through to the wholesale spot market, the refiner only has to produce 90% of the gasoline volume (for E10) with cheaper blendstocks.

Figure 4 below compares the spot market price for New York Harbor conventional gasoline to the net cost of New York Harbor spot ethanol over the five years from 2016 through 2020. During this time frame, the spot price of gasoline exceeded the net cost of ethanol on nearly 98% of trading days (the exception is for a brief period at the onset of COVID-19 shutdowns in 2020 when gasoline prices fell more quickly than ethanol prices), and the average difference was 56 cents per gallon.

Item 12 below describes how refiners are similarly able to profitably blend biodiesel into diesel in order to comply with that portion of their RFS obligation.

[8] EPA Notice of Receipt of Petitions for Waiver, 76 Fed. Reg. at 5183

Figure 4. New York Harbor Gasoline and Ethanol Prices



Source: *OPIS, Stillwater analysis*

5. **A retroactive RFS waiver for 2019 and 2020, as requested by the petitioners, would not have any impact on land use for corn used to produce ethanol and soybeans used to produce biodiesel. Thus, the proposed retroactive waivers do not address any concerns over claimed adverse impacts resulting from RFS-driven land use.**

   The corn used to produce ethanol in most of 2019 was planted in the Spring of 2018 and harvested in the Fall of 2018. The corn used to produce ethanol in most of 2020 was, similarly, planted in the Spring of 2019 and harvested in the Fall of 2019. All of this activity occurred prior to the onset of COVID-19. Additionally, planting decisions for 2020 were largely set during the winter of 2019-20 as individual farmers placed seed orders based on their pre-COVID assessment of the optimal use of their land given their expectations for market conditions in the Fall of 2020. Accordingly, a retroactive waiver cannot affect land use for 2019 and 2020 because that land use has already occurred.

   In any event, land use for the RFS has actually declined. Analysis of U.S. crop acreage data, as published annually by the U.S. Department of Agriculture[9] does not support NWF's assertion that RFS has increased agricultural land use in the U.S. As shown in Table 1 below, total planted acreage in the U.S. has actually declined since the beginning of the RFS. Corn acreage did initially increase to support ethanol production for the RFS but peaked in 2012 as RFS demand began to level off and steady increases in per acre yields have reduced acres planted for corn in the past eight years. Table 1 shows that the RFS has not caused an increase in U.S. crop acreage but instead caused a shift in crop acreage from wheat, hay, and other crops to corn and soybeans. Thus, NWF's assertion of increased agricultural land use due to RFS requirements in 2019 and 2020 cannot be substantiated as U.S. agricultural land use in 2019 and 2020 continued the long-term decline which began before the implementation of the RFS.

   COVID-19 reduced corn use for ethanol production as ethanol demand for gasoline blending has decreased in proportion to reduced gasoline consumption, and U.S. corn ethanol plants reduced operating rates as a result. As such, if the pandemic affects land use, it will be to reduce direct and indirect land use for RFS compliance in 2021 and probably in 2022 as well because of the decline in

[9] https://usda.library.cornell.edu/concern/publications/j098zb09z

the use of transportation fuel. While final figures for 2020 are not yet available, U.S. ethanol production in the first eleven months of 2020 was 12.7 billion gallons significantly reduced from the 14.4 billion gallons produced during the same months of 2019[10]. This 12% reduction in U.S. ethanol production was due to reduced demand associated with lower gasoline consumption resulting from COVID-19.[11] USDA estimates corn demand supply and demand, including that used for ethanol production, based on Marketing Years (which run from September 1st through August 31st). In their most recent estimate,[12] USDA forecasts corn demand for ethanol during the 2019/20 Marketing Year as 4,852 million bushels, down almost 10% from 5,378 million bushels used during the 2018/19 Marketing Year. USDA will make their first projection of corn acreage to be planted in 2021 in a report to be issued in March 2021.

Even in the complete absence of an RFS, ethanol would continue to be widely used in the U.S. gasoline pool due to its favorable economics and high octane. The growth in production capacity and nationwide installation of ethanol distribution and blending infrastructure which occurred with the RFS means that ethanol blending would be expected to continue at levels near current use even if waivers for future years were granted. In spite of this, land use associated with ethanol production would be expected to decline. The impacts of the pandemic on gasoline demand are expected will take at least two years to recover from. While this demand recovery is taking place, corn yields and ethanol plant efficiencies will continue to improve, which will cause direct and indirect land use factors to decrease.

Table 1. U.S. Annual Crop Acreage since 2000

Crop	Pre-RFS 2000-2007	Since RFS 2008-2020	Maximum Acreage
Corn Acres	81.0 million	90.7 million	97.1 million in 2012
Soy Acres	72.8 million	80.6 million	90.1 million in 2017
Wheat Acres	59.9 million	53.0 million	63.5 million in 2001
Hay Acres	62.2 million	55.9 million	64.5 million in 2002
All Other Crop Acres	47.0 million	38.6 million	51.9 million in 2000
Total Planted Acres	***323 million***	***319 million***	***328 million in 2000***

Sources: *USDA, Stillwater analysis*

Soybean acreage has also increased since the start of the RFS but, as illustrated in Figure 5 below, domestic demand for soybeans for all uses, including soybean oil for biodiesel, has been generally constant since 2000 while exports of soybeans, soybean oil, and soy meal have grown steadily to supply demands not related to the RFS.[13]

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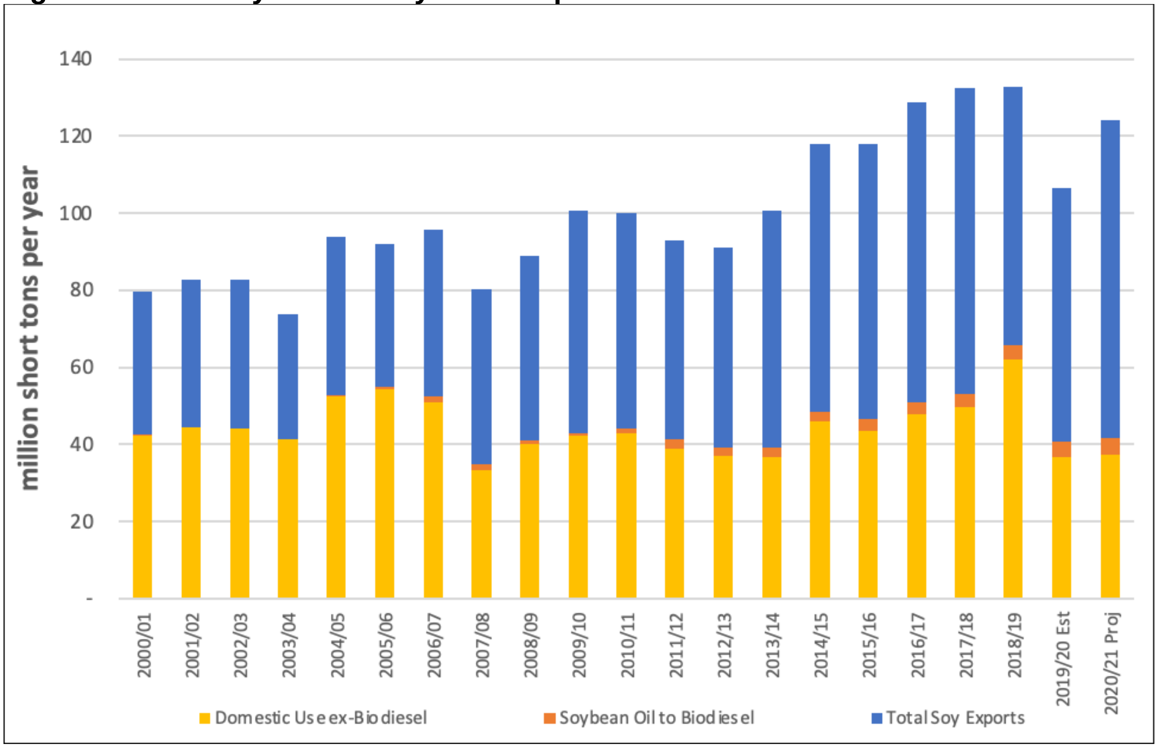
[10] Data from U.S. EIA: https://www.eia.gov/dnav/pet/pet_pnp_oxy_dc_nus_mbbl_m.htm

[11] In addition to supplying U.S. gasoline markets, U.S. corn ethanol plants export a significant portion of their production. Additionally, as demand in domestic gasoline markets declined, a number of U.S. ethanol plants produced ethanol to supply the large increase in hand sanitizer demand due to Covid.

[12] World Agricultural Supply/Demand Estimate (WASDE) for February 2021 available at https://usda.library.cornell.edu/concern/publications/3t945q76s?locale=en&page=34

[13] https://usda.library.cornell.edu/concern/publications/3t945q76s?locale=en

Figure 5. Summary of U.S. Soybean Disposition



Sources: *USDA WASDE, Stillwater Analysis*

EPA is required, under Section 211(v) of the Clean Air Act to report whether the RFS has caused any adverse impacts on air quality as a result of changes in vehicle and engine emissions attributable to the RFS. This section also requires EPA to promulgate fuel regulations, as needed, to mitigate any such air quality impacts to the greatest extent achievable. EPA released a Final Determination in fulfillment of this requirement in January 2021.[14] This analysis found that, due to the 2017 implementation of the Tier 3 Motor Vehicle Emissions and Fuels Standards,[15] no additional mitigations were required.

EPA is also required to periodically report to Congress on the overall impact of biofuels usage on the environment. In fulfillment of this requirement, EPA issued their Second Triennial Report to Congress on Biofuels and the Environment on June 29, 2018.[16] In this report, EPA considered how the RFS impacts farmers' decisions on crop planting and the consequent environmental impacts and concluded:

> *Farmers' decisions regarding land use and management are influenced in part by market prices (e.g., future price of corn), which are in turn affected by myriad antecedent factors, such as weather and policies (Roberts et al. 2013; Hellwinckel et al. (2016); Carter et al. 2017). The dominant biofuel feedstocks in the U.S. currently are corn and soybeans; thus, the environmental effects of biofuels at this time are due to some portion of the land use and management of growing corn and soybeans. However, these feedstocks are also produced for other purposes, such as animal feed, many food and industrial products, and export. Soy, for example, is primarily grown for the meal (about 80% of the bean). The oil (20%), which gets used for food as well as biodiesel, is a by-product whose supply depends on soy meal demand.*

[14] https://www.epa.gov/sites/production/files/2021-01/documents/420r21002.pdf

[15] https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-motor-vehicles-tier-3

[16] U.S. Environmental Protection Agency. Biofuels and the Environment: The Second Triennial Report to Congress. June 29, 2018. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=IO&dirEntryId=341491

> *Therefore, only a percentage of the environmental consequences of growing corn and soybeans can be attributed to biofuel feedstock production.*[17]

Review of U.S. planting and production data for corn, soybeans, ethanol and biodiesel since this report was issued shows that there has been no change to these long-term economic and technical factors since EPA issued the Second Triennial Report.

6. **Historical physical realities cannot be changed by a retroactive waiver.**
The production, blending, marketing, and consumption of renewable fuels in 2019 and 2020 due to the RFS cannot be undone. As a result, the retroactive waivers requested for the 2019 and 2020 RFS would have no impact on agricultural land use as the feedstock crops have already been planted and harvested as a result of decisions made by individual farmers before the onset of COVID-19. Even if that were not the case, analysis of USDA data for years 2000 through 2020 clearly show that the RFS has not been a driver for increased U.S. planted crop acreage; total acreage has been declining since before 2000, acres for corn peaked in 2012 and acres for soybeans, which are driven predominantly by export markets, peaked in 2017. Finally, the extensive U.S. build-out of ethanol production capacity, distribution and blending since before the RFS means that extensive blending of ethanol would be expected to continue even in the absence of future RFS mandates. Accordingly, no environmental benefit could be attributed to any waiver granted.

7. **EPA's RFS waiver authority exists to address severe economic harm to a state, region, or the U.S. as a whole, but that threshold has not been met for these waiver petitions.**
EPA's RFS waiver authority is not intended to address all economic costs to refinery owners. The severe harm intended to be addressed by the waiver is for the state, region or the U.S. as a whole, not a refinery. Even in states with high concentrations of refineries (TX, LA), those refineries represent only a small share of the economy, and any relief granted would not materially improve the economy of those states. In April 2020, governors from the states of Louisiana, Oklahoma, Texas, Utah, and Wyoming submitted letters to EPA concerning RFS waivers.

8. **The 2020 COVID-19 pandemic had no effect on 2019 events.**
The governors' letters are mistaken in citing support for the requests for RFS economic waivers for 2019 using as justification a claim of financial strain due to the Covid-19 pandemic which did not start until the following year. In fact, 2019 was a good year economically for the U.S., the states of Louisiana, Oklahoma, Texas, Utah and Wyoming and the refining industry. No data was presented in this letter to demonstrate "that implementation of the RFS volume requirements would severely harm the economy or environment of a State, region, or the United States, or that there is an inadequate domestic supply"[18] in 2019.

   For 2020, the governors' letters assume that since the pandemic and all its negative impacts occur in the same year that the RFS petitions address there must be some correlation between the two. This letter does not, however, provide data to support this connection.

   The governors' letters request that these petitions be approved but do not demonstrate that approval of these petitions would, in fact, help to alleviate any of the severe harm that results from the pandemic. In fact, since 2020 is over and done, there are no steps that EPA can take to alleviate any of the claimed severe harm.

[17] U.S. Environmental Protection Agency. Biofuels and the Environment: The Second Triennial Report to Congress. June 29, 2018. pg. 54. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=IO&dirEntryId=341491

[18] U.S. Environmental Protection Agency Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards; https://www.govinfo.gov/content/pkg/FR-2021-01-19/pdf/2021-01017.pdf, page 5183

9. **Retroactive waivers choose winners and losers, rewarding those who did not comply.** In considering the requested retroactive waivers for 2019 and 2020 RFS requirements, EPA needs to not only consider the statutory requirements for granting the requested waivers, but also weigh the value of the requested relief to the allegedly harmed parties against the impacts on other stakeholders, including all those who complied with the regulations in good faith or otherwise made business decisions on the assumption that the regulations would be enforced.

    a. **Parties who acquired 2020 RINs under the assumption that EPA would enforce the RFS regulations will be financially harmed by a waiver.**
    While any RINs already retired by obligated parties for compliance with the 2019 and 2020 obligations may be returned, any 2018 or 2019 RINs returned will be worthless and the volume of non-retired 2020 RINs will likely be in excess of the 20% cap on how many carryover RINs can be used for 2021 compliance, rendering them much less valuable than compliant parties spent to acquire them initially. Thus, parties who have complied with the regulations by acquiring RINs as they produced fuel for the market will be penalized compared to parties who have chosen to wait until the deadline to acquire RINs.

    b. **Financial harm, if any, to refiners and obligated parties (and their stakeholders) would not be alleviated through issuance of a waiver.**
    Any 2018 or 2019 RINs retired for compliance to meet the 2019 or 2020 obligations would be worthless if unretired to implement the requested waivers. Any 2020 RINs retired for compliance would still be valid for compliance with 2021 obligations (subject to the 20% maximum limit on the use of prior-year RINs for compliance with RIN obligations) but a substantial return of such 2020 RINs would greatly increase the supply of RINs for 2021 obligations and, thus, reduce their value to well below what the obligated parties spent to acquire them. Accordingly, the economic harm, if any, incurred by obligated parties and their stakeholders due to enforcement of the 2019 RFS would not be alleviated at all by the grant of the requested waivers, and for the 2020 RFS would only be partially alleviated by the grant of the requested waivers.

    c. **The precedent of granting waivers retroactively would undermine incentives for parties to make future business decisions reliant on the value of RINs.**
    Producers of the renewable fuels required for the achievement of the RFS annual requirements make long-term investment decisions informed, in part, by the anticipated value of the RINs generated by their production. A retroactive waiver will undermine the confidence of firms considering investment in future renewable fuel capacity, undermining the aims of the program. A significant portion of the compliance activities required by the RFS are performed by non-obligated parties who voluntarily blend and market renewable fuels with the expectation that they will be able to sell the RINs they have acquired to obligated parties who are otherwise unable to comply with the RFS through their proprietary operations. A retroactive waiver will make those non-obligated parties wary of blending renewable fuels in the future, making it less likely that the RFS targets in subsequent years will be met.

In summary: Any retroactive waiver will harm parties who have acted in good faith to deliver market compliance with the RFS, damage the long-term credibility of the program, deliver little if any benefit to the parties whose economic stress purportedly justifies the waivers, and not undo any aspect of the production, blending, marketing and end use of renewable fuels which has already occurred in 2019 and 2020.

10. **Retroactive waivers may negatively affect consumers and retail prices in the future.** Fuel prices in 2019 and 2020 were determined by supply and demand and cannot be changed retroactively via waiver. While granting these waivers will not have any impact on past events, EPA's decision to continue to grant these waivers might have a detrimental impact on 2021 and future RFS compliance and fuel prices. Retroactive waivers effectively change the enforcement of the RFS rules after the fact, creating market uncertainty which might increase both RIN prices and consumer prices going forward.

    Under current RFS rules, obligated parties are expected to meet their annual RIN obligation by acquiring RINs to match their production. By March of the following year, all obligated parties must retire those RINs to demonstrate compliance. If EPA issues a requested retroactive waiver, EPA will return the RINs used for compliance. Some of the returned RINs may no longer have any value. In such a situation, an obligated party might be tempted to never purchase RINs in the first place counting on being granted another waiver. Since the market is unaware of whether obligated parties are purchasing RINs or not, there would then exist a great deal of uncertainty around the number of RINs the total market needs for compliance. This uncertainty would create volatility and unnecessarily high RIN prices.

    Since consumers ultimately pay the cost of RINs, any increase in RIN prices due to market confusion, failure of the RIN market to function properly, or increases in RIN price volatility will impact retail prices of gasoline and diesel fuel and increase the price the consumer has to pay.

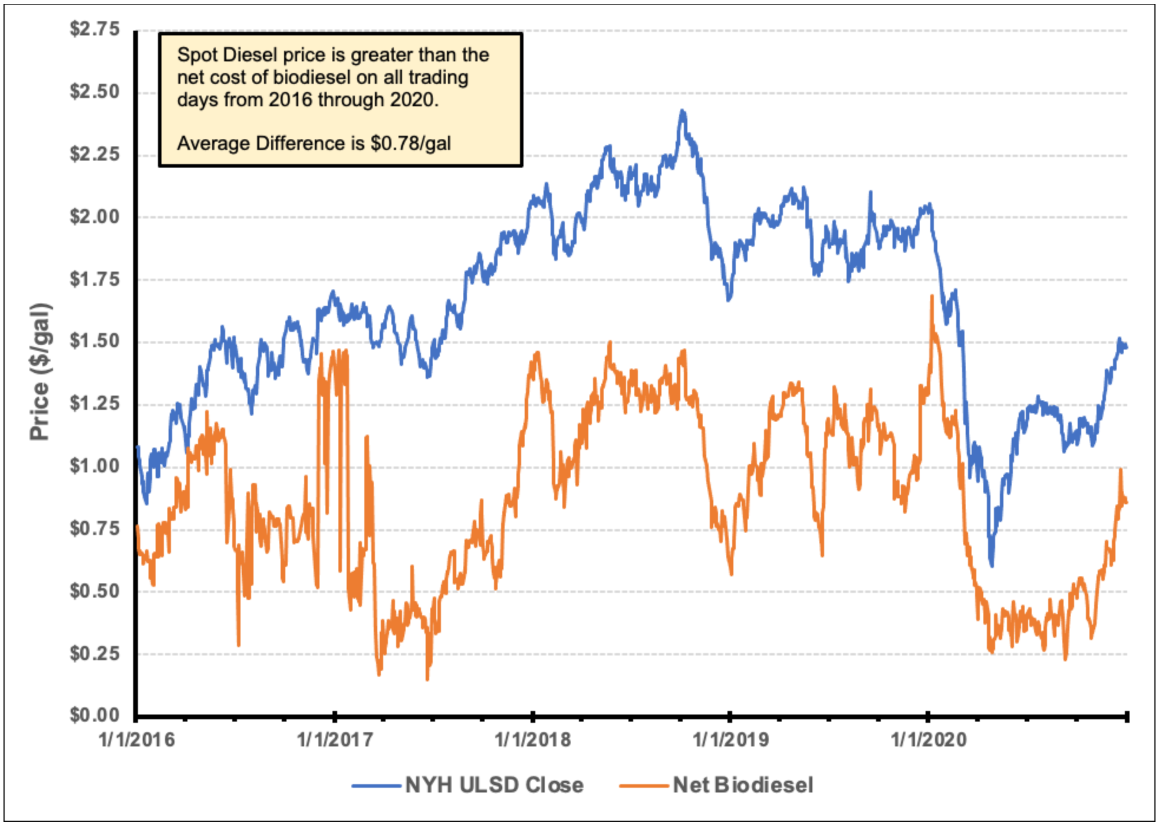
11. **Waivers would not provide real-time relief or support to refiners.** The refiners were obligated to acquire the RINs needed for compliance in 2019 and 2020 under EPA's well-established RFS regulations. If EPA were to grant the requested waivers in 2021 or later, the RINs that EPA gives back would have mostly expired due to their two-year life. The RINs used for 2019 RFS compliance would have entirely expired because they were 2018 and 2019 vintage RINs. At the end of 2020, all of these RINs had expired, and are now worthless. The RINs used for 2020 RFS compliance were both 2019 and 2020 vintage RINs. Of these, the 2019 RINs, which could have constituted up to 20% of the obligations, expired at the beginning of 2021.

    If, as part of its resolution of these petitions, EPA elects to return the RINs used for 2019 and 2020 RFS compliance, it will be returning mostly expired RINs. These will provide little to no relief in 2021 and certainly will not help alleviate any of the claimed small refinery disadvantage in 2019 and 2020.

12. **The value of the contained RINs and the biodiesel Blenders Tax Credit (BTC) reduces the net cost of biodiesel to a level where it can be blended profitably. As a result, consumers do not bear any increased cost for diesel fuel attributable to the RFS.** With the consideration of the value of the attached RINs and the $1.00 Blenders Tax Credit (BTC), most biodiesel blended during 2019 and 2020 was priced at or below the production costs of diesel fuel. As such, the RFS, through the value of the RIN, creates an incentive for the blending of biodiesel into petroleum diesel, just as it does for ethanol blended with gasoline. As the spot market price of biodiesel includes 1.5 attached D4 RINs, the net cost of biodiesel to a diesel-biodiesel blender is actually the spot price minus the 1.5 times the current value of a D4 RIN minus the $1.00/gal BTC. This cost can be compared to the spot price of diesel for a given market. In general, this comparison will show that the net cost of biodiesel is consistently below that of petroleum diesel. Accordingly, blending biodiesel reduces the cost of production of blended diesel and thus increases refiner profitability; as a result,

consumer prices for diesel fuel were not increased as a result of the RFS. Figure 6 below compares the spot market price for New York Harbor ultralow sulfur diesel (ULSD) to the net cost of New York Harbor spot biodiesel over the five years from 2016 through 2020. During this time frame, the spot price of ULSD exceeded the net cost of biodiesel on every trading day and the average difference was 78 cents per gallon.

Figure 6. Spot Price for New York Harbor ULSD vs. Net Cost of New York Harbor Spot Biodiesel



Sources: *OPIS, Stillwater analysis*

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 2

The RFS Reset: A Look at Corn Land Use and Conventional Ethanol Production

Prepared for

Growth Energy

By

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Irvine, California, USA

August 30, 2019

Stillwater Associates

Disclaimer

Stillwater Associates LLC prepared this report for the sole benefit of Growth Energy. Growth Energy may submit this report to the U.S. Environmental Protection Agency in connection with any proposed rulemaking or other agency action.

Stillwater Associates LLC conducted the analysis and prepared this report using reasonable care and skill in applying methods of analysis consistent with normal industry practice. All results are based on information available at the time of preparation. Changes in factors upon which the report is based could affect the results. Forecasts are inherently uncertain because of events that cannot be foreseen, including the actions of governments, individuals, third parties, and competitors. Nothing contained in this report is intended as a recommendation in favor of or against any particular action or conclusion. Any particular action or conclusion based on this report shall be solely that of Growth Energy. NO IMPLIED WARRANTY OF MERCHANTABILITY SHALL APPLY. NOR SHALL ANY IMPLIED WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE.

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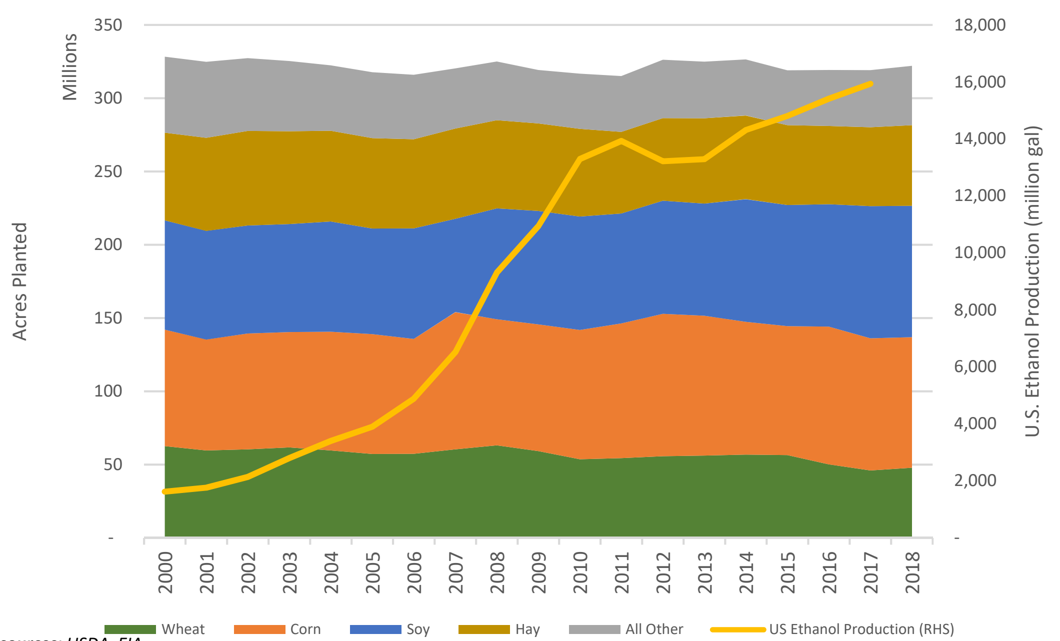
Executive Summary

This report examines U.S. agricultural land use and crop production. It also examines how much additional corn and conventional ethanol could be produced if the historic trends for corn production and ethanol processing continue through 2022. This report uses the term "ethanol" to refer to conventional ethanol. The analysis allows the food and other non-ethanol portions of the corn crop to continue to grow in a manner that would not increase concerns about the availability of corn for the world's food supply.

In many sources, including its Second Triennial Report to Congress, the U.S. Environmental Protection Agency (EPA) claims that biofuel growth driven by the renewable fuel standard (RFS) has resulted in increased U.S. agricultural land use. However, that is not the whole story. As can be seen in Figure ES-1, since about 2010 the crop acreage devoted to corn production has remained relatively constant while ethanol production has substantially increased. The land use increase determined by EPA appears to be dependent on the beginning and end points selected for the analysis. In addition, EPA's Second Triennial Report looks at total biofuel land use, which combines both corn and soy. There is general agreement that soy land use has increased during the period since the RFS was implemented, but that does not mean that corn land use has also increased. Finally, EPA was unable to identify the corn land use increase specifically caused by the production of conventional ethanol under the RFS. EPA points out these errors and its inability to prove its contention in various parts of the report which are not highlighted or mentioned in its key findings. In fact, the conclusions that EPA reaches in the report are not fully supported by EPA's own analysis or independent study of the data.

Figure ES-1. U.S. Crop Acreage and Ethanol Production

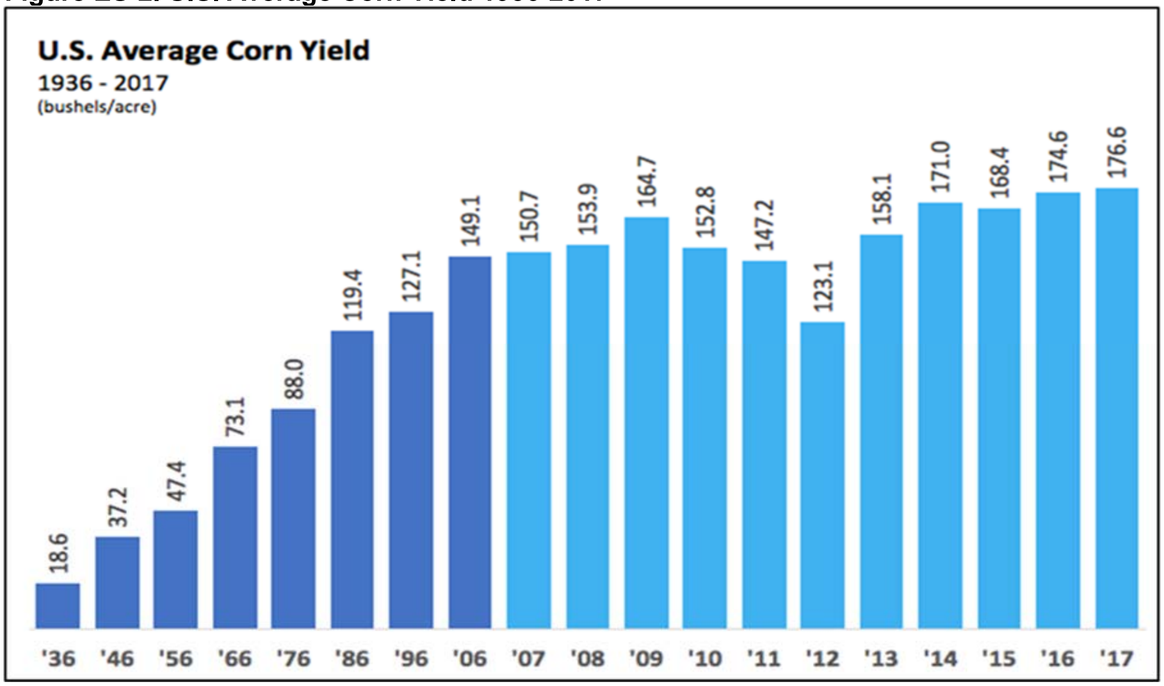


sources: *USDA, EIA*

In its Second Triennial Report, EPA fails to recognize that U.S. farmers choose the allocation of their crop acres to different crops based on a wide variety of market drivers including weather, world crop supply balances, U.S. and world inventories, and imports and exports worldwide. The RFS has a slight influence on some of these variables, but it is not the large driver that EPA seems to imply. Since the U.S. is currently exporting corn and soy beans plus ethanol and distiller's dried grains with solubles (DDGS) in amounts at or above pre-RFS levels, and imports of ethanol and biomass-based diesel (BBD) are currently minimal, there can be no indirect land use impacts from other countries for corn ethanol or BBD. Therefore, EPA's claim of increased indirect land use impacts from other countries is unsupported.

Stillwater examined historic trends for U.S. farm acres planted in corn and harvested plus the volume of corn produced. While there is variability in the data, over the past 12 years, corn production has increased at an average rate of 2.3 bushels per acre per year. That rate closely aligns with the rate of growth maintained over the previous seven decades, and there continue to be new technologies introduced enabling this rate of growth to continue. Figure ES-2 demonstrates this historic growth in corn yields per acre.

Figure ES-2. U.S. Average Corn Yield 1936-2017[1]



As shown in Figure ES-3, conventional ethanol production from corn has maintained a steady rate of increase over the last three to four decades (the period for which data are available). New developments in conventional ethanol production technology should allow conventional ethanol production efficiency to continue its historic rate of increase of 0.01 gallons of ethanol produced per bushel of corn per year into the future.

[1] National Corn Growers Association. U.S. Average Corn Yield 1937-2017. January 12, 2018. http://www.worldofcorn.com/#us-average-corn-yield

Figure ES-3. Conventional Ethanol Refinery Conversion Efficiency[2]

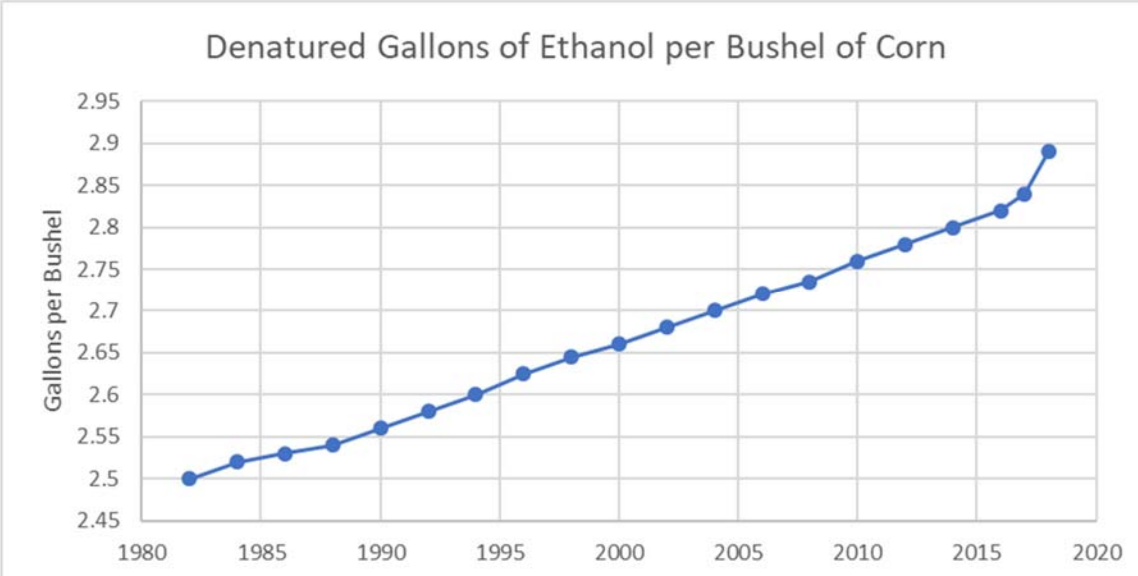


Table ES-1 shows that the 2.3 bushels of corn per acre per year increase corresponds to a growth in corn harvested from 14.4 billion bushels in 2018 to 16.1 billion bushels in 2022. If the food and other non-ethanol corn volume is allowed to grow at the rate of population growth projected by the U.S. Department of Agriculture (USDA) for the same period – 1% per year – about 0.3 of these additional 1.7 billion bushels of corn would be devoted to food and other non-ethanol corn uses. The remaining additional corn produced – about 1.2 billion bushels – can be directed to new ethanol production of around 4.0 billion gallons in 2022.

Table ES-1. Projected Conventional Ethanol Production 2018-2022*

	2016	2017	2018	2019	2020	2021	2022
Corn Acres Planted, million acres	94.2	89.9	89.1	94.0	94.0	94.0	94.0
Planted to Harvested Ratio	92%	92%	92%	92%	92%	92%	92%
Corn Acres Harvested, million acres	86.7	82.7	81.7	86.5	86.5	86.5	86.5
Corn Yield, bushels per acre	174.6	176.6	176.4	178.7	181.0	183.3	185.6
Corn harvested, billion bushels	15.1	14.6	14.4	15.5	15.7	15.9	16.1
Corn used for non-Ethanol Purposes	9.7	9.0	8.9	9.0	9.0	9.1	9.2
Corn Used for Ethanol Production, Billion Bushels	5.5	5.6	5.6	6.5	6.6	6.7	6.8
Ethanol Plant Efficiency, gallons per bushel	2.82	2.84	2.89	2.90	2.91	2.92	2.93
Ethanol Production, billion gallons	15.4	15.8	16.1	18.8	19.2	19.6	20.0
Ethanol Production above 2018, billion gallons				2.8	3.2	3.6	4.0

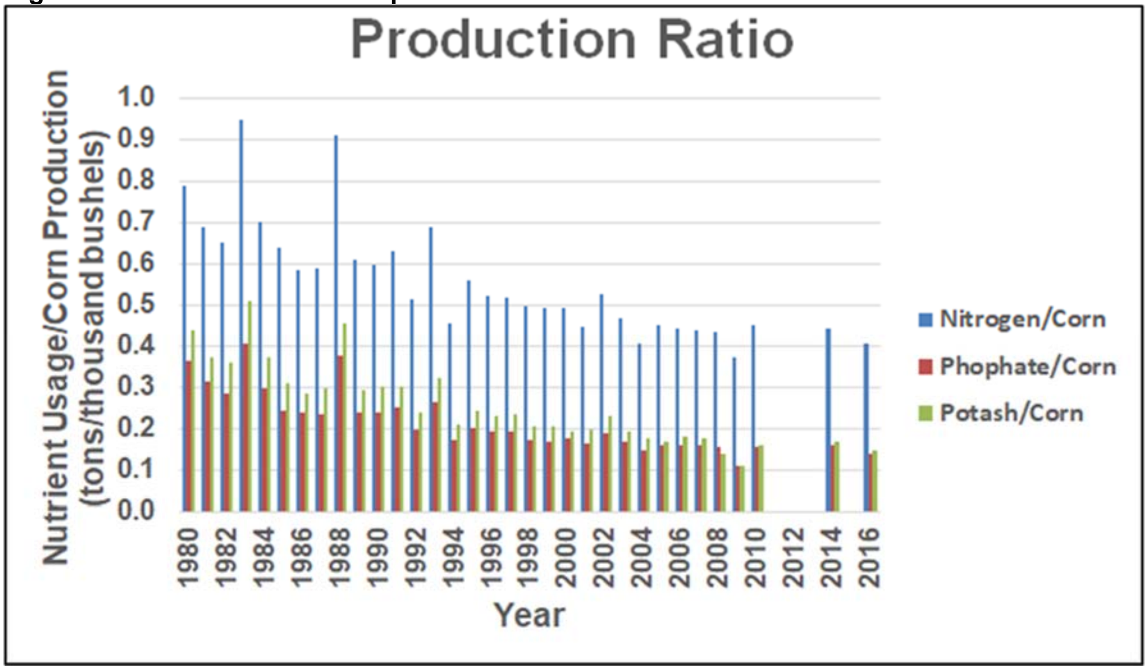
* The values for years 2016 and 2017 are actual values not projected values.

Since these additional gallons of ethanol could be produced with no new acreage required and with the volume of corn available for food and other non-ethanol purposes allowed to grow to match the population growth, any concerns about indirect land use and the sufficiency of corn available for world food resulting from such an increase in ethanol production should be negligible. This analysis also shows ethanol production could increase by about 0.4 bgy or 1.1 billion gallons (bg) every 3 years *without* increasing the number of corn acres planted and harvested.

This report also examines the nutrients required to produce 0.8 billion bushels of new corn and finds that the total nutrient requirements are relatively unchanged; while corn and ethanol production is increasing. In fact, on a per-bushel basis the nutrient requirements are dropping as depicted in Figure ES-4.

[2] United States Department of Agriculture. Economic Research Service. U.S. Bioenergy Statistics. https://www.ers.usda.gov/data-products/us-bioenergy-statistics/

Figure ES-4. Corn Nutrient Requirements Per Bushel



This report is made up of two sections. The first section deals with the use of U.S. agricultural land for corn and conventional ethanol production. In this section we seek to demonstrate that even though crop acreage increased for soy beans and perhaps very slightly for corn during the time period of the RFS, there were many other factors at play in addition to the RFS. Also, these additional acres came from land previously used for other crops and not from the creation of new farm land. This section is also devoted to issues discussed in EPA's Second Triennial Report. The second section of this report demonstrates that with continual improvements being made in growing corn and in conventional ethanol production, it is feasible to produce some limited additional volumes of corn and conventional ethanol without an associated increase in the crop acreage used by corn.

1 Review of U.S. Agricultural Land Use History Before and After the RFS

1.1 Overview

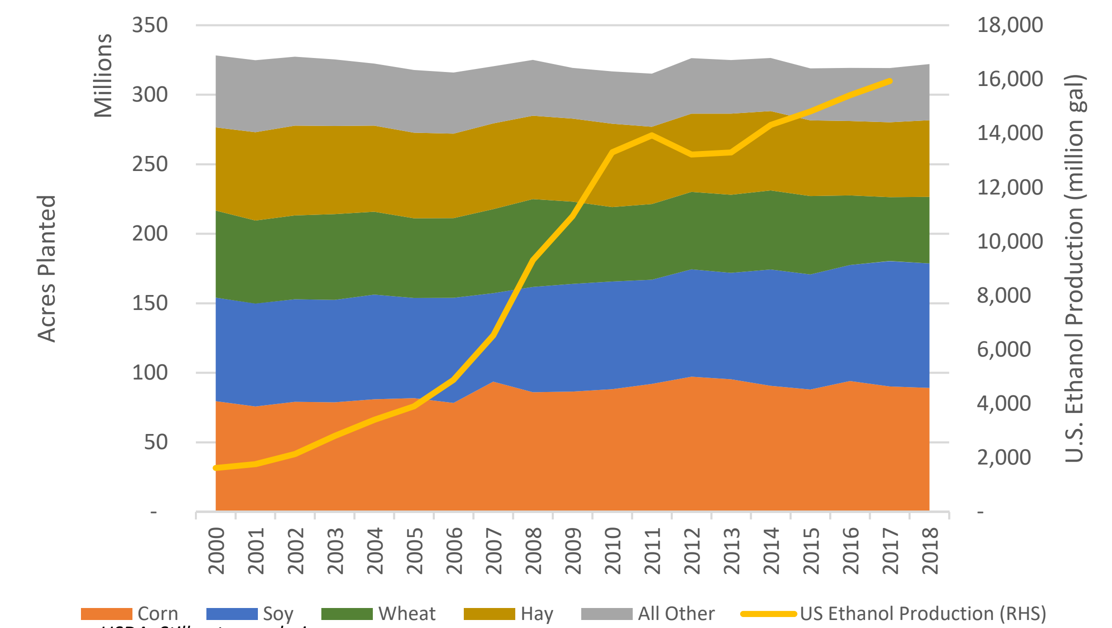
The use of land for agriculture in the U.S. and the disposition of the crops produced is monitored annually by the United States Department of Agriculture (USDA) through the National Agricultural Statistical Services (NASS). A detailed understanding of traditional trends in agricultural land and crop use is a prerequisite for assessing any impacts on land use which may or may not be attributable to the implementation of the RFS. To create the necessary foundation for assessing potential RFS impacts, this section begins by reviewing land use and crop use for U.S. agriculture over the years 2000 through 2018, with an emphasis on corn and soybean crops. This foundation provides context for reviewing the discussion on agricultural land and crop use contained in the U.S. Environmental Protection Agency's (EPA) Second Triennial Report to Congress (the "Triennial Report").[3]

1.2 Review of USDA Historical Land Use Data

As a first step in understanding the impact of the RFS on U.S. agriculture, it is important to review the overall landscape of how agricultural land use has changed over time. This section reviews and interprets USDA data on total U.S. crop acreage as well as a more detailed look into supply and demand for U.S. corn and soybeans acreage specifically. Analysis of these data is presented in order to provide insight into factors other than the RFS which may be influencing production and demand for corn and soybeans in the U.S.

Figure 1 illustrates annual planted acreage in the U.S. from 2000 through 2018 with a breakout of the four highest-acreage crops – corn, soybeans, wheat and hay.[4] These four crops comprise 85 to 90 percent of all planted acres. This chart is overlaid with annual U.S. ethanol production as found in USDA Quick Stats.[5]

Figure 1. U.S. Crop Acreage and Conventional Ethanol Production



sources: *USDA, Stillwater analysis*

[3] U.S. Environmental Protection Agency. Biofuels and the Environment: The Second Triennial Report to Congress. June 29, 2018. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=IO&dirEntryId=341491

[4] Data drawn from the annual Acreage report published by USDA National Agricultural Statistical Service (NASS) every June. https://usda.library.cornell.edu/concern/publications/j098zb09z?locale=en. All acreage data used, with the exception of the 2018/2019 market year, are the final estimates as reported in the Acreage report published in the June following harvest. For the 2018/2019 market year, the June 2018 estimates have been used.

[5] USDA Quick Stats. Accessed January 10, 2019 https://quickstats.nass.usda.gov

In interpreting the USDA acreage data, it is important to recognize the level of accuracy achieved through the statistical sampling methods employed. In their annual Crop Production Summary report published in January 2018,[6] USDA reports cite reliability of their final (post-harvest) crop estimates in terms of 95 percent confidence limits for the national crop totals, indicating ± 2.2 percent for corn and ± 2.0 percent for soybeans. This corresponds to uncertainties of about ± 2 million acres for corn and ± 2 million acres for soy. Assuming similar uncertainty in the national total crop acreage would imply 95 percent confidence limits of ± 6 million acres. In many cases, the year-to-year variation in reported crop acreage is within the 95 percent confidence limits of USDA's estimates, and thus cannot be distinguished from measurement uncertainty.

The data displayed in Figure 1 reveal a number of key points about trends in U.S. agriculture from prior to enactment of RFS to the current date.

First, total annual planted acres averaged nearly 322 million over this timeframe but experienced an overall decline from 328 million in 2000 to 320 million in 2018. There is year-to-year variation, represented by a standard deviation of over four million acres; thus, comparisons taken between individual years can be misleading; it is necessary, therefore, to look at multi-year averages in order to identify any potential long-term trends. Total annual acreage in the pre-RFS period (2000-2007) averaged 323 million acres, declining to an average of 321 million acres since the start of RFS (2008-2018). The highest acreage year in that time interval was 2000 (pre-RFS) with 328 million acres planted; the lowest acreage year in that time interval was 315 million acres in 2011 (post-RFS). Thus, overall trends clearly indicate that total crop acreage declined during the years of the RFS.

These USDA annual acreage data, however, are aggregate figures and therefore do not indicate whether the same acres are put into or taken out of agricultural use each year. As agricultural acres are regularly converted to other uses (e.g., housing, industrial and recreational uses), new lands need to be cultivated each year if total planted acres are to remain constant. That influence on land cultivation is independent of the RFS. Thus, it is not accurate to designate RFS as the primary cause for any conversion of previously non-agricultural lands to crop production. In fact, these data demonstrate that, as the aggregate acreage has declined despite the growing feedstock requirements of the RFS, U.S. farmers did not replace all of the acres converted away from agriculture with newly-cropped acres.

Second, EPA's Second Triennial Report to Congress[7] examines the issue of land conversion. Citing work from Lark, et al,[8] based on interpretation of apparent land use changes derived from satellite photographs, the EPA review notes a net increase in U.S. cropland of three million acres between 2008 and 2012 and adds that gross land conversion was nearly four times greater than net land conversion (i.e., implying that nearly 12 million acres were newly cultivated while nearly nine million acres were removed from cultivation). The USDA annual acreage data, based primarily on farmer surveys, in comparison, shows a much smaller increase in planted acres, from 325.0 million acres in 2008 to 326.3 million acres in 2012 but, as just explained, does not indicate how many acres may have been newly cultivated. Yet, the Lark study is flawed because it took single-year snapshots; this fails to capture the extent of year-to-year variability in planted acres. Looking at the individual years around 2008 as reported by USDA in their annual acreage report, USDA reports total planted acres of 316.0 million in 2007, 325.0 million in 2008 and 319.3 million acres in 2009. Examining USDA's annual reports for individual years around 2012, finds total crop acres reported as 315.1 million acres in 2011, 326.3 million acres in 2012, and 324.9 million acres in 2013. Thus, one-year changes in their selection of comparison years could have greatly changed

[6] USDA. Crop Production 2017 Summary. January 2018. https://downloads.usda.library.cornell.edu/usda-esmis/files/k3569432s/f4752k06n/th83m180b/CropProdSu-01-12-2018.pdf, See p127 for a discussion of Statistical Methodology

[7] U.S. Environmental Protection Agency. Biofuels and the Environment: The Second Triennial Report to Congress. June 29, 2018. pg. 34. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=IO&dirEntryId=341491

[8] Lark TJ, Salmon JM and Gibbs HK (2015). Cropland expansion outpaces agricultural and biofuel policies in the United States. Environmental Research Letters 10(4): 10.1088/1748- 9326/10/4/044003.

the conclusion – a decline of 0.9 million acres between 2007 and 2011, or an increase of 5.6 million acres between 2009 and 2013. This large year-to-year variability in acreage data means that long-term trends, such as any impact from RFS, can only be accurately discerned through analysis of multiple years, which the Lark study did not do.

Third, EPA's Second Triennial Report fails to mention that overall U.S. planted acres, as reported by USDA, have decreased since the start of the RFS program, even while corn and soybean acres have increased. This omission ignores the fact that increased corn and soybean acreage was predominantly realized through reduced plantings of other crops rather than through conversion of previously un-cropped land. Further, 2012 was the recent peak year for corn planting at 97 million acres and has since fallen to 90 million acres in 2017 and 89 million acres in 2018.[9] Soybean acres have continued to rise since 2012 but, as will be analyzed later in this report, this increase in soybean acres has been driven by rapidly growing exports and not RFS-driven demand for soybean oil. The Lark study also cites that the converted acres were planted 27% in corn, 25% in wheat, 20% in soybeans and 7% in alfalfa; this is lower in corn and soybean share than the overall U.S. crop distribution as reported by USDA – 30% corn, 24% soybeans, 17% wheat and 17% hay (roughly 30% of the total hay acres, corresponding to 5% of total acres are alfalfa)[10]. As the new acres claimed in the Lark study are not predominantly corn or soybeans, it is not reasonable to conclude that these new acres were put into production because of the RFS.

Fourth, in addition to the annual variation in total planted acres, the total acres planted for individual crops also varies significantly from year to year. After observing many years of USDA agricultural land use, Stillwater has found that these changes are observed in both pre- and post-RFS time periods and, thus, should not be attributed to the RFS but to changes in factors such as demand patterns, relative crop prices and global supply and demand.[11,12] For the pre-RFS years, corn acreage averaged 81 million acres with a standard deviation of over 5.4 million acres; in the RFS timeframe, the average increased to nearly 91 million acres with a standard deviation of 5.4 million acres. Soybean acres increased from 72 million acres with a standard deviation of 3.9 million acres pre-RFS to 81 million acres with a much larger 8.5-million-acre standard deviation in the RFS time frame.[13] As total planted acreage for all crops has not increased since RFS, these increases in corn and soybean plantings have been achieved through reduced plantings of other crops.

Fifth, on a national level, the diversity of U.S. agriculture has not materially changed under the RFS. During the pre-RFS years of 2000-2007, the four leading crops accounted for an average of over 85% of planted acres and increased slightly to 88% of planted acres since 2007. This concentration actually peaked at 88.6% in 2009 and has since fallen to 87.4% in 2018.[14]

For its part, USDA acreage estimates are based on a combination of surveys of farmers (current response rates to USDA surveys are about 60%), satellite imagery and comparison with data reported by farmers to the Farm Service Agency (required for participation in federal crop insurance programs). USDA collects data each year for its March report on planting intentions, its June report issued after most summer crops have been planted and its January report utilizing data acquired after the summer crops have been harvested. For this report, the post-harvest data are used for all

[9] U.S. Department of Agriculture. National Agricultural Statistical Service (NASS) Annual Acreage Reports. https://usda.library.cornell.edu/concern/publications/j098zb09z?locale=en

[10] Calculations derived from USDA annual Acreage reports for years 2000 through 2018. https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1000

[11] https://www.researchgate.net/profile/Daniel_De_La_Torre_Ugarte/publication/5146588_Bioenergy_Crop_Production_in_the_United_States_Potential_Quantities_Land_Use_Changes_and_Economic_Impacts_on_the_Agricultural_Sector/links/0c960524f4570b731e000000/Bioenergy-Crop-Production-in-the-United-States-Potential-Quantities-Land-Use-Changes-and-Economic-Impacts-on-the-Agricultural-Sector.pdf

[12] https://www.researchgate.net/profile/Milind_Kandlikar/publication/226200760_Scale_context_and_decision_making_in_agricultural_adaptation_to_climate_variability_and_change/links/0c9605376a89024091000000/Scale-context-and-decision-making-in-agricultural-adaptation-to-climate-variability-and-change.pdf

[13] U.S. Department of Agriculture. National Agricultural Statistical Service (NASS) Annual Acreage Reports. https://usda.library.cornell.edu/concern/publications/j098zb09z?locale=en.

[14] U.S. Department of Agriculture. National Agricultural Statistical Service (NASS) Annual Acreage Reports. https://usda.library.cornell.edu/concern/publications/j098zb09z?locale=en

years. Table 1 below summarizes the average planted areas for all U.S. crops and the four major individual crops for the pre-RFS (2000-2007) and RFS (2008-2018) periods. The standard deviations are provided as a measure of the year-to-year variability observed in each of the two time periods.

Table 1. Planted Acres Pre- and Post-RFS

	Averages		Standard Deviation	
	Pre RFS (2000-2007)	RFS (2008-2018)	Pre RFS (2000-2007)	RFS (2008-2018)
Total Planted Acres	**323 million**	**321 million**	**4.5 million**	**3.3 million**
Corn Acres Planted	81 million	91 million	5.4 million	5.4 million
Soy Acres Planted	73 million	81 million	3.9 million	8.5 million
Wheat Acres Planted	60 million	54 million	1.9 million	1.9 million
Hay Acres	62 million	57 million	1.5 million	1.1 million
Other Crop Acres	47 million	39 million	3.9 million	0.7 million
Top 4 Crops Share of Acres	85.4%	88.0%	1.1%	0.3%

While corn and soybean acreage have increased from the pre-RFS to the RFS timeframe (an average of ten million acres for corn and eight million acres for soybeans), it is necessary to examine how all uses of these crops have changed over this timeframe before attributing the reasons for these increases. Below, we review the uses of these two crops based on the World Agricultural Supply Demand Estimates (WASDE) report published by the USDA.[15]

1.3 The Evolution of Corn Supply and Demand

U.S. corn production has experienced a long trend of increasing production due to steadily increasing yields. The acreage planted each year is the collective result of individual land use allocation decisions made by the many thousands of farmers who plant corn each year. As corn is widely traded in global markets, it can be inferred that individual farmers will make their annual planting choices after assessing supply, demand and economics relative to other crop choices they have based on their experience with their land. Annual corn production averaged 10.6 billion bushels per year during the pre-RFS period (2000-2007). Average production since the start of the RFS in 2008 has been 13.3 billion bushels, an increase of about 2.7 billion bushels. Average yields during this timeframe increased from 143.8 bushels per acre pre-RFS to 160.6 bushels per acres since 2008. Accordingly, 1.2 billion of the 2.7 billion bushels per year increase can be attributed to improved yields with the remaining 1.5 billion bushels per year production attributable to increased acreage[16].

[15] U.S. Department of Agriculture. World Agricultural Supply and Demand Estimates. August 12, 2019. https://usda.library.cornell.edu/concern/publications/3t945q76s?locale=en

[16] The 10.6 billion bushel average production (2000-2007) was achieved through harvesting an average of 73.6 million acres with an average yield of 143.8 bushels per acre. Increasing the average yield to the 160.6 bushels per acre average (2008-2018) while holding harvested acres constant, would produce 11.8 billion bushels (160.6 X 73.6/1000), an increase of 1.2 billion bushels per year. Applying the 161.0 bushel per acre average yield (2008-2018) to the 83.0 million acres harvested, on average for 2008 through 2018, results in an average production of 13.3 billion bushels, an average 1.5 billion bushel per year increase due to increased acreage.

In addition to production of conventional ethanol and co-products, the other primary use categories tracked by USDA for corn in the U.S. are Feed and Residual; Food, Seed and Industrial; and Exports. Proper allocation of annual corn acreage to the various demand categories requires two adjustments be made to the raw data:

1. **Inventory Change –** While inventory changes average out over periods of years, inventory builds or draws of hundreds of millions of bushels can occur in a given year.[17] For example, the 2004/2005 market year saw an inventory build of 1,155 million bushels and the 2006/2007 market year saw an inventory draw of 663 million bushels[18].
2. **Distiller's Dried Grains with Solubles (DDGS) Production** – DDGS is the primary co-product from dry mill ethanol plants. Conventional ethanol production consumes only the starch contained in the corn, while the remainder of the corn kernel comprising all the protein, fiber, and oil is sold as a high-protein animal feed which can replace a significant portion of the corn used to feed cattle and other livestock. Accordingly, it is appropriate to subtract DDGS production from the amount of corn used as ethanol plant feed and report the DDGS as an addition to the domestic feed and export categories based on USDA data on DDGS supply and demand.

Some key observations based on the WASDE data on U.S. corn and DDGS use –

1. **Ethanol** – While ethanol production grew steadily prior to implementation of the RFS, growth accelerated, as expected, once the RFS took effect. Corn grain demand for ethanol production grew from 1.43 billion bushels per year during the pre-RFS period (2000-2007) to 5.00 billion bushels per year since 2008. Proper perspective, however, requires that this gross corn grain use be offset by the co-production of DDGS which is available as a high-quality animal feed in both domestic and export markets. With the increase in ethanol production, DDGS production grew from 8.7 million metric tons (343 million bushels[19]) per year pre-RFS to 35.5 million metric tons (1,396 million bushels) per year since 2008. This adjustment for DDGS results in a net corn demand for ethanol production of 1,083 million bushels per year pre-RFS, increasing to 3,587 million bushels per year since 2008.
2. **Exports** – U.S. exports of corn grain have remained nearly constant since the start of the RFS. Exports averaged 1,985 million bushels per year during the pre-RFS (2000-2007) period and 1,860 million bushels per year since 2008, well within the standard deviation of 251 million bushels per year (pre-RFS). Accordingly, other countries have not been required to increase their corn production due to increased U.S. domestic corn demand for ethanol production. Further, while corn grain exports have held constant, DDGS exports have increased with growing ethanol production, increasing from 1.4 million metric tons (54.6 million bushels) per year pre-RFS to 9.7 million metric tons (381.6 million bushels) per year since 2008.
3. **Food, Seed and Industrial (other than ethanol)** – Demand for food use is expected to grow with U.S. population. Demand for seed is expected to grow with planted acres. Demand for Industrial uses, including high fructose corn syrup, cationic starch and renewable chemicals (such as bio-propanediol, PDO) is expected to increase with population and GDP. Estimated demand for corn in this category increased from 1,409 million bushels per year pre-RFS to 1,783 million bushels per year since 2008.
4. **Feed** – Use of corn grain has decreased from an average of 5,836 million bushels per year pre-RFS to an average 5,047 million bushels per year since the inception of the RFS in 2008. However, this loss is offset by increasing use of DDGS. DDGS used as feed in

[17] USDA WASDE data are reported by market year. The market year begins on September 1st of the year indicated and runs through August 31st of the following year. As an example, the 2006 market year (often listed as 2006/2007) runs from September 1, 2006 through August 31, 2007. Thus, the bulk of the annual U.S. corn harvest is at the start of the market year and the end of the market year corresponds to nearly the low point of the annual inventory cycle.

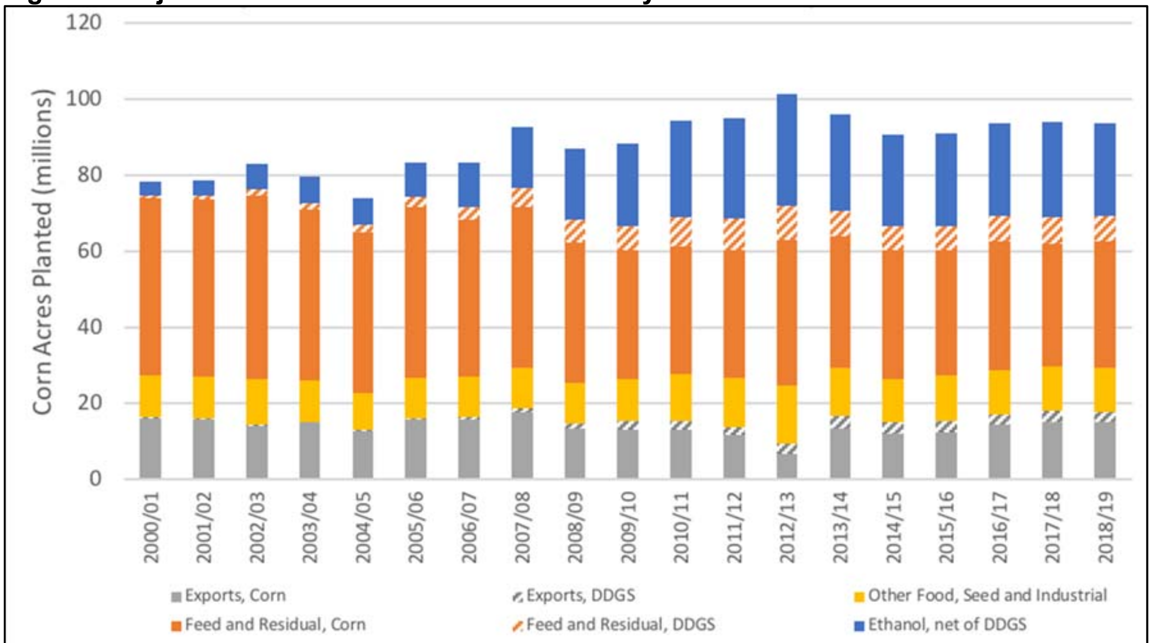
[18] Accordingly, allocated acres in this analysis need to be increased in years when there is an inventory draw and decreased in years when there is an inventory build. The size of the increase or decrease in allocated acres is the inventory change divided by that year's average yield.

[19] Data on DDGS production and use are taken from Table 08 of U.S. Bioenergy Statistics published monthly by USDA's Economic Research Service (ERS) and available at https://www.ers.usda.gov/data-products/us-bioenergy-statistics/. For comparison to corn production in bushels, DDGS production is converted to bushels at 56 pounds per bushel.

the U.S. market has increased from 7.5 million metric tons (294 million bushels) per year pre-RFS to 26.2 million metric tons (1,029 million bushels) per year since 2008.

Figure 2 illustrates the annual allocation of corn acres to these different uses by year. It illustrates that while U.S. corn acreage (adjusted for inventory changes and DDGS) has increased with the advent of the RFS, this effect maximized in the 2012/2013 market year and has since decreased and leveled off even as corn ethanol production continues to grow.

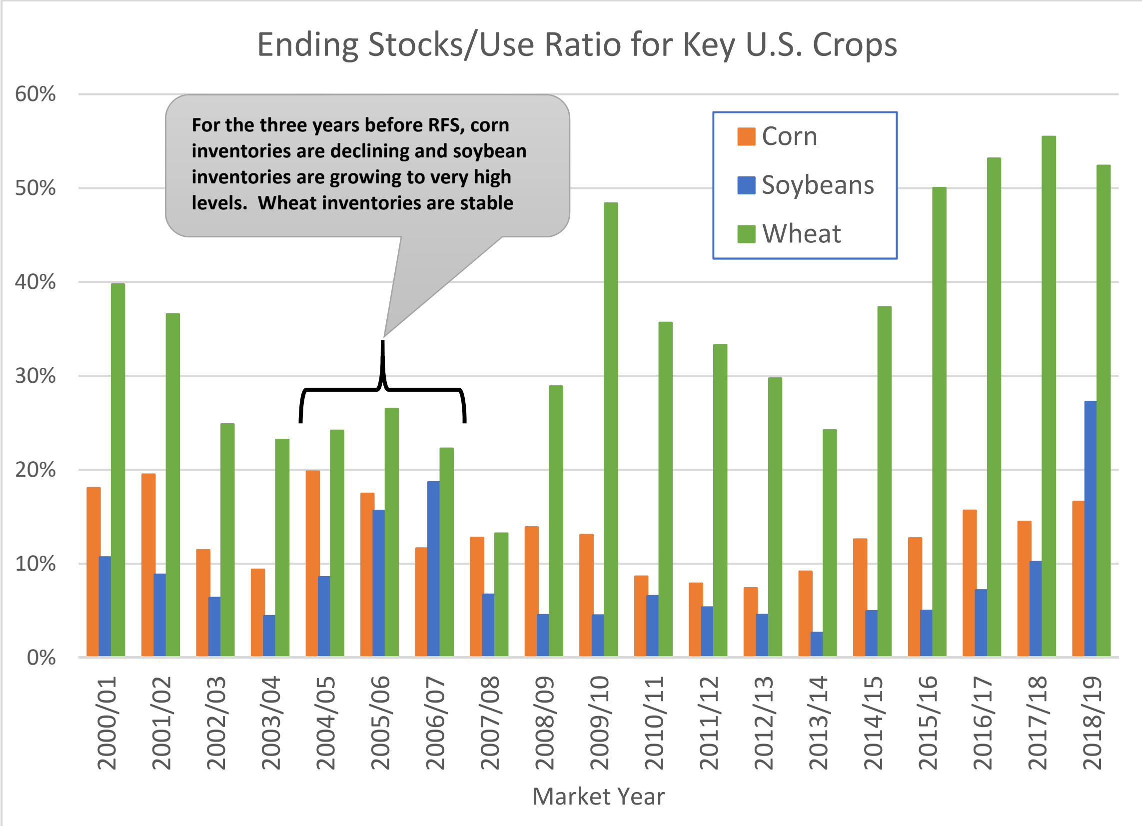
Figure 2. Adjusted Corn Acres Planted Allocated by End Use



***source**: USDA, Stillwater Analysis*

The increase in corn acres for 2007/2008 shown in Figure 2 is often attributed to increased corn demand due to the RFS. Corn acres planted were 15 million acres higher than the prior year and came largely from an 11-million-acre reduction in soybean acres (wheat acres increased by three million acres, total acres increased by 4.4 million). However, it is not possible to conclusively assign a single reason to this change, the collective result of individual planting decisions made by tens of thousands of farmers across all of the states where these crops are grown. A different explanation, based on market supply and demand factors independent of RFS can be seen in Figure 3, displaying the annual ending stocks-to-use ratio (the ending stock level for the market year divided by total use for the same market year). This chart shows that the ending stocks-to-use ratio for corn had declined from a relatively high 20 percent to a relatively low 12 percent in the three years prior to the RFS; since then, the ratio has oscillated between about 8 and 15 percent. The three years prior to the RFS also saw the corresponding ending stocks-to-use ratio for soybeans increased from a historically low nine percent to a historically high 19 percent during the same time period; since then the ratio has generally remained below 10 percent (2019 saw a record soy crop and the stocks-to-use ratio climed to 27%). In the U.S. Midwest, it is common practice for corn and soybeans to be grown in rotation – soybean crops replenish soil nitrogen levels, reducing the need for nitrogen fertilizer for corn crops grown the following year on the same acres. Accordingly, the large number of farmers who grow both crops can readily shift acres between the two in response to market conditions. (Wheat ending stocks-to-use ratios were relatively constant during this period, but have since risen markedly. Farmers have responded by steadily reducing wheat acres while increasing acres dedicated to corn and soybeans). Given those market trends, it was very logical for the many farmers who grow both corn and soybeans to shift their plantings to favor corn, enabling inventories for both commodities to move back towards their long-term averages.

Figure 3. Ending Stocks-to-Use Ratio for Key U.S. Crops



In summary, the U.S. crop acreage required to supply all demands for U.S. corn, including a steady level of exports, has been broadly constant since the 2007/2008 market year (prior to enactment of the RFS). This was achieved while U.S. ethanol production increased from 6.5 billion gallons in 2007 to 15.9 billion gallons in 2017.

1.4 The Evolution of Soybean Supply and Demand

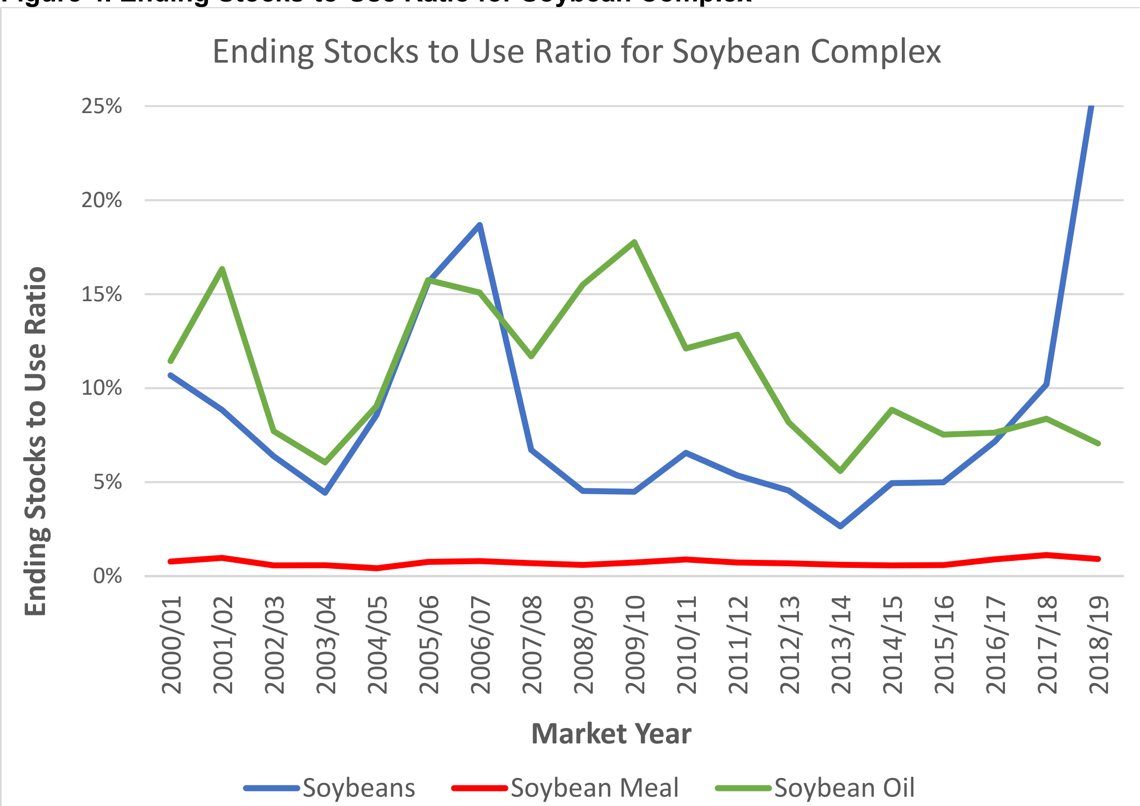
Comparing the pre-RFS period (2000-2007) to the RFS years (2008-2018), soybean planted acres have increased from 72.9 million to 80.7 million. Soybean yields also increased from an average of 39.5 bushels per acre harvested pre-RFS to 45.7 bushels per acre harvested since 2008. Combined, this has resulted in an increase in the U.S. soybean crop from 2.83 billion to 3.66 billion bushels per year. Of this 830 million-bushel-per-year increase, about 440 million bushels can be attributed to increased yield while 390 million bushels are attributable to the increased acreage[20].

The two key uses for soybeans as tracked by USDA are crushing (to produce soybean meal and soybean oil) and exports of whole beans. Comparing the pre-RFS period to the years starting with 2008, soybean crushing increased from 1.68 billion bushels to 1.82 billion bushels. The primary change in soybean demand, however, has been in exports, with average annual exports increasing from 1.03 billion bushels per year to 1.67 billion bushels per year. Increased exports actually account for 80 percent of the increase in U.S. soybean production. As U.S. exports of soybeans have increased substantially since the start of the RFS, soybean acres planted in the rest of the world have not needed to increase due to the RFS.

[20] The 2.83 billion bushel average for 2000-2007 comes from an average of 71.7 million acres harvested at an average yield of 39.5 bushels per acre. Increasing the yield to the 2008-2018 average of 45.6 bushels per acre, while holding harvested acres constant, would yield 3.27 billion bushels per year (71.7*45.6/1000), an increase of 440 million bushels. Increasing the harvested acres to the 2008-2018 average of 79.9 million, gives the post-RFS average of 3.66 billion bushels, a further increase of 390 million bushels per year.

The crushing process separates the protein-rich solids, which comprise about 80 percent of the whole soybean, from the soybean oil, which comprises about 20 percent of the whole soybean. The solids (soybean meal) are utilized primarily as a high-protein animal feed with most of the production consumed within the U.S. Exports of soybean meal have, however, also grown substantially from an average of 7.5 million short tons per year pre-RFS (2000-2007) to 11.4 million short tons per year on average since 2008. Corresponding domestic demand has declined slightly from an average 32.9 million short tons per year pre-RFS to an average of 32.0 million short tons per years since 2008. Some of this decline can be attributed to increasing competition from DDGS. Crushing plants produce soybean meal to meet market demand and the soybean oil produced in the process is then priced to sell in competition with other vegetable oils in the market. This management of soybean crushing rates can be seen in Figure 4 which compares ending stocks-to-use ratios for whole soybeans, soybean meal and soybean oil – while the ending stocks-to-use ratios for both soybean and soybean oil vary considerably from year to year, the ending stocks-to-use ratio for soybean meal is considerably lower with minimal year to year variability. While biodiesel is an important and growing use for soybean oil, soybeans are not grown to produce oil; the biodiesel market provides a valuable outlet for an otherwise surplus product.

Figure 4. Ending Stocks-to-Use Ratio for Soybean Complex



***Source**: USDA WASDE, Stillwater analysis*

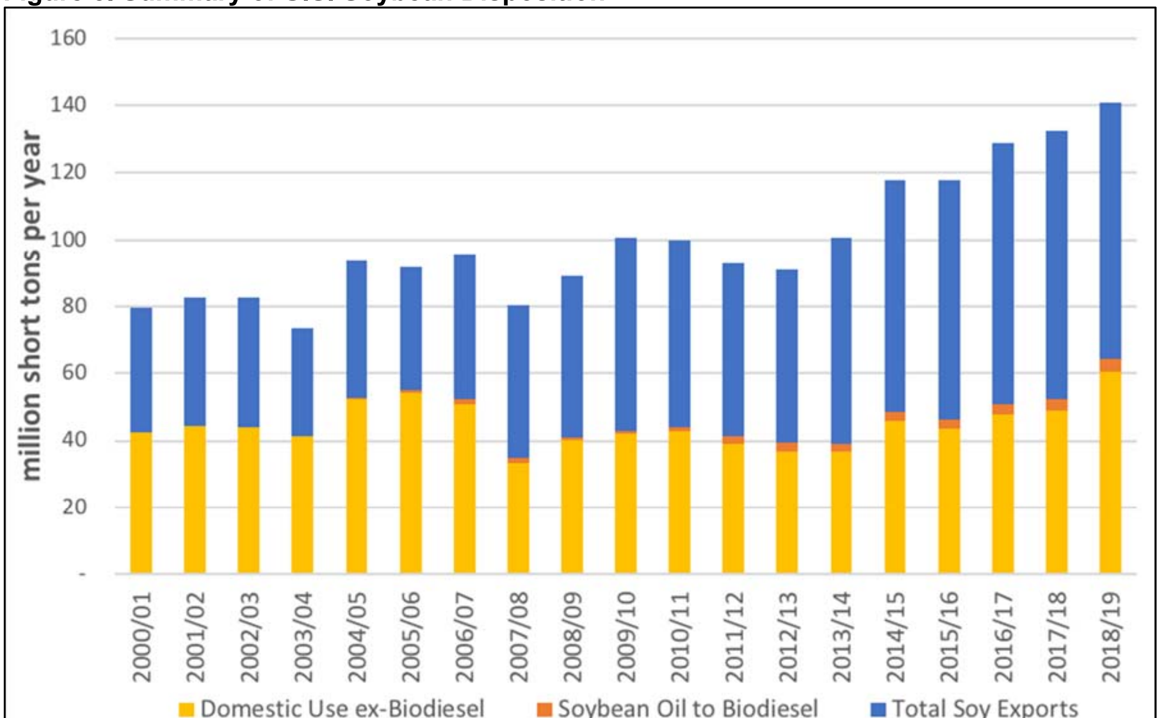
The primary market for soybean oil is food, feed, and industrial where it competes with a number of other vegetable oils (primarily corn oil, canola oil and sunflower oil). Use as a biodiesel feedstock has grown steadily under the RFS where it also competes with other vegetable oils (primarily non-food-grade corn oil co-produced with ethanol) as well as animal fats and greases. Exports of soybean oil have also grown steadily. A summary of average annual production and demand for soybean oil, as reported by USDA WASDE is provided in Table 2.

Table 2. Average Annual Production and Demand for Soybean Oil

	Pre-RFS (2000-2007)		RFS (2008 to Date)	
Billion pounds per year	Average	Standard Deviation	Average	Standard Deviation
Production	19.1	1.3	20.9	1.8
Food, Feed and Industrial	16.3	0.6	14.1	0.3
Biodiesel	1.0	1.3	4.8	2.0
Exports	1.7	0.7	2.3	0.6

Figure 5 summarizes the annual uses for the U.S. soybean complex (whole soybeans, soybean meal and soybean oil combined) since 2000 as reported by USDA in the WASDE. For all domestic uses, including biodiesel feedstock, 2018 is the first year when the projected demand for soybeans exceeds pre-RFS levels. As illustrated in Figure 5, growth in demand for the U.S. soybean complex since the 2008/2009 market year is primarily driven by growing demand in export markets, not the RFS. The projected 2018/2019 growth in U.S. domestic demand is attributable to a projected record crop in 2018 and an anticipation of weak demand for U.S. exports due to current trade disputes. Reduced domestic use of soybeans is attributable to growing competition with DDGS in animal feed markets.

Figure 5. Summary of U.S. Soybean Disposition



source: USDA WASDE, Stillwater analysis

1.5 Review of U.S. Crop Acreage and Disposition Analysis in EPA's Second Triennial Biofuels Report

EPA's Second Triennial Report to Congress is intended to be the definitive look at RFS landuse impacts. However, we have found several shortcomings in this report. Many of these are acknowledged by EPA in the report but are not highlighted in a manner that would attract the attention of the average reader. In the following section we offer a critique of EPA's Second Triennial Report informed by the preceding analysis of annual USDA data.

EPA's key land-use finding in their Second Triennial Report[21] relevant to land-use change is primarily that biofuel feedstock production is responsible for some of the observed and reported changes in agricultural land use, but EPA is unable to quantify this land-use increase with any degree of precision. USDA, as described above, publishes annual data on U.S. agricultural land use with detailed review of the precision. EPA states that since the passage of the Energy Independence and Security Act of 2007 (EISA or RFS), actively managed cropland has increased by 4-7.8 million acres. This is contrary to what can be clearly observed in USDA's acreage reports. EPA also states that cropland expansion and natural habitat loss (including forests) have been observed internationally during the implementation of the RFS program. The fact that exports of the three major U.S. export crops have held stable (corn and wheat) or substantially increased (soybeans and derivatives) since the start of RFS strongly counters any causal linkage between international cropland expansion and the RFS.

In its Second Triennial Report, EPA makes bold statements about the RFS's responsibility for land-use increases but also admits there are significant uncertainties making it impossible to precisely quantify the amount of land with increased intensity of cultivation or to confidently estimate the portion of crop land expansion that is due to the market for biofuels. EPA also points out the need for more research and improvement in the models used for this research. Our preceding analysis of USDA's annual data on corn and soybean useage shows that (1) corn acreage has been relatively constant (after adjusting for annual inventory changes) since 2007 despite conventional ethanol production increasing from 6.5 billion gallons in 2007 to 15.9 billion gallons in 2017; and (3) total domestic demand for soybeans, soy meal and soybean oil remained below pre-RFS levels from 2008 through 2017, with all of the increase in soybean planting to support exports of soybeans, soy meal and soybean oil.

Table 4 of the Second Triennial Report summarizes the land-use studies EPA drew upon to reach its conclusion that the RFS has driven agricultural land-use changes. These studies (all of which ended in 2012) found land-use changes of 5-7.8 million acres amounting to changes of 1.5, 2.4, 1.4, 1.2 and 1.0 percent. The implied accuracy of 1.0 to 2.4 percent in crop acreage measurement is very difficult to achieve in a database that is created by surveys in which there is not 100% participation. USDA estimates the 95 percent confidence limits of their annual estimates of corn and soybean acreage as the equivalent of ±2 million acres for each crop. The year-to-year variability in planted acres for these crops (see Table 1) is considerably larger. Accordingly, the utility of comparing acreage between two individual years is severely limited; analysis of multiple years of annual data, such as that published by USDA, is needed to demonstrate the presence or absence of a trend. Given the many factors impacting planting decisions of individual farmers, attributing any such trend data to the RFS requires further analysis on the actual use of the corn and soybean crops.

These studies all looked at total land use and total corn and soy bean production.[22] They had no ability to look at corn acres used for the RFS but assumed that all of the land use increases were due to RFS biofuels. In fact, only about 30 to 35 percent[23] of corn has been used for ethanol production, and ethanol production was already at nearly five billion gallons per year (bgy) in 2006 before the the RFS was in effect. As such, EPA should have only looked at corn planted for incremental ethanol produced in 2007 and later. Further, analysis of USDA WASDE data shows that demand for all uses of corn and DDGS have increased since the implementation of the RFS and that land required to supply all of these demands (domestic and export) has been essentially flat since 2007.

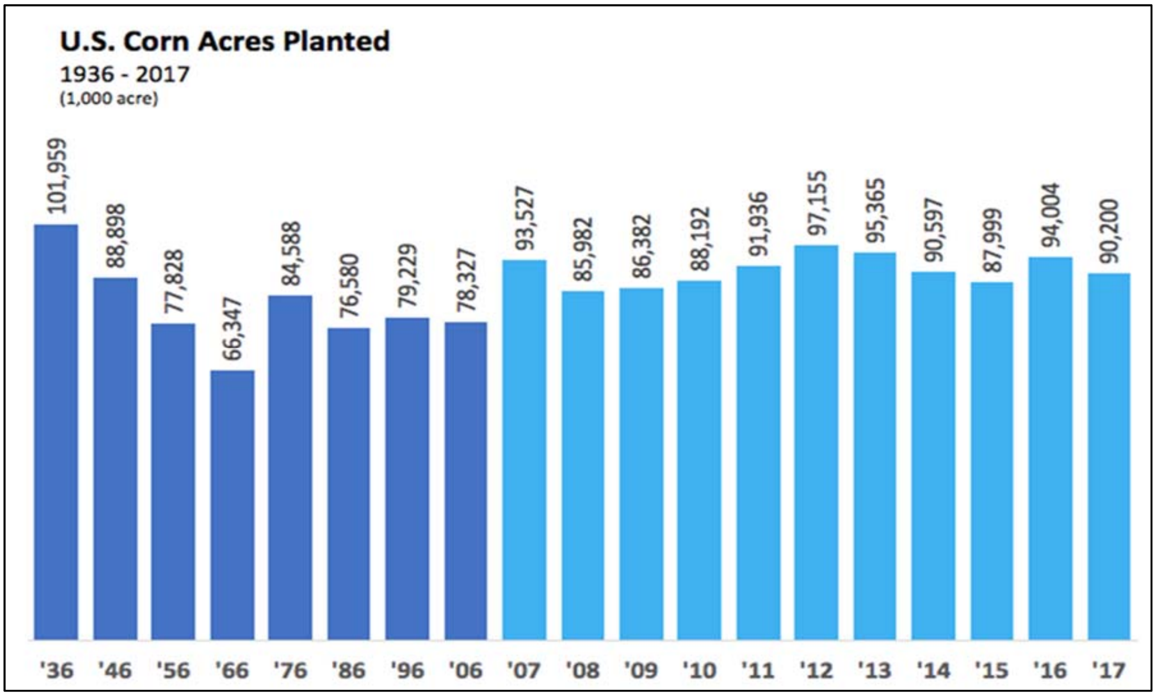
[21] U.S. Environmental Protection Agency. Biofuels and the Environment: The Second Triennial Report to Congress. June 29, 2018. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=IO&dirEntryId=341491

[22] Note that in Figure 1 of the Second Triennial Report, EPA uses data from USDA and other public sources to build up to its 16.6 bg of biofuels in 2016. The ethanol portion of this is 15.33 bg. Figures 10-13 in this report use data from the National Corn Growers Association. Use of this data in Tables 2, 4, and 5 results in a calculated ethanol volume of 15.4 bg in 2016. There are only very small differences between the two data sets.

[23] According to DOE's Alternative Fuels Data Center, in 2008 30.8 % of US corn produced was used to manufacture ethanol.

On the surface, EPA's approach to comparing the ten years before the RFS to the first ten years of the RFS might seem reasonable. However, data variability makes it possible to demonstrate land use increases or land use decreases simply by changing the beginning and ending years of the analysis. Looking at Figure 6 below reveals that 2012 and 2013 had the highest acreage planted in corn in recent years, and 2012 was the last year examined by most of the studies EPA referenced. This means that any examination of land use with 2012 as its endpoint would portray the appearance of land-use increases. However, if any of the years 2014 or later are used as the endpoint of the analysis, any previously perceived land-use increases disappear—even though the relevant RFS volume requirements continued to increase in those later years. EPA does not acknowledge this in their analysis.

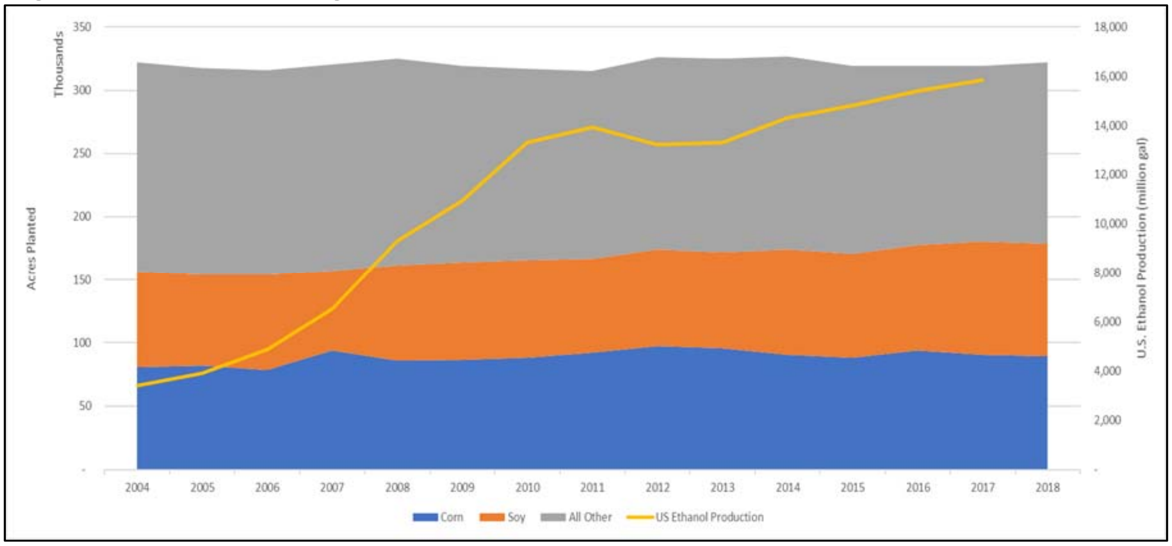
Figure 6. U.S. Corn Acres Planted 1936-2017[24]



EPA has a similar problem with using 2007 as the beginning year in their analysis. While the EISA legislation is dated 2007, it was not signed by president Bush until December of 2007. As such, it had very little impact on 2007 corn production. Looking at Figure 7 below, it can be seen that the corn acres planted in 2007 are an anomaly and are higher than the years before and after. This increase in acres planted occurred before the RFS drivers were in place and were the result of the overall corn market drivers (non-RFS drivers), such as increased corn exports, unusually low corn inventories, and unusually high soy bean inventories. Rather than using the year 2007 as the beginning of the RFS-driven land use analysis, EPA should have viewed 2007 as the last year before EISA and the RFS impacted corn-planting decisions.

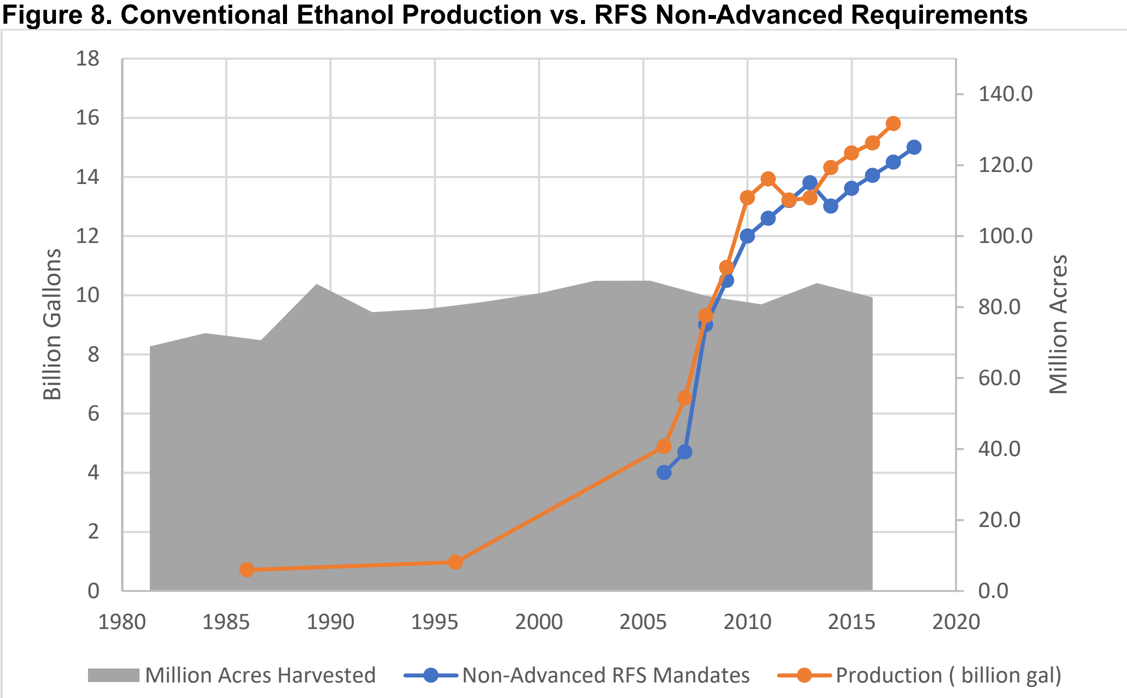
[24] National Corn Growers Association. U.S. Corn Acres Planted 1937-2017. January 12, 2018. http://www.worldofcorn.com/#us-corn-acres-planted

Figure 7. U.S. Crop Acreage 2004-2018



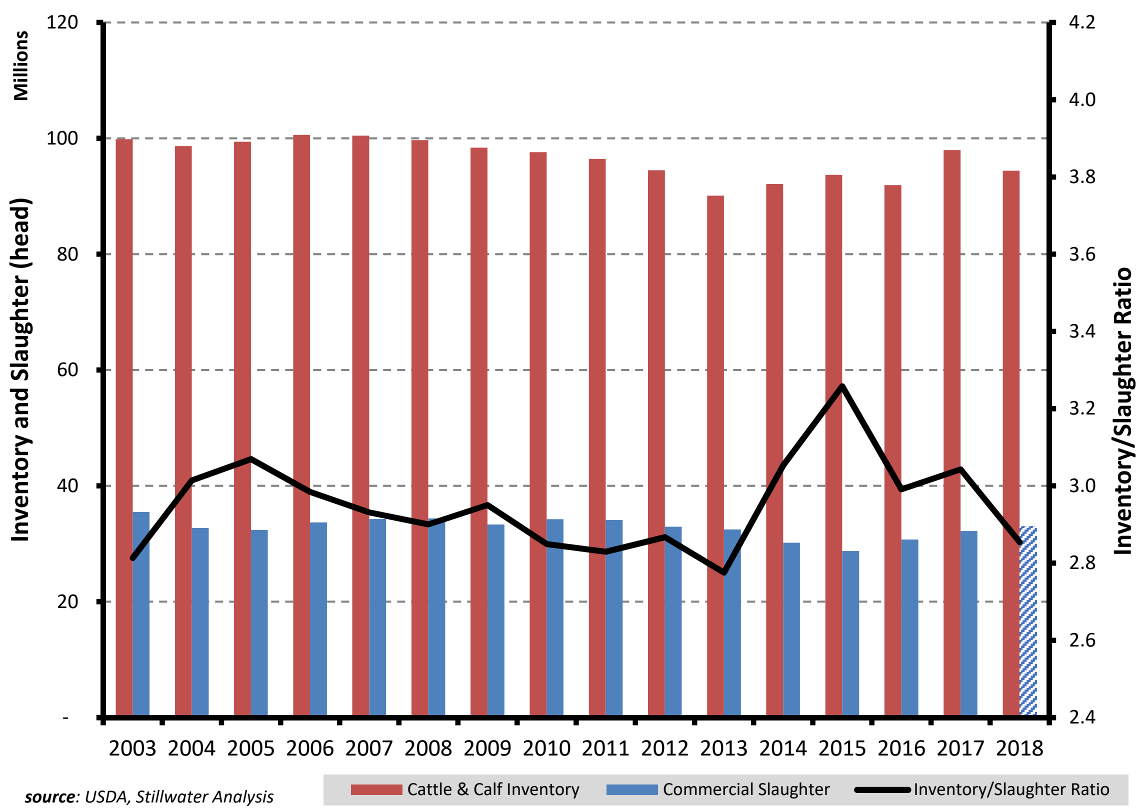
As shown in Figure 8 below, ethanol production has grown since long before the RFS and domestic ethanol production has exceeded the RFS non-advanced requirements every year except 2013 (in recent years, the U.S. has been a net exporter of ethanol). As reviewed in Section 1.3, the corn acreage utilized for this ethanol production has been relatively unchanged since the beginning of the RFS, so any land use concerns relative to conventional ethanol preceded, and were not caused by, the RFS.

Figure 8. Conventional Ethanol Production vs. RFS Non-Advanced Requirements



Yet another factor to consider when looking at land use in the U.S. is the cattle herd as feed is a major source of demand for corn, DDGS and soy meal. U.S. cattle herd size has varied significantly since 2003. Herd size fell significantly from 2006 though 2013 due to the U.S. outbreak of Bovine Spongiform Encephalopathy (BSE, commonly "mad cow disease") first detected in mid-2005 and the consequent loss of export markets. U.S. herd size has expanded since the 2013 low as the impacts of the 2005 BSE outbreak ended and U.S. beef exports began to recover. Each of these up years corresponds to an increase in demand for cattle feed in the form of corn or DDGS and of course the down years represent a reduction in demand for cattle feed. Significantly, from 2013 to 2017 the cattle and calf inventory increased from 90 million to almost 100 million, causing a corresponding ten-percent increase in cattle-feed demand. Some of this increasing feed demand has been met by increased DDGS production which was available due to the increase in corn ethanol production. USDA WASDE data reviewed in Sections 1.3 and 1.4 above estimate the quantities of corn, DDGS, and soy meal utilized in domestic and export markets. In summary, increasing production of DDGS, coupled with growing yields for corn and soybeans, have enabled U.S. feed demands to be met with fewer acres. The topic of changing land use is complex, and EPA should take into account all of these factors when evaluating the U.S. cropland used for biofuel production.

Figure 9. Trends in U.S. Cattle and Calf Inventory



source: *USDA, Stillwater Analysis*

In summary, individual farmers make their annual decisions on how much acreage to devote to each crop based on their expectations of how the future corn and soy markets will value those products, their expected yields and input costs, and alternative uses for their land. While EPA's annual RFS standard-setting can have some influence in the future market valuation of corn and soy, it is only a small piece of the valuation puzzle. EPA acknowledges this complexity in its Second Triennial Report:

> *Farmers' decisions regarding land use and management are influenced in part by market prices (e.g., future price of corn), which are in turn affected by myriad antecedent factors, such as weather and policies (Roberts et al. 2013; Hellwinckel et al. (2016); Carter et al. 2017). The dominant biofuel feedstocks in the U.S. currently are corn and soybeans (see Section 2.2); thus, the environmental effects of biofuels at this time are due to some portion of the land use and management of growing corn and soybeans. However, these feedstocks are also produced for*

> *other purposes, such as animal feed, many food and industrial products, and export. Soy, for example, is primarily grown for the meal (about 80% of the bean). The oil (20%), which gets used for food as well as biodiesel, is a by-product whose supply depends on soy meal demand.*
>
> *Therefore, only a percentage of the environmental consequences of growing corn and soybeans can be attributed to biofuel feedstock production. The question is what percentage of the environmental effects of producing corn and soybeans are attributable to corn-grain ethanol and soy biodiesel, respectively? And, from this follows – what percentage of these environmental effects are attributable to the Renewable Fuel Standard Program specifically?*[25]

Stillwater believes that crop acreage and supply/demand reports produced by USDA provide considerable insight into how the RFS has affected U.S. agricultural land use and the variety of markets which U.S. farmers supply.

1.6 Indirect Land Use Concerns

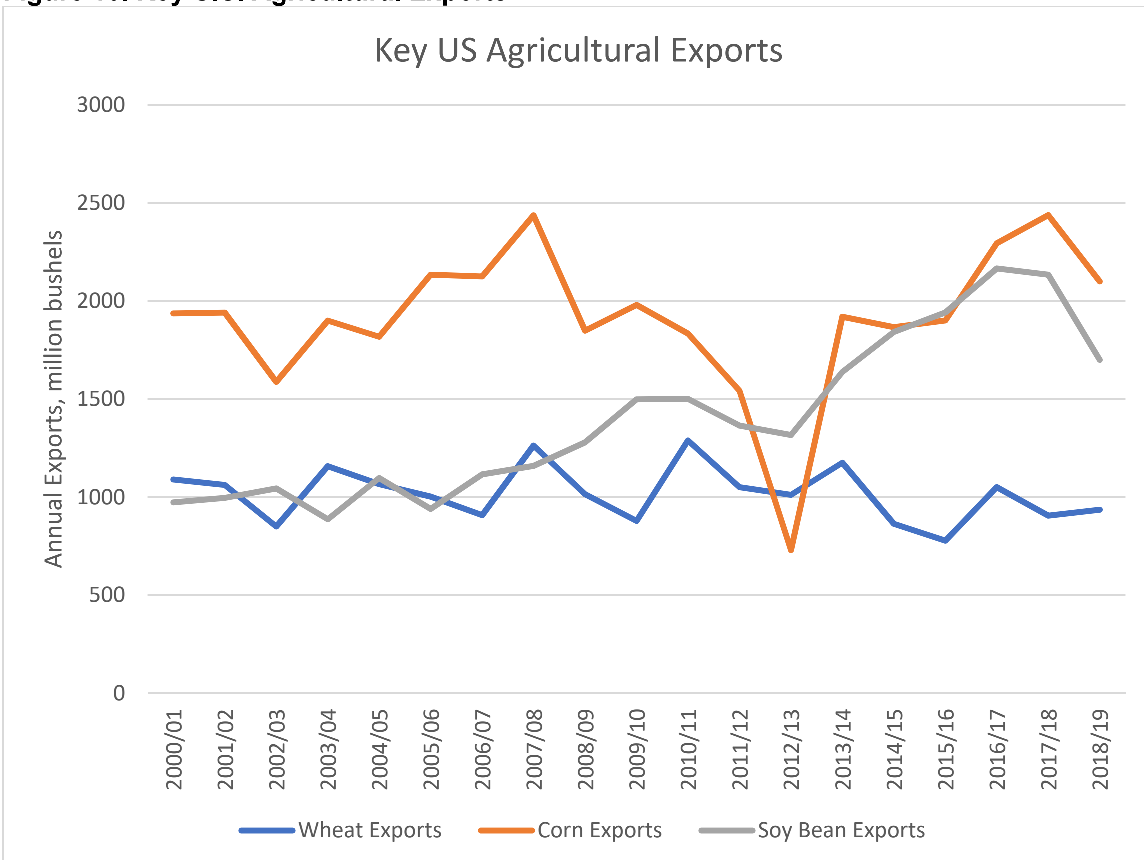
The indirect land use discussions have raised concerns about the need for countries other than the U.S. to contribute crops to aid in meeting the U.S. RFS mandates. The premise is that the use of U.S. farmland to produce biofuels feedstocks (such as corn and soybeans) will reduce the supply of those crops for other demands and, therefore, result in new land being converted to agriculture to make up for the presumed shortfall. EPA implies there are indirect land use issues due to the RFS in its Second Triennial report. However, analysis of U.S. agricultural land use and trends in U.S. agricultural exports contradict that assertion. As reviewed in Section 1.2 above, U.S. agricultural land use has not increased since implementation of the RFS and, as displayed in figure 10 below, USDA data[26] on U.S. exports for the three large commodity crops – wheat, corn and soy – show that, since the start of the RFS, U.S. exports for corn and wheat have stayed largely flat while soy exports have markedly increased. (Not shown in this figure is the increase in U.S. DDGS exports during this timeframe.) Decreases in U.S. crop exports in the 2018/19 market year can best be attributed to current trade disputes that are not related to the RFS. These data suggest that the RFS is not responsible for any increase in agricultural land use either inside the U.S or outside of the U.S. (i.e., no need for other countries to grow more to offset U.S. production sent to biofuels).[27]

[25] U.S. Environmental Protection Agency. Biofuels and the Environment: The Second Triennial Report to Congress. June 29, 2018. pg. 54. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=IO&dirEntryId=341491

[26] Data drawn from USDA World Agricultural Supply Demand Estimate (WASDE) published monthly. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1194.

[27] Note: 2011 and 2012 for corn diverge from the corn trend due to back-to-back low-yield years due to floods and then drought.

Figure 10. Key U.S. Agricultural Exports



Source: USDA WASDE

1.7 Summary on Land Use Concerns

While the RFS volume requirements mandates increased ethanol production by 12.4 bgy from 2004 to 2017 (from 3.4 bg to 15.8 bg), corn acreage in the U.S. only increased by nine million acres. Furthermore, while BBD mandates increased from 0.5 to 2.0 bg under EISA, U.S. soy acreage increased by about 20 million acres. Both of these mandated increases had a small impact on the total amount of corn and soy beans grown during the RFS years. Since corn used for ethanol is about 30 percent of total corn, the prorated acreage for ethanol-directed corn was just three million acres (30 percent of nine million acres) and since only 12 percent of soy is directed to RFS requirements, only about 2.4 million acres of soy production can be attributed to this use. Also, corn used for ethanol above 15 bgy is not driven by RFS; it is driven by ethanol demand in export markets.

Combined, these acreage increases for corn and soy represent only 5.4 million acres compared to the 4.0-7.8 million acres of general agricultural land use which EPA discusses in its latest Triennial Report. This acreage increase represents one-to-two percent of total U.S. crop land and thus is roughly the same size as the variability within the data.

Since the U.S. is exporting corn and soy beans plus ethanol and DDGS at amounts at or above pre-RFS levels, imports of ethanol and BBD are currently minimal, and U.S. agricultural land use is decreasing, there are no indirect land use impacts for corn ethanol or BBD either within the U.S. or the rest of the world resulting from the RFS.

2 The Ethanol Industry's Production Capabilities

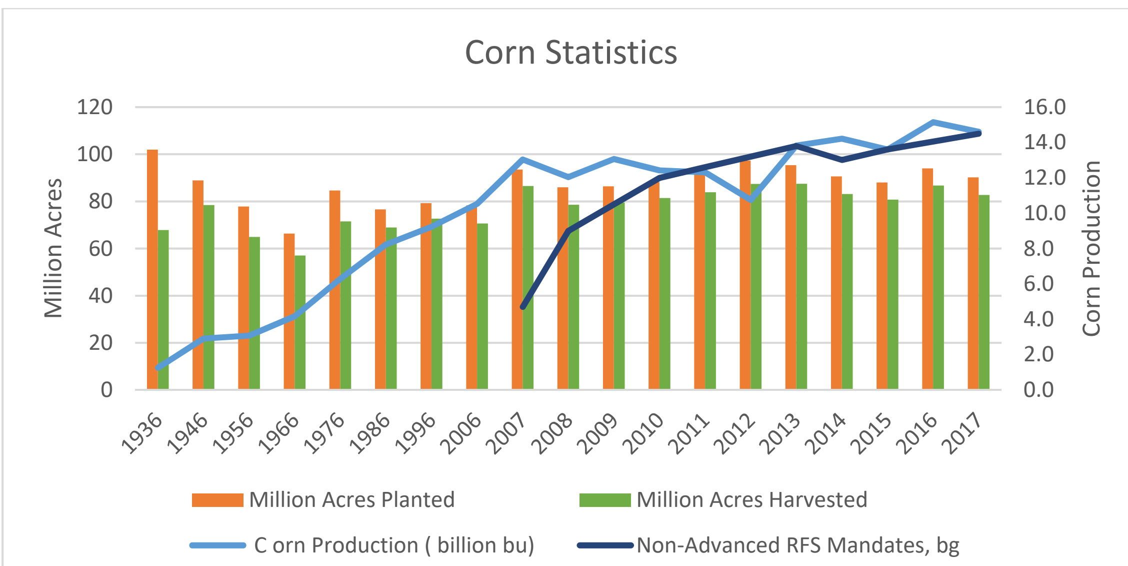
Having examined corn land use and EPA's Triennial report in the above sections, this report now examines whether the ethanol industry could take advantage of continued improvements in corn production and ethanol manufacturing to produce additional volumes of conventional ethanol without the need for increased acreage for growing corn.

This report provides insights into the capability of U.S. agriculturalists to produce additional ethanol for transportation fuel in the future. This analysis is conducted keeping corn acres harvested constant for future years at 86.5 million acres – the acreage harvested in 2007. Using a 92% ratio factor for the ratio of acres planted in corn to acres harvested, 86.5 million acres harvested would required 94 million acres of planted corn. For the purposes of this analysis, non-ethanol corn usage has been allowed to increase each year by 1%, the same rate as the world population is projected to grow. These two steps should minimize environmental and food concerns.

2.1 The History of U.S. Ethanol Production

The RFS has provided a significant incentive for increased U.S. ethanol production, increased production of corn, and the increased allocation of farmland to corn production. Looking back 50 to 80 years, however, there was a steady increase in U.S. corn production on a relatively steady number of farm acres dedicated to corn. Figure 11 shows 80 years of corn production, ending with 14.6 billion bushels of corn in 2017. It also shows 80 years of the farm acres planted in corn and the actual acres of corn harvested in the same time period.

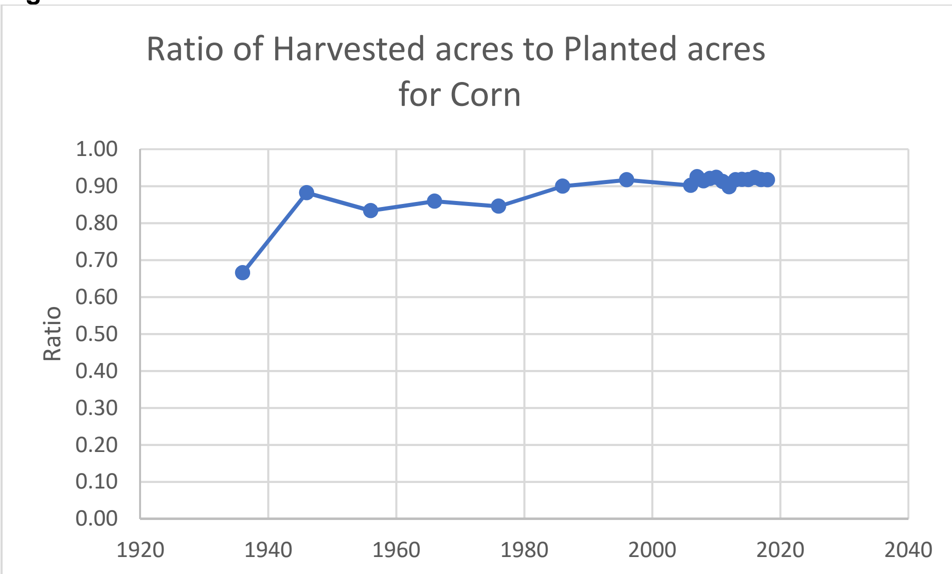
Figure 11. U.S. Corn Statistics 1936-2017[28]



The increased corn production shown in Figure 11 has come from roughly the same number of harvested acres. Meanwhile, the number of acres planted in corn in 2017 is actually lower than the number in 2007 and significantly lower than the number in 1936. The ratio of acres harvested to acres planted has been steady for many decades. The USDA data used in Figure 11 indicates that in 1936, only roughly 2/3 of the planted acres were harvested, but within ten years it had reached about 90 percent, and since 1996 it has been nearly constant at 92%.

[28] National Corn Growers Association. U.S. Corn Production 1936-2017. January 12, 2018. http://www.worldofcorn.com/#us-corn-production

Figure 12. Ratio of Harvested Acres to Planted Acres for U.S. Corn[29]

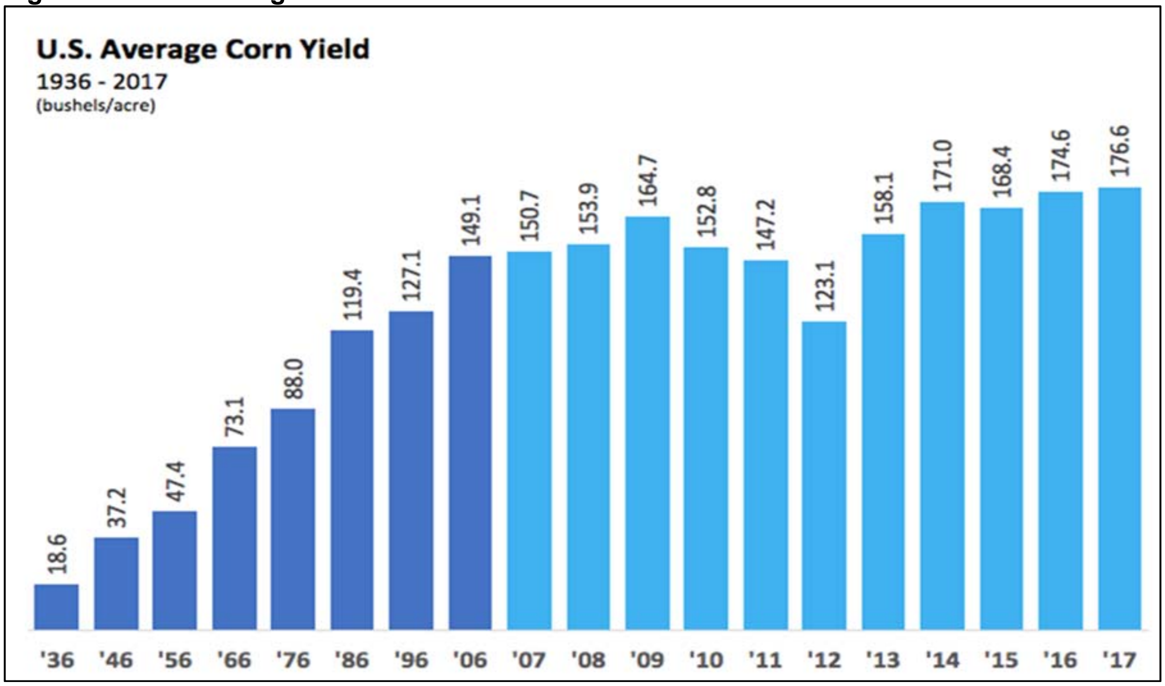


In looking at Figure 11, from 2007 forward (the year before the RFS effects started) a nearly level pattern of acres planted and acres harvested is apparent. While there is some variability in the data, it would be difficult to characterize the red and blue bars as representing an increasing or decreasing farm land use for corn over this period. Yet EPA, in their Second Triennial Report, found that: “It is likely that the … impacts associated with land use change are, at least in part, due to increased biofuel production and use associated with the RFS.” Our analysis in section 1 found that while corn production and yields have increased, as shown in Figures 11 and 13, land use for corn has remained relatively stable from 2007 to 2017.

One of the largest keys to increased corn production is the increase in corn yield per acre, which is shown in Figure 13. The overall rate of increase is mainly steady over the past 80 years, with a slightly higher rate of increase in the past ten years on average. These improvements are due to new higher-yield varieties of corn with improved drought- and pest-resistance. The 176.6 bushels of corn produced per acre of farm land in 2017 represented an all-time high for the U.S.

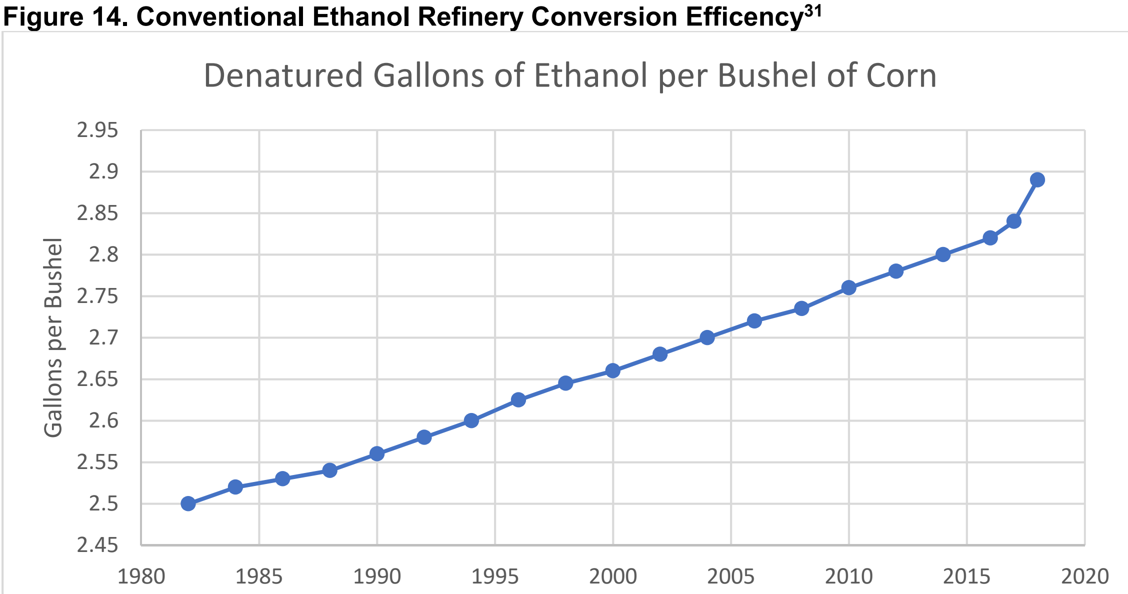
[29] https://quickstats.nass.usda.gov/

Figure 13. U.S. Average Corn Yield 1936-2017[30]



While the number of bushels of corn produced per acre in the U.S. has steadily increased, the productivity of ethanol refineries in turning corn into ethanol has also improved to the point at which 2.82 and 2.84 gallons of undenatured ethanol were produced per bushel of corn in 2016 and 2017 respectively. This increased productivity is shown in Figure 14.

Figure 14. Conventional Ethanol Refinery Conversion Efficency[31]



[30] USDA Quick Statistics, https://quickstats.nass.usda.gov/

[31] United States Department of Agriculture. Economic Research Service. U.S. Bioenergy Statistics. https://www.ers.usda.gov/data-products/us-bioenergy-statistics/

2.2 Modeling Future Conventional Ethanol Production

Three main factors must be included in any model of future ethanol production: acreage harvested, rate of increase in corn yields per acre, and rate of increase in ethanol refinery productivity. While it is possible to represent the two rates by higher-order regression equations, a conservative approach – which simply represents these variables as straight lines with constant slopes – is typically the best way to project these variables into the future. Quadratic and higher-order equations tend to become infeasible when used to depict values outside of the original data set or when extended for 20 years or more.

2.2.1 Corn Acreage Harvested

For the initial phase of this analysis, we assumed that for the future years modeled, the harvested corn acreage would remain constant at 86.5 million acres – the acreage that was harvested in 2007.

2.2.2 Increased Corn Yields

For the past 12 years, corn yields have improved at an average of 2.3 bushels per acre per year. This increase is shown in Table 3 below and is used in our model. While there is some variability in the year-to-year corn production data, the overall trend in corn yield has increased. Although there is no guarantee that this rate of increase will continue through 2022, there is no particular basis to believe that the rate will decline over the next few years. On the contrary, there are solid reasons to believe the rate will hold, or even rise further: About 33% of the total corn production in 2017 came from Illinois[32] and Iowa[33], where statewide yields were above 200 bushels per acre. New developments, such as precision agriculture,[34] GPS planting[35], improved seeds, and planting narrower rows[36] should enable these rates of increase in corn yields to continue. Iowa and Illinois have the advantage of larger farms. These larger farms have the ability to implement these new farming developments earlier and some of the yield increase to above 200 bushels per acre is due to this early adoption. Once a new development is recognized as beneficial, it can quickly be adopted on smaller farms elsewhere in the country. New developments are implemented over time and over different farms, bringing about the increase of 2.3 bushels per acre per year that has been seen over the past 12 years. Future improvements at this rate are already "locked in" by practices being tried by the early-adopter farmers.

Table 3. **Corn Yield Increases**

For the past:	Average Increases per Year (bushels per year per acre)
10 years	2.3
22 years	2.2
42 years	2.1
82 years	1.9

2.2.3 Increased Conventional Ethanol Refinery Productivity

Figure 14 shows increasing ethanol plant efficiency from 2.5 gallons of ethanol for every bushel of corn feedstock in 1982 to 2.84 gallons of ethanol per bushel of corn in 2017. The 2018 ethanol plant efficiency of 2.89 represents a significant increase from the straight line trend from 1982 to 2017. The 1982 to 2017 data represents a relatively constant increase of 0.01 gallons of ethanol per bushel of corn over this 35-year period. We use this value in our analysis.

32 https://www.nass.usda.gov/Statistics_by_State/Illinois/Publications/County_Estimates/2017/IL-Corn-Production-by-County.pdf
33 https://www.nass.usda.gov/Statistics_by_State/Iowa/Publications/County_Estimates/2018/IA-CtyEst-Corn-16-17.pdf
34 Schimmelpfennig, D., and R. Ebel. On the Doorstep of the Information Age: Recent Adoption of Precision Agriculture. U.S. Department of Agriculture, Economic Research Service. 2011.
35 https://boucherfarms.wordpress.com/2014/04/10/how-farmers-use-gps-and-vrt-technology-to-plant-efficiently/
36 www.agriculture.com/crops/corn/production/narrow-advtage-f-narrow-rows_137-ar21003

There are many reasons to believe that these increases in ethanol refinery productivity can continue into the future. Future increases based on the implementation of technology improvements in ethanol plants – corn kernel fiber to ethanol[37], fiber separation to ethanol, improved selective milling processes[38] – will contribute to improve productivity. There are already many refineries achieving higher than 2.84-gallons-per-bushel productivity and the 2018 rate of 2.89 gallons per bushel maybe indicative of a faster adaptation of new technology. Most ethanol refineries should be able to achieve similar future gains. Some new refinery designs are projecting 3.1 gallons per bushel.[39]

2.2.4 Conventional Ethanol Production Modeling Results

Future ethanol production rates can be projected when all of the variables mentioned above are modeled together. In 2017, 38% of all corn produced – 5.6 billion bushels out of the total corn production of 14.6 billion bushels – was used for ethanol production. For 2019 and beyond, our model allows non-ethanol corn production to grow by one percent per year, matching the growth rate of the world's population projected by the U.S. Department of Agriculture for the same period.[40] This growth in non-ethanol corn use should allow the U.S. corn contribution to world food and other non-ethanol uses to continue to meet demand in these areas. Given these assumptions, new ethanol production above the 2018 levels is projected to increase by 3.9 bg – from 16.1 to 20.0 bgy – in 2022. This analysis also shows ethanol production could increase by almost 0.5 bgy or about 4.0 bg every 4years *without* increasing the number of corn acres planted and harvested. But even if the gain in plant efficiency experienced in 2018 is an anomaly, a return to longstanding historical trends would still mean that ethanol production would increase by about 0.3-0.4 bgy annually through 2022.

Table 4. Projected Conventional Ethanol Production 2016-2022 Base Case*

	2016	2017	2018	2019	2020	2021	2022
Corn Acres Planted, million acres	94.2	89.9	89.1	94.0	94.0	94.0	94.0
Planted to Harvested Ratio	92%	92%	92%	92%	92%	92%	92%
Corn Acres Harvested, million acres	86.7	82.7	81.7	86.5	86.5	86.5	86.5
Corn Yield, bushels per acre	174.6	176.6	176.4	178.7	181.0	183.3	185.6
Corn harvested, billion bushels	15.1	14.6	14.4	15.5	15.7	15.9	16.1
Corn used for non-Ethanol Purposes	9.7	9.0	8.9	9.0	9.0	9.1	9.2
Corn Used for Ethanol Production, Billion Bushels	5.5	5.6	5.6	6.5	6.6	6.7	6.8
Ethanol Plant Efficiency, gallons per bushel	2.82	2.84	2.89	2.90	2.91	2.92	2.93
Ethanol Production, billion gallons	15.4	15.8	16.1	18.8	19.2	19.6	20.0
Ethanol Production above 2018, billion gallons				2.8	3.2	3.6	4.0

** 2016, 2017 and 2018 are actual values while 2019-2022 are projections.*

2.2.5 Modeling Sensitivity

Because the model presented here projects volumes in the face of uncertainty, its robustness can be examined by looking at its sensitivity to the impact of changes in its input variables. The key variables used in this ethanol production model are Acres Harvested, Corn Yield per Acre, and Ethanol Plant Conversion Efficiency. Acres Harvested is assumed to remain constant.

Tables 5, 6, and 7 show the values used for these two variables in the base case shown in Table 4 plus values ten percent lower and ten percent higher than the base case to demonstrate the sensitivity of the model to changes in these variables.

[37] https://www.energy.gov/sites/prod/files/2017/10/f38/cagle_bioeconomy_2017.pdf
[38] https://grains.org/wp-content/uploads/2018/07/Chapter-5.pdf
[39] Scharping, Jeff. ICM, Inc. and The Andersons, Inc. Revolutionize the Ethanol Industry with ELEMENT. ICM, Inc. March 6, 2018. http://www.icminc.com/icm-media/whats-new-at-icm/23-press-releases/271-icm-inc-and-the-andersons-inc-revolutionize-the-ethanol-industry-with-element1.html
[40] ICF. A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol. January 12, 2017. https://www.usda.gov/oce/climate_change/mitigation_technologies/USDAEthanolReport_20170107.pdf

Table 5. Comparison of Variables Used in Sensitivity Cases

	10% Low Case	Base Case	10% High Case
Corn Yield per Acre Increase	2.07	2.3	2.53
Ethanol Plant Efficiency Increase	0.009	0.01	0.011

Table 6. 10% Lower Case

	2016	2017	2018	2019	2020	2021	2022
Corn Acres Planted, million acres	94.2	89.9	89.1	94.0	94.0	94.0	94.0
Planted to Harvested Ratio	92%	92%	92%	92%	92%	92%	92%
Corn Acres Harvested, million acres	86.7	82.7	81.7	86.5	86.5	86.5	86.5
Corn Yield, bushels per acre	174.6	176.6	176.4	178.5	180.5	182.6	184.7
Corn harvested, billion bushels	15.1	14.6	14.4	15.4	15.6	15.8	16.0
Corn used for non-Ethanol Purposes	9.7	9.0	8.9	9.0	9.0	9.1	9.2
Corn Used for Ethanol Production, Billion Bushels	5.5	5.6	5.6	6.5	6.6	6.7	6.7
Ethanol Plant Efficiency, gallons per bushel	2.82	2.84	2.89	2.90	2.91	2.92	2.93
Ethanol Production, billion gallons	15.4	15.8	16.0	18.8	19.1	19.4	19.7
Ethanol Production above 2018, billion gallons				2.7	3.1	3.4	3.7

Table 7. 10% Higher Case

	2016	2017	2018	2019	2020	2021	2022
Corn Acres Planted, million acres	94.2	89.9	89.1	94.0	94.0	94.0	94.0
Planted to Harvested Ratio	92%	92%	92%	92%	92%	92%	92%
Corn Acres Harvested, million acres	86.7	82.7	81.7	86.5	86.5	86.5	86.5
Corn Yield, bushels per acre	174.6	176.6	176.4	178.9	181.5	184.0	186.5
Corn harvested, billion bushels	15.1	14.6	14.4	15.5	15.7	15.9	16.1
Corn used for non-Ethanol Purposes	9.7	9.0	8.9	9.0	9.0	9.1	9.2
Corn Used for Ethanol Production, Billion Bushels	5.5	5.6	5.6	6.5	6.6	6.8	6.9
Ethanol Plant Efficiency, gallons per bushel	2.82	2.84	2.89	2.90	2.91	2.92	2.93
Ethanol Production, billion gallons	15.4	15.8	16.0	18.9	19.4	19.8	20.3
Ethanol Production above 2018, billion gallons				2.9	3.3	3.8	4.2

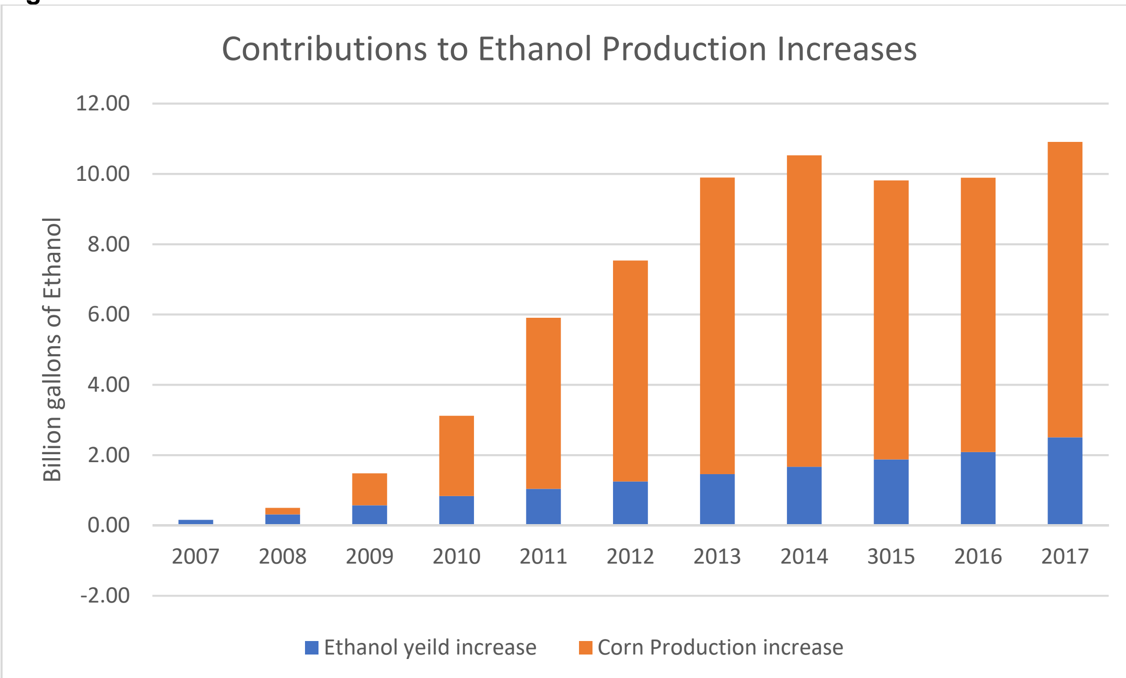
The sensitivity cases show that if the estimated corn yield per acre increase and the ethanol plant efficiency are ten percent higher or lower than those estimated for the base case, the amount of calculated ethanol produced above 2018 volumes can range from 3.7 to 4.2 bg in 2022. This is compared to the base case increase of 4.0 bg. Further, these results imply that, without increasing corn acres harvested, the industry could produce an additional 0.3 to 0.4 bg of ethanol in one year (2022 compared to 2021) and 1.0 to 1.3 bg can be produced in the three years between 2019 and 2022. As we explain in an accompanying report,[41] that incremental volume of ethanol could easily be distributed and consumed in 2022.

2.2.6 Comparison of Corn Yield Improvements to Ethanol Plant Improvements

Figure 15 shows a comparison of the gallons of increased ethanol production due to increased corn yields per acre and the gallons of increase ethanol production due ethanol plant improvements. While the improvements in ethanol plant efficiencies has steadily increased since 2007, the largest contribution to the increased ethanol production has been made by the increases in corn yields per acre. Going forward the relative sizes of increased ethanol production are expected to continue to follow this trend.

[41] *See* Stillwater Associates LLC, *The RFS Reset and Potential Increased Ethanol Sales Through E85 and E15* (DATE, 2019).

Figure 15. Contributions to Ethanol Production Increases



3 Environmental Impacts

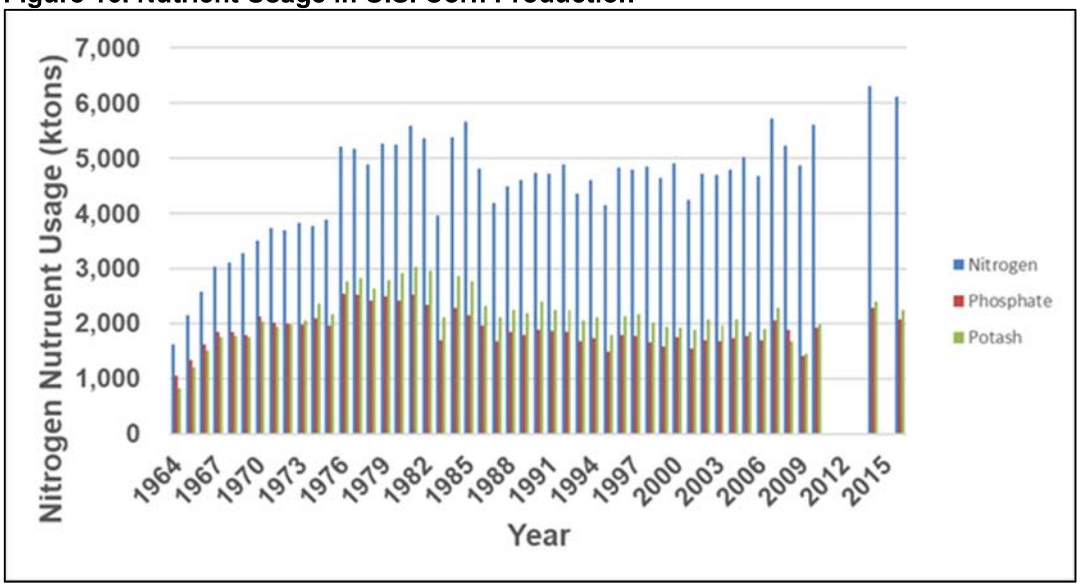
There are several environmental concerns involved with the continued increasing growth of corn and production of conventional ethanol. These concerns principally include greenhouse gas (GHG) lifecycle emissions, water usage, over-usage of agricultural land, runoff and drainage issues, and increased nitrogen oxides (NOx) emissions. However, many of these concerns assume that additional acreage is required to grow more corn and produce more ethanol. As this analysis demonstrates, a considerable increase in corn and ethanol production can occur over time without the need to plant more acreage in corn.

From 15.4 bgy of ethanol in 2016 to 20.0 bgy in 2022 is about a 23 percent increase in ethanol production, while total corn production increases from 15.1 billion to 16.1 billion bushels – or almost a seven percent increase – in a six-year period with no additional acres of farmland being used for corn. With no additional U.S. farmland required, there is no additional indirect land use to consider as part of the GHG lifecycle emissions. Indirect land-use concerns are predicated on the assumption that more land will be required to grow more of a particular crop. If more of a crop can be grown over the years with no need for increased farm land, then the indirect land-use impacts should be minimal or non-existent. If the GHG benefits of growing corn remain constant on a per-corn-bushel basis, there would be a seven percent improvement in the GHG reduction benefits per acre of corn grown. The growth of seven percent more corn per acre enables the production of 4.0 bgy of ethanol over the four years from 2019 through 2022 and the benefits of this versus the petroleum-based gasoline which it could replace.

Likewise, concerns about increased runoff, drainage issues, and overuse of agricultural land are eliminated as most of these are based on the use of new acreage, which would not occur in this scenario. In addition to the removal of land use concerns, recent improvements in farming technology and techniques promise a reduction in future NOx emissions and the use of nutrients in the growth of corn. NOx emissions can be decreased by 20-60 percent through the application of NOx inhibitors.[42,43] Fertilizer use can be reduced through the use of precision agriculture, variable-rate application, and GPS- and sensor-based mapping which restrict the addition of fertilizer to the area immediately around the plant.[44] Seed improvements have produced plants with improved efficiency at utilizing available nitrogen, thus lowering fertilizer application requirements. These techniques offer the ability to reduce NOx and fertilizer requirements per acre even while bushels per acre increase. While these developments will not eliminate environmental concerns, they should prevent such concerns from becoming any worse and may help minimize such concerns in the future.

Another environmental challenge with U.S. corn production has been eutrophication – oxygen depletion in water bodies caused by excessive algae growth absorbing the oxygen content in water, which can lead to the death of aquatic life. This excessive algae growth is stimulated by high levels of phosphates and nitrates from water from agricultural runoff. While corn yields and corn production continue to increase, more efficient methods of nutrient application have either flattened or reduced nutrient growth in corn production as shown in the figure below. While more progress needs to be made on nutrient efficiency and runoff, it appears the problem is not getting worse with higher levels of corn production. Figure 16 shows nutrient usage in corn production as relatively constant over time with a slight uptick in recent years. When the data is examined on a per-bushel basis, as in Figure 17, however, it can be seen that nutrient requirements are trending down on a per-bushel basis.[45] This means that even though the model shows increased production of corn, this does not result in the increased usage of nutrients and in fact has resulted in a reduction in nutrients on a per gallon basis.This improvement comes from better placing the correct amount of nutrients, which reduces the amount of excess nutrients applied.

Figure 16. Nutrient Usage in U.S. Corn Production

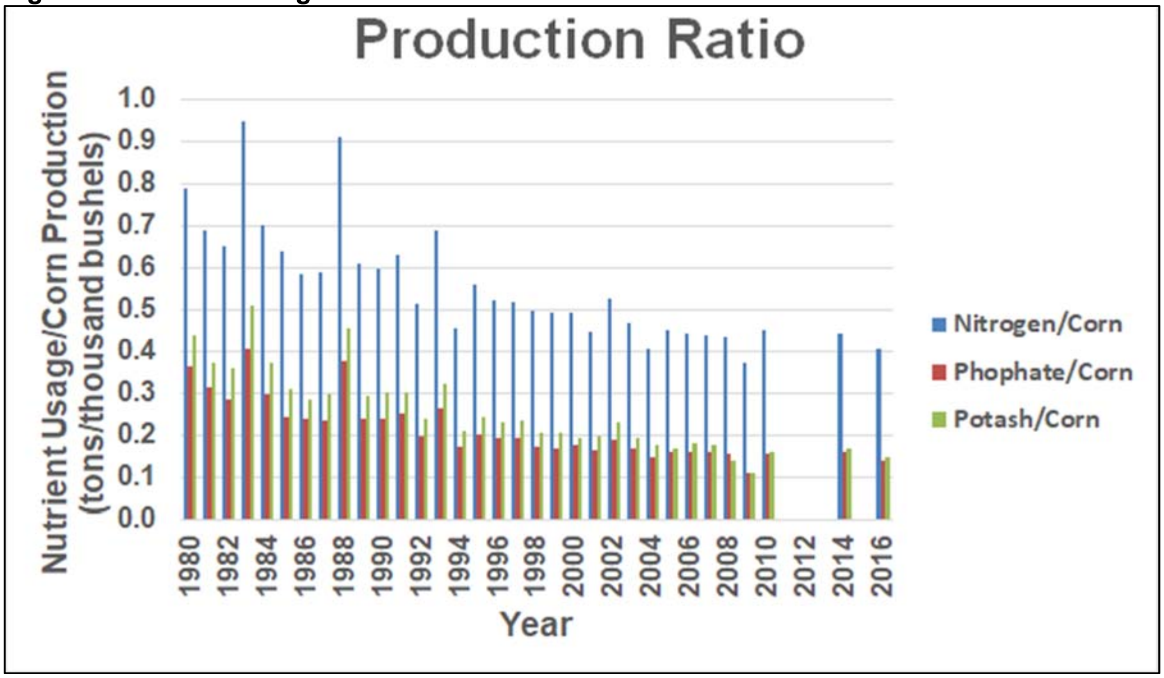


Source: USDA

[42] Halvorson, A.D., 2014. Nitrogen Fertilizer Source and Management Effects on Nitrous Oxide Emissions. 16th World Fertilizer Congress of CIEC, Rio de Janeiro, Brazil, 20-24 October 2014, p. 68-71.
[43] Thapa et al., 2015. Stabilized Nitrogen Fertilizers and Application Rate Influence Nitrogen Losses under Rainfed Spring Wheat. Agronomy Journal, 107(5): 1885-1894.
[44] The Fertilizer Institute. Fertilizer Use. 2016. https://www.tfi.org/statistics/fertilizer-use
[45] Stillwater and EPA are using the same data. EPA looks at Nitrogen (N), Phosphate (P), Potash (K) and Sulphur (S) fertilizers in total (stacking the bars) while Stillwater looks just at N, P, and K and does not stack the bars. EPA's then looks at total application rate per acre and sees it leveling off. They further comment that as application rates per acre have leveled and per-acre yields improve, application rates per bushel have declined. Stillwater does not comment on application rates per acre but goes directly to rates per bushel and shows a decline. Stillwater then moves its focus to future trends which are expected to further decrease per-bushel application rates while EPA's Second Triennial Report looks only at trends up to the present.

Projecting out through 2022, continued improvements in farming techniques such as precision farming, variable-rate application, and GPS- and sensor-based mapping will lead to reductions in fertilizer usage[46] while there is continued growth in corn yields per acre. The net results will be relatively level amounts of nitrogen and phosphates on a per-acre basis but a decrease in these nutrients on a per-bushel basis. In addition to growing more corn per acre, the productivity of ethanol refineries will also increase in terms of ethanol produced per bushel of corn. This will result in even lower nutrient usage per gallon of ethanol. Both of these types of improvements will take place on a farm-by-farm and plant-by-plant basis to continue the historic trend of increases that have taken place for the past 50-80 years in the production of corn and ethanol.

Figure 17. Nutrient Usage in Corn Production on a Per-Bushel Basis



[46] Schimmelpfennig, D., and R. Ebel. On the Doorstep of the Information Age: Recent Adoption of Precision Agriculture. U.S. Department of Agriculture, Economic Research Service. 2011.

4 Conclusions on the Growth of Conventional Ethanol Production

The farmland acreage devoted to corn production for the past ten years since the beginning of the RFS (2008-2017) has been fairly constant while corn yields have increased 12 percent from 13.0 billion to 14.6 billion bushels per year and conversion efficiencies at biorefineries have increased. Specifically, the 2017 USDA study documents that corn planted acreage has remained fairly constant (varying between ~86 and 97 million acres) between 2007 and 2017, while average crop yield, as measured in bushels/acre, has trended upward from 150.7 to 176.6. Additionally, the USDA analysis found that ethanol conversion (the amount of ethanol produced from a bushel of corn) has increased from 2.73 gallons/bushel to 2.84 gallons/bushel over 2007-2017 timeframe. Our analysis anticipates that these trends will continue through 2022.

This analysis has examined the continuation of these trends and found that from 2018 to 2022 an additional 1.7 billion bushels of corn can be produced on the same number of acres that was used in 2007. Assuming that non-ethanol demands for corn grow at the same rate as population, 0.3 billion additional bushels would be required annually to supply feed, seed, and non-ethanol industrial uses of ethanol (such as high fructose corn syrup, cationic starch and renewable chemicals feedstock). This would leave 1.4 billion bushels of new corn available for ethanol production, enough to achieve a production rate of 4.0 bgy of new ethanol in 2022.

Since this 4.0 bgy of new ethanol can be produced with no new farm land needed and while continuing to grow sufficient corn for food and other non-ethanol needs, there should be minimal concerns about additional indirect land use or new corn-for-food needs. It also appears that the nutrients needed for this new corn are fewer on a per-bushel basis than the nutrients required prior to 2000.

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 3

THE RFS AND ETHANOL PRODUCTION: LACK OF PROVEN IMPACTS TO LAND AND WATER

Prepared at the Request of
Growth Energy

Prepared by
Ramboll

Date
August 18, 2019

RAMBOLL

CONTENTS

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
CDL	cropland data layer
CGF	corn gluten feed
CRP	Conservation Reserve Program
DDGS	distiller's dried grains with solubles
EISA	Energy Independence and Security Act
EPA	U.S. Environmental Protection Agency
FSA	Farm Service Agency
ha	hectare
ITRC	Interstate Technology & Regulatory Council
LUC	land use change
NOx	nitrogen oxide
NASS	National Agricultural Statistics Service
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
NWI	National Wetlands Inventory
RFM	Reduced form model
RFS	Renewable Fuel Standard
SOA	secondary organic aerosols
SOx	Sulphur oxide
TPH	total petroleum hydrocarbons
UOG	unconventional oil and gas
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USEIA	U.S. Energy Information Administration
VOC	volatile organic compound

1. EXECUTIVE SUMMARY

This report was prepared by Ramboll for Growth Energy in anticipation of the United States Environmental Protection Agency (EPA) issuing proposed rulemaking on the Renewable Fuel Standard (RFS), commonly referred to as the "RFS Reset." One of the factors that EPA must consider in resetting renewable fuel volumes in the program is potential environmental impacts.

The key conclusion of this report is that there are no proven adverse impacts to land and water associated with increased corn ethanol production under the RFS. Accordingly, EPA could decide to reset renewable volumes in a manner that would incentivize greater production and consumption of conventional corn ethanol in US transportation fuel without discernible adverse environmental impacts to land and water, to the extent any exist. The major factors supporting this conclusion are that continued improvements in agricultural practices and technology indicate that increased demand for corn grown for ethanol in the United States can be met without the need for additional acres of corn planted, while at the same time, reducing potential impacts to water quality or water supplies.

Our review focused on analyses concerning water quantity and quality; as well as ecosystems, wetlands, and wildlife. Analyses concerning ecosystems, wetlands, and wildlife were presented primarily as part of the body of literature addressing land use change (LUC) and conversion of land from non-agricultural to agricultural uses in the United States. We focused particular attention on EPA's recent environmental review of the RFS, *Biofuels and the Environment: Second Triennial Report to Congress* (EPA 2018a), and studies relied upon by the agency therein. Ramboll also reviewed other key publications pre- and post-dating EPA (2018a). A full list of refences cited in this report is presented in Section 8.

We also reviewed a recent paper by Hill et al. (2019) investigating the air quality-related health impacts of growing corn. Finally, we provide a brief overview of certain environmental impacts of oil and gas exploration and production and gasoline refining, in response to EPA's (2018a) acknowledgement that its assessment is not fully comprehensive because it does not consider a comparative assessment of the impacts of biofuels relative to petroleum-derived fuels.

The principal findings of our review by topic include, but are not limited to:

- **Land use change**—Some investigators have asserted that the RFS has resulted in extensive conversion of non-agricultural land to agriculture due to increased demand for corn for ethanol. Our findings indicate that these claims are not borne out, in part because the studies do not establish a causal link between the RFS, increased ethanol production, and LUC. Indeed, in a follow-up analysis to its Triennial Report EPA (2018b) reached the same conclusion—that no causal connection has been established between LUC associated with corn production and the RFS.
  - **The number of acres planted in corn has remained effectively constant despite significant increases in production.** Acres planted in corn across the United States has remained close to or below the total acres planted in the early 1930s, despite increases in demand for corn as human food, animal feed, and biofuels over this nearly 90-year period. The increase in demand has largely been met by an approximately 7-fold increase in yield (bushels per acre).
  - **Most studies asserting a connection between the RFS and LUC fail to adequately account for the myriad factors that drive farmers' choices to**

plant a given crop or to convert non-agricultural land to cropland. The price of corn is only one of many such factors, and the literature does not support that the RFS is the predominant driver of pricing of this global commodity. Moreover, assertions that the RFS drives LUC, fail to adequately recognize the increased efficiency in corn production per acre as well as the diminished demand for corn crop acreage due to co-products of the ethanol refining process, such as distiller's dried grains with solubles (DDGS). Assessments of LUC and the RFS generally fail to recognize external factors that might be driving expansion of farmland, such as the loss of farmland near urban areas.

- **Water use and water quality**—EPA (2018a) and other authors raise concerns that increased corn grown for ethanol may be overstressing water sources and resulting in regional water quality impacts. Our findings indicate that these concerns are not borne out primarily due to research that fails to establish a causal relationship between corn grown for ethanol and impacts to water use and water quality. We further find that EPA (2018a) does not adequately acknowledge the role of advances in agricultural practices in mitigating potential water use and water quality impacts.
  - **A quantitative or causal relationship between the RFS and concerns over water use has not been established.** From a geographical standpoint, much of the corn that is used for ethanol production is grown on non-irrigated land where impacts to water availability are minimal, and while noted, this is not quantitatively considered by EPA (2018a). In addition, the increased adoption of modern farming practices and precision agriculture (Vuran et al. 2018) is reducing the potential impact of agriculture in general, including increased corn production, on water availability. EPA (2018a), in fact, noted that the increased use of these best management practices should substantially limit impacts to water resources. While some investigators have claimed that growth in corn production has resulted in greater stress to water resources, those studies that focus on negative impacts fail to acknowledge, or do not appear to emphasize, that the current focus on best management practices and resource protection is being widely adopted by the corn growing community and incentives to adopt such practices continue. The technical publications we have reviewed do not establish that the RFS drives corn planting decisions and potential associated water impacts.
  - **A quantitative or causal link between corn production associated with the RFS and adverse water quality impacts has not been established.** While observed environmental impacts, such as excessive algae blooms in western Lake Erie and low oxygen levels in the Gulf of Mexico have been documented, we found that the literature on this issue fails to quantitatively link these regional water quality problems to increases in corn production for ethanol. Indeed, nutrient loading to the Gulf of Mexico, as measured by nitrates and nitrites, has remained relatively constant since at least 1980 despite increases in corn production. In addition, very few investigators have looked closely at agriculture trends over the past decade that show the implementation of modern farming practices are helping to reduce potential watershed impacts; modern farming practices include improved products such as slow-release fertilizers, and improved practices such as precision agriculture and better water and stormwater management. This trend is expected to continue well into the future and provide additional benefits to other agricultural products in addition to corn. Finally, expected future gains in corn yield (bushels produced per acre per year) in combination with steady or even declining fertilizer and pesticide

use (in pounds per acre per year), will naturally result in a decrease in the potential for water quality impacts.

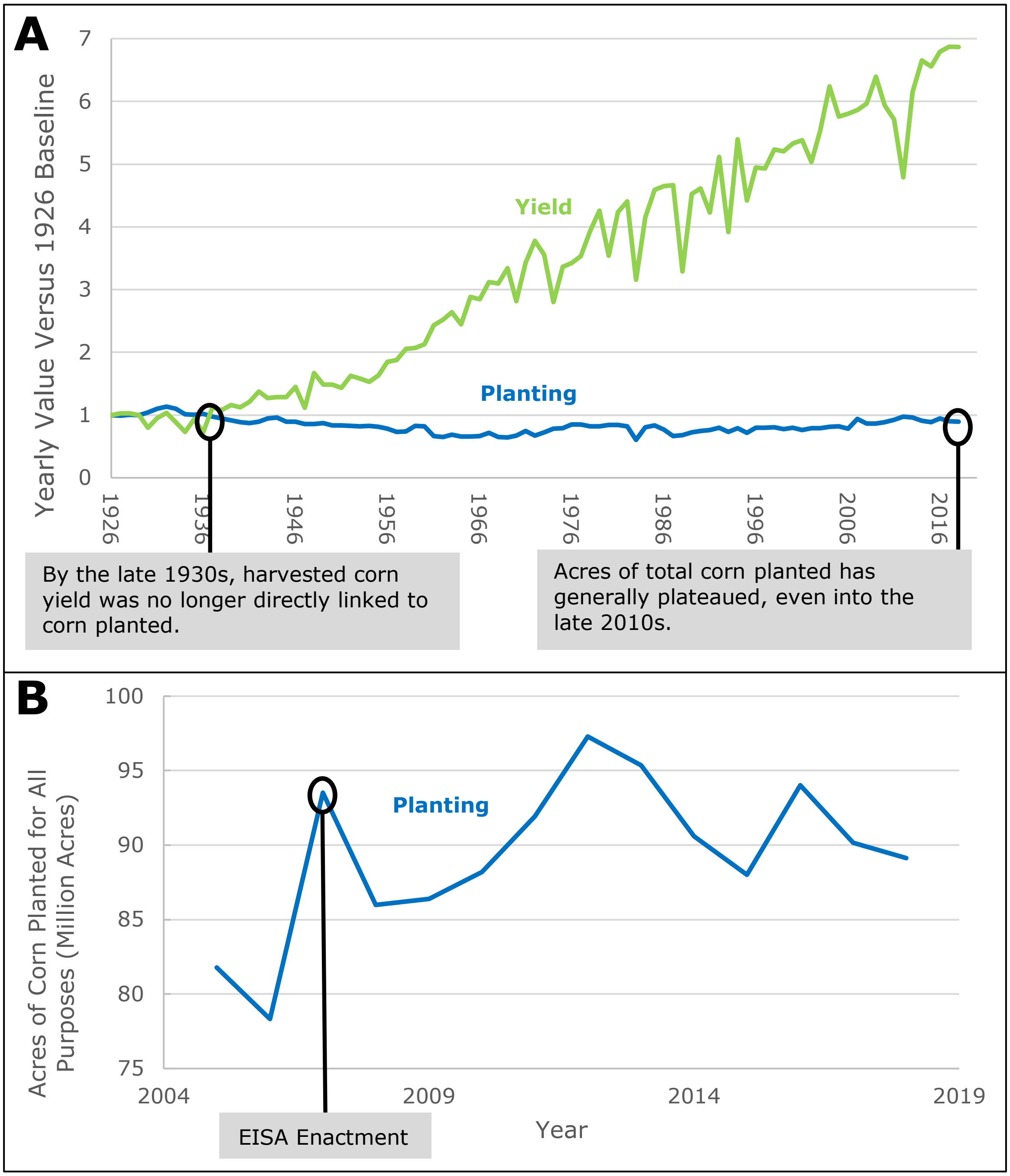
- **The RFS Reset is well-timed to coincide with ongoing improvements in agricultural practices—**Nearly all published investigations Ramboll has reviewed that focus on the potential impact of increased corn growth for biofuel production have focused on past practices with only passing mention of future expectations. EPA (2018a) acknowledges the benefits of the increased use of best management practices on the environment. Modern agricultural practices are economically beneficial to corn producers when they result in reduced input costs associated with water and agricultural chemicals. The timing for increasing corn production and reduced potential environmental impacts due to precision agriculture coincides with increased biofuel demand, and the coincidence of these trends will benefit both producers and the environment into the future.

1.1 Total Acres Planted in Corn Has Remained at or Below Levels in the Early 1930s While Total Production Increased 7-Fold

The United States Department of Agriculture (USDA) has maintained annual statistics on domestic crop production for decades. Corn production in the United States annually exceeds 10 billion bushels, with approximately 50% of corn currently grown for ethanol production and 50% for grain use. Accordingly, corn is documented to be the most widely produced feed grain in the United States (U.S.), accounting for more than 95 percent of total production and use followed by sorghum, barley, and oats (USDA 2019). Most of the corn crop for feed grain is used for livestock feed. Other food and industrial products include cereal, alcohol, sweeteners, and byproduct feeds.

While the approximate share of U.S. corn (in bushels) dedicated to production of ethanol has increased from 4% in 1986, to 38% in 2015 (USDA-ERS 2019b), and to approximately 50% in 2018, the total corn planting (in acres) has remained relatively stable since the 1930s (**Figure** 1). On a shorter time-scale, acres of corn planted each year does vary, but when examining data between 2007 and 2018, there is no long-term upward trend. In fact, acres of corn decreased 8.07% in 2008, the year after the enactment of the Energy Independence and Security Act (*EISA*), then rebounded through 2012, then decreased again such that in 2018, acres of corn were 4.7 % lower than in 2007. These data, from the USDA Crop Production Historical Track Record (updated in USDA, 2019) demonstrates the increased efficiency, planting and production of the corn crop without a need to secure appreciable additional acreage for production. Efforts in better crop management, improved fertilizer use, and precision agriculture are all likely contributors to improved yields. The USDA further anticipates changes in corn production to result in an increase of approximately 16.1 more bushels per acre by 2028 without a substantial increase in farmed acres (and with a corresponding reduction in the use of water resources and fertilizer).

Figure 1: A) Annual Yield in Bushels of Corn Per Acre and Annual Acres Planted in Corn Versus 1926. B) Annual Acres of Corn Planted 2004-2018.

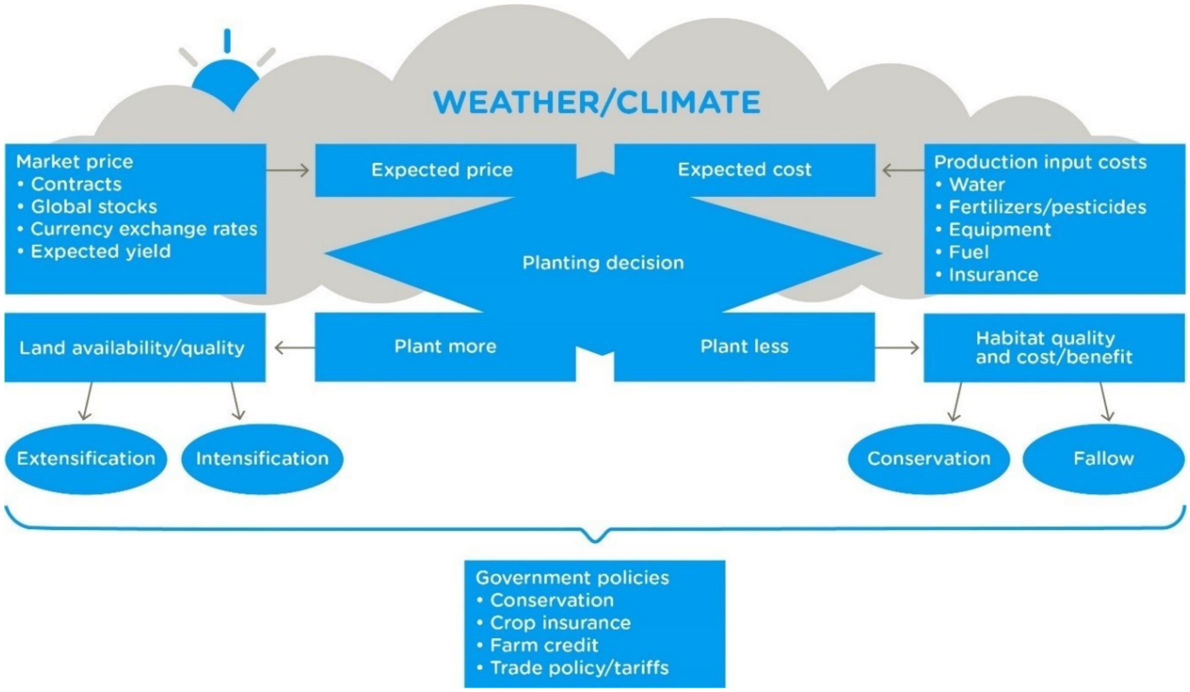


Source: USDA Crop Production Historical Track Records, 2019

1.2 Studies Have Failed to Establish a Quantitative Link Between the RFS and Land Use Change

The decision by farmers and landholders on whether to plant a bioenergy crop such as corn reflects complex relationships between biophysical, economic, and social factors (**Figure 2**).

Figure 2: Illustration of the Complexity of Biophysical, Economic, and Social Factors Affecting Planting Decisions.



One factor that is of paramount importance is weather and climate. Regional weather patterns largely dictate crop patterns across the country, but this is also influenced by the availability (and price) of water for irrigation in areas with relatively low annual precipitation or highly variable precipitation. The probability of severe weather such as drought and flood as well as severe storm events in any given year, may also influence planting decisions. Government policy is another overarching factor affecting planting decisions, and these include potential monetary incentives associated with the U.S. Department of Agriculture Conservation Reserve Program (USDA CRP), other conservation programs such as local conservation easements, the availability of crop insurance, and market incentives that might affect commodity prices. Other factors include market price and the price of production inputs, which can be strongly influenced by the price of oil, exchange rates and trade policies. Local market prices are influenced by a wide range of factors including status of commodity stores, distance to markets, and competition from regional and even global markets. Input prices are also highly variable due to market prices, and volume requirements for some inputs such as irrigation water are weather and climate dependent. Finally, all of the above factors, plus the availability and quality of land and ecosystem characteristics and ecological value play into decisions regarding land use—whether to plant new acreage (extensification) or plant more of a given crop on existing acreage (intensification).

The influence of the RFS on LUC is poorly understood and likely weak. To the extent it suggests otherwise, EPA (2018a) inadequately assesses the range of market and nonmarket factors influencing land use change and does not consider key studies that suggest that the RFS likely had a small, and perhaps negligible effect on LUC, especially changes in land use from non-agriculture to biofuels feedstock (corn and soy). In particular, EPA (2018a) does not adequately consider the role of farm policy such as crop insurance, land characteristics, input and output prices, and technology on growing decisions by farmers.

Studies relied upon by EPA (2018a) to quantify LUC around the time of enactment of the RFS are based on unreliable data and likely overestimate LUC. In particular, EPA (2018a) cites work by several authors who report findings of considerable LUC, including LUC in ecologically sensitive areas such as the Prairie Pothole Region, but do not sufficiently acknowledge or discuss findings by more recent research that indicates that many of the earlier studies were flawed or substantially overstated the extent of LUC in and around the enactment of the RFS. EPA (2018a) also does not sufficiently acknowledge that the studies it relied on do not establish a causal relationship between the RFS and LUC. In addition, EPA (2018a) makes no attempt to quantify, or even describe in any detail, the potential ecological impacts of the alleged LUC, so the actual environmental harm, if any, associated with the RFS remains nebulous. Notwithstanding these shortcomings of the report, EPA clarifies in a subsequent discussion of environmental impacts of the RFS that it *does not* view the literature it identified in the Triennial Report as supportive of a causal link between LUC and the RFS; rather, there is a myriad of "complex regulatory and market factors that are relevant to such a relationship" (EPA 2018b).

A recent effort by Lark et al. (2019) to develop a quantitative link between the RFS and LUC may be the most exhaustive effort to date, but their reliance on an uncertain "business as usual" baseline and on estimating price increases attributable to the RFS are major weakness of the work. Most important, the entire analysis presented by Lark et al. (2019) rests on estimating price increases attributable to RFS, yet the authors fail to adequately acknowledge the role of important factors such as the dietary transition from cereals toward more animal protein in developing countries resulting in rapid growth in the consumption of agricultural commodities. Other important factors affecting corn prices over the period include higher oil prices and the link between the U.S. dollar exchange rate and commodity prices. In addition, the data sets and models used in their analysis are not made explicit, and some data are not in the public domain, precluding a thorough independent review of their work.

EPA (2018a) also failed to adequately account for the role of cropping practices and production of DDGS at ethanol refineries as important LUC offsetting factors. Several studies indicate that a substantial portion of increase corn production following the introduction of the RFS was met via farmers' cropping practices, including switching from other row crops to corn or double cropping corn instead of rotating between corn and soy (or other crops). These studies are not given adequate consideration by EPA (2018a). Although EPA (2018a) acknowledges that production of DDGS may offset some demand for corn as livestock feed, key studies estimate this offsetting effect is considerable. In addition, EPA (2018a) does not discuss whether and to what extent this offset for demand for corn is a market driver that provides downward pressure for LUC to corn.

1.3 Changes in Agricultural Practices Broadly Reduce the Likelihood of Environmental Impacts to Water Resource Availability and Quality

Advancements in technology and water management techniques have continued to increase the efficiency in water resource management by stabilizing, and potentially reducing, the overall volume of water necessary for corn growth. Agriculture accounts for an estimated 80 percent of national consumptive water use in the US according to the USDA's Economic Research Service (2018) and reaffirmed by the National Academy of Science (2019). According to the 2012 statistics from the USDA, irrigated corn acreage represented about 25% of all irrigated acreage in western states, and about 24% of all irrigated acreage in the eastern states (USDA-ERS 2018a). Additionally, the USDA has shown that irrigation for all crops, including corn, has decreased even as the farming acreage has essentially been stable over the past 35 years. The USDA attributes this trend to improvements in physical irrigation systems and water management. The USDA also notes that significant capital investments in on-farm irrigation is continuing, particularly in the western states, where most of the irrigated farm-land is concentrated. As an indication of a positive trend in irrigation reduction, the University of Nebraska, Lincoln reports that in Nebraska (as a bell-weather of other dry western states), the percentage of all corn acreage that is irrigated has declined from a high of 72% in 1981 to 56% in 2017 (University of Nebraska 2018).

Increasing crop yield per area of farmed land is taking place on both irrigated and unirrigated corn crops, suggesting that changes in yield are not attributed to irrigation alone. In certain areas, more corn is now being grown on the same number of acres, which has resulted in increases in irrigation. However, watersheds where most intensification has occurred are mostly in Western states which account for less ethanol feedstock than the less- or non-irrigated Midwest and Eastern States.

Trends and expectations in the biofuel refining process also show increasing water use efficiency and lower water demand over time (upwards of 50% reductions in recent years). This trend is anticipated to continue as ethanol refining technology advances.

Advances in sustainable farm management, including substantial improvements in nutrient formulation and use, and technological improvements in pesticide and fertilizer application, will continue to reduce the potential for impacts to water quality in regional watersheds near corn growing areas regardless of the cause of historical water quality impacts. Additionally, the EPA acknowledges that corn production for ethanol has not been reliably linked to large scale degradation of water quality. The hypothesized causal relationship between the hypoxic zones in the northern Gulf of Mexico and eutrophication in Western Lake Erie with corn grown specifically for ethanol production is weak and lacks supporting data. It is recognized that urban and agricultural runoff in the subject watersheds have likely contributed to the conditions; but EPA (2018a) notes that attributing these water quality issues to ethanol production is speculative and not based on specific data.

1.4 Recent Estimates of Health Damages from Corn Production are Unreliable and Misleading

Although the primary focus of this report is on studies assessing the implications of the RFS program and corn ethanol production for land and water, a recent report that attempts to link corn production to adverse public health impacts from air emissions merits a brief response. A recent publication in Nature Sustainability (Hill et al. 2019) purports to estimate US annual health damages caused by particulate air quality degradation from all direct farm and indirect supply chain activities and sectors associated with maize (corn) production. Although the authors do not reference the RFS, they do mention corn grown for ethanol, and the publication has been referenced by third parties in a manner suggesting that corn grown for ethanol may be associated with adverse health outcomes. Ramboll's review indicates that the conclusions presented by Hill et al. (2019) are unsubstantiated and likely overestimate adverse health impacts, where it is not clear any health impacts exist.

The direct and indirect activities explored by Hill et al. (2019) include air emissions from farms and upstream processes that produce the chemical and energy inputs used in corn crop production: fuel, electricity, agrichemical production, transportation, and distribution. The paper focuses on particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$), which is a concern for human health because particles of this size can penetrate deep into the lungs and enter the bloodstream, and potentially result in both acute and chronic effects to the respiratory and cardiovascular systems. Ramboll reviewed the underlying models and assumptions employed in the Hill et al. (2019) analysis and we present the following findings:

- The model relied upon by the authors uses annual-average data for emissions, meteorology, and chemical/removal rates to estimate annual-average $PM_{2.5}$ impacts. Use of annual averages is inappropriate for representing processes that operate over shorter time scales ranging from minutes to several months (e.g., atmospheric dispersion and chemical formation of $PM_{2.5}$) and results in a high level of uncertainty. The authors acknowledge that this weakness in their approach results in spatial errors in annual average $PM_{2.5}$ calculations. These spatial errors can significantly impact the resulting exposure and mortality estimates. The authors, however, do not present sensitivity analyses to assess the impact of the model assumptions, nor do they include any plausible range of uncertainty or variability with their modeled $PM_{2.5}$ concentration or mortality estimates.
- The 2005 modeling year upon which modeling is based is not representative of more recent chemical conditions of the atmosphere in the U.S., which may lead to an overestimate of the $PM_{2.5}$ contributions from corn production by more than a factor of 2, and this overestimate results in overestimates of health and economic damages.
- Several major sources of uncertainty in the modeling are not acknowledged or accounted for by the authors, including the following key uncertainties:
  - Ammonia emission estimates, which are the largest driver of mortality in the Hill et al. (2019) modeling analysis, are also the most uncertain aspects in any $PM_{2.5}$ air quality modeling, because: (1) emissions are largely from agricultural sources that vary both spatially and temporally due to weather and farming practices; (2) many different methods are used to estimate ammonia emissions, and each can yield very different emission rates and exhibit a high degree of error; (3) annual average ammonia emission inventories used in the modeling fail to account for important seasonal variations and related complex interactions with sulfate and nitrate chemistry; and (4) ignoring diurnal and intra-daily ammonia emission variations have been shown in the literature to overestimate ambient ammonia concentrations by as much as a factor of 2.
  - The health impact assessment is based on a single epidemiological study that found associations between $PM_{2.5}$ concentrations and mortality, but a clear causal link has not been established in the scientific community. In fact, the components of $PM_{2.5}$ that may be associated with adverse health effects are yet unknown, but evidence suggests that carbonaceous particles are more toxic than inorganic particles such as those derived from ammonia and nitrate or sulfate.

Based on our review of literature documenting the development and testing of the simplistic model employed by Hill et al. (2019), we conclude that the model is not able to faithfully reproduce $PM_{2.5}$ impacts estimated by more complex state-of-the-science air quality models. In fact, its performance is at its worst for the very $PM_{2.5}$ component (ammonium) that the Hill et al. (2019) model indicates is the largest contributor to PM mortality from corn production. This renders the modeling especially unreliable for this key PM component. Overall, the uncertainties enumerated above result in unreliable estimates of $PM_{2.5}$ exposure, mortality and related costs associated with corn production, each associated with a large range of variability.

1.5 Environmental Impacts Associated with Ethanol Production Cannot be Viewed in a Vacuum, Without Consideration of Such Impacts Associated with Gasoline Production

EPA (2018a) acknowledges its Triennial Report fails to address environmental impacts associated with gasoline production, but it is important not to view environmental impacts of ethanol in a vacuum given the biased view this presents.

Land use for oil and gas production is extensive. In 2011, the direct footprint of oil and gas production was approximately 1,430,000 acres (Trainor et al. 2016). By 2040, Trainor et al. (2016) estimate the direct footprint of oil and gas production will be approximately 15,890,000 acres.

Habitat fragmentation from oil and gas production is also high and is known to decrease biodiversity (Butt et al. 2013). For example, the fragmentation caused by the dense placement of over 55 pads per square mile in Texas is known to cause a reduction in habitat quality for lizards in the short term (Hibbitts et al. 2013), while in the long term, habitat restoration after the removal of oil and gas infrastructure does not eliminate adverse effects to biodiversity (Butt et al. 2013).

Figure 3: Illustration of Habitat Fragmentation in Jonah Field, Wyoming from Oil and Gas Production.

SOURCE: EcoFlight (USDA 2012)

Oil and gas products, production fluids, and refinery effluent have negative impacts on soil and water quality and flora and fauna when released in the environment (EPA 1999, Wake 2005, Pichtel 2016). The toxicity of crude oil and its individual components has been well studied and these products are known to have negative impacts on wildlife depending on the exposure and dose received (Interstate Technology & Regulatory Council [ITRC] 2018).

Production water, fracking fluids, and refinery effluent, though less well-studied, have also been found to have adverse effects on plants and wildlife, resulting in decreased populations and biodiversity (Wake 2005, Pichtel 2016).

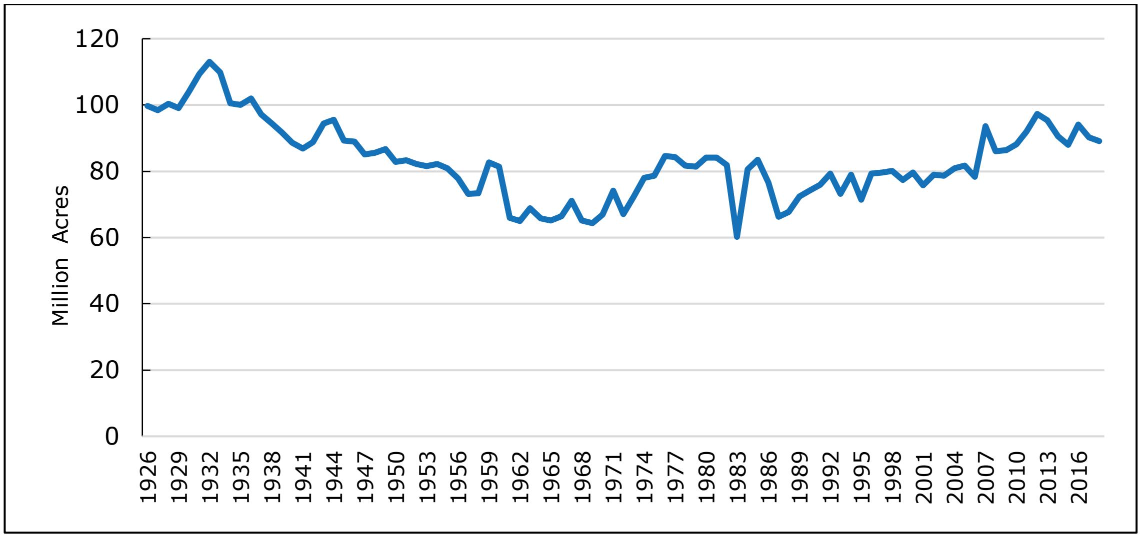
American Petroleum Institute (API) reported approximately 10.8 million gallons of oil were spilled into U.S. Navigable Waters from 1997-2006 with the amount spilled per year varying from 466,000 (2005) to 2.7 million (2004). This figure clearly does not include the Exxon Valdez spill in Alaska in 1989 or the Deepwater Horizon spill in 2010. National data suggest that spills from unconventional oil and gas may amount to one million gallons each year (Patterson et al. 2017). These data are exclusive of major offshore releases and incidents.

The findings and conclusions summarized above and set forth in the remainder of this report are subject to the limitations stated in Section 7.

2. ACRES PLANTED IN CORN HAVE REMAINED AT OR BELOW LEVELS IN THE EARLY 1930s WHILE TOTAL PRODUCTION INCREASED 7-FOLD

The total acres of corn planted in the U.S. has remained relatively stable and in fact has decreased slightly since the 1930s as shown in **Figure 4,** while the approximate share of U.S. corn (in bushels) dedicated to production of ethanol has increased from 4% in 1986 to 38% in 2015 and currently to approximately 50% in 2018 (USDA-ERS 2019b).

Figure 4: Total U.S. Planted Acres of Corn Per Year (million acres).

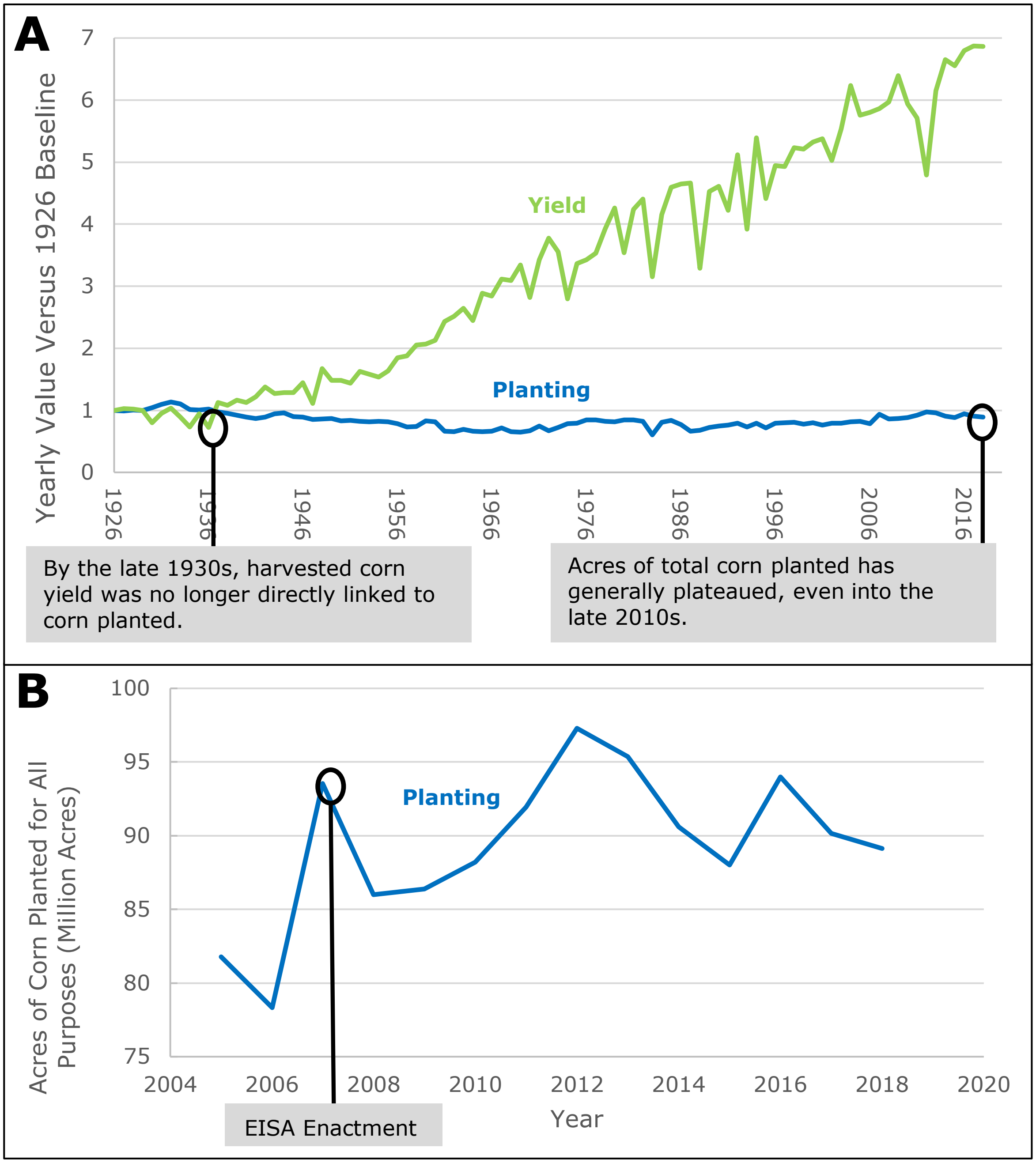


(Source: USDA 2019)

Even as the total corn acreage has been relatively stable or has slightly decreased since the early 1930s, the yield in bushels per acre during this same approximate period has increased dramatically as illustrated by **Figure 5**: A) Annual Yield in Bushels of Corn Per Acre and Annual Acres Planted in Corn Versus 1926. B) Annual Acres of Corn Planted 2004-2018.

These statistics reported by the U.S. Department of Agriculture (USDA) are a positive sign of the ability of farming practices to become more efficient and optimized to generate more yield without adding additional acreage. Also noticeable is that the stability of farming acreage and continued increase in yield extends into the last decade, following the enactment of the EISA. In 2018, 4.7% fewer acres of corn were planted for all purposes in the U.S. as compared with 2007, even though the approximate percentage of corn for ethanol versus other uses has increased. There was regional variation in changes in corn planting; for example, comparing data from 2017 with 2007, approximately two million fewer acres of corn were planted for all purposes in Illinois, with approximately 860,000 additional acres in North Dakota. Regional changes are driven by a wide range of competing macroeconomic conditions, mostly unrelated to ethanol production, including the relative value of crops like spring wheat and cotton, or changes in corn outputs from other countries. Indeed, the EPA confirmed that, for a variety of reasons, even the proposed 2019 RFS renewable volume obligation standards would not be expected to result in an increase in farming acreage (EPA 2018b).

Figure 5: A) Annual Yield in Bushels of Corn Per Acre and Annual Acres Planted in Corn Versus 1926. B) Annual Acres of Corn Planted 2004-2018.



(Source: USDA Crop Production Historical Track Records, 2019)

According to 2018 USDA projections, annual U.S. corn production is anticipated to surpass 15 billion bushels by 2025, while the USDA projects a 2.1-million acre decline in planted corn acres for 2018/19 (Capehart et al. 2018, USDA-ERS 2018b). Schnepf and Yacobucci (2013) cite the following projections by USDA and industry for future increases in corn yield: USDA predicts yields will reach about 240 bushels per acre by 2050 (overall increase of 55% over the 37-year period), whereas the outlook from biotechnology seed company Monsanto is an increase of 300 bushels per acre by 2030, (overall increase of 93% over the 17-year period).

The continued trend of decreases in farmable acres and increases in yield will likely continue to some stable equilibrium that will be controlled by economic and general land resource conditions. There appears to be little or no discussion in reports and documents, such as EPA (2018a), Lark et al (2019) and others, of the significance of these trends.

3. STUDIES HAVE FAILED TO ESTABLISH A QUANTITATIVE RELATIONSHIP BETWEEN THE RFS AND LUC

3.1 Overview of LUC and Environmental Impacts

In this section we first present a discussion of the lack of evidence for a quantitative causal link between increased demand for ethanol from the RFS and LUC. Second, we present a summary of some of the largest sources of uncertainty in studies that EPA (2018a) relies on to assert that the RFS may have resulted in considerable LUC. Third, we discuss the information presented by EPA (2018a) on the topics of cropping practices as well as the role of distiller's dried grains with solubles (DDGS) in offsetting LUC potentially associated with the RFS.

The literature attempting to relate LUC to ethanol production generally acknowledges shortcomings in some of the major data sets, and authors such as Lark et al. (2015) and Dunn et al. (2017) attempt to address these shortcomings by using advanced geospatial analysis techniques and data corrections (Lark et al. 2015, Dunn et al. 2017). Importantly, studies relied upon by EPA (2018a) to quantify LUC around the time of enactment of the RFS are based on unreliable data and likely overestimate LUC.

Assertions made by EPA (EPA 2010, 2018a) to link LUC (including land taken out of the CRP as well as non-agricultural land converted to agriculture) to increased demand for ethanol due to the RFS cannot be substantiated by the underlying literature for a variety of reasons, including, but not limited to the following:

- There are a myriad of complex, interrelated market and non-market factors affecting farmers' decisions on land use and a thorough assessment of the causative factors was not undertaken in the literature cited by EPA (2018a).
- Many studies do not differentiate among crop type (e.g., corn and soy) when looking at LUC and thus it is not possible to establish a causal linkage between LUC and demand for ethanol versus demand for biodiesel from those studies.
- Most studies of LUC are regional or state-specific and there is substantial inconsistency between studies regarding the geographical area of focus. This inconsistency precludes arriving at broad regional or national conclusions. For example, several studies focus on LUC in the Prairie Pothole Region due to this region's environmental fragility; whereas other studies assessed the "western corn belt", "lake states", or the entire continental United States.
- Many studies focus on specific land use types prior to conversion to agriculture (e.g., grassland, wetlands, or land in the CRP) and thus are not inter-comparable.
- Increased demand for all uses of corn may be met via either expansion of agricultural land onto previously uncultivated land (extensification) and by increased production from existing land (intensification). Intensification does not result in LUC and EPA (2018a) does not adequately represent the role of intensification in mitigating the propensity for extensification and LUC.
- Use of corn in ethanol refining produces substantial amount of DDGS and the use of DDGS as a substitute for corn as livestock feed reduces the demand for corn as livestock feed. This issue is not adequately accounted for in the assessment by EPA (2018a) of the potential role of RFS in LUC.

- The literature assessing LUC relative to the RFS generally fails to consider the considerable loss of agricultural land in urban areas and the role this loss may have in extensification elsewhere.

EPA (2018a) reviewed a wealth of information documenting LUC to biofuel crops and potential environmental impacts, but the report presents no coherent arguments or convincing lines of evidence of: (1) a quantitative relationship between ethanol production spurred by increase demand from the RFS and the documented LUC, or (2) quantitative impacts to ecosystems, wetlands, or wildlife. EPA (2010 and 2018a) reference numerous studies of LUC around the time of the enactment of the EISA. Many of these studies combine data over the period pre- and post-2007, making it difficult or impossible to confidently associate observed LUC to the time the RFS came into effect. Many authors also simply infer that there is a relationship between LUC and the RFS without any meaningful exploration of the market drivers for such change. In fact, EPA (2018b) asserts that historically the annual RFS requirements have not driven increased ethanol production and consumption. EPA asserts that this is due to the fact that consumption of ethanol has remained fairly steady since 2013 (when the 10% ethanol/gasoline blend became the predominant fuel), yet corn starch ethanol production has continued to rise well beyond the volumes required by the RFS standard, driven by favorable export markets. Ethanol exports more than doubled over the 2013-2017 period from about 0.62 billion gallons to 1.72 billion gallons (US EIA 2018).

Irrespective of market drivers, EPA (2018a) acknowledges that attributing the causes of land use change to any one factor, including the RFS, is difficult and speculative. Interestingly, EPA (2018a) acknowledges many of these shortcomings, especially in their concluding statement that "*we cannot quantify with precision the amount of land with increased intensity of cultivation nor confidently estimate the portion of crop land expansion associated with the market for biofuels*".[1] EPA (2018a) acknowledges that contributing factors to LUC include market dynamics such as crop prices and input prices (e.g., fuel, transportation costs, costs of equipment, etc.) and nonmarket costs such as those resulting from adverse weather and pests. EPA (2018a) further acknowledges that these and other factors influence land use change and that these factors may be "*coincident with the passage of EISA and therefore correlated in an empirical analysis*".[2] A fundamental problem with many of the studies cited by EPA (2018a) is that they focus on establishing correlations, or simply temporal associations between observed LUC and the RFS, and do not establish causation. EPA (2018b) succinctly summarizes the issue of relating LUC to the RFS as follows: "…*there is no scientific consensus about how to accurately and consistently attribute land use change in the context of biofuels*".[3]

3.2 The Impetus for LUC is Influenced by Complex Factors; and the Influence of the RFS is Poorly Understood and Likely Weak

EPA (2018a) identifies LUC as one of the primary drivers of potential environmental impacts from increased biofuels production, and they devote an entire section to the topic. However, EPA (2018a) also acknowledges the weakness and lack of certainty in many reports that attempt to establish a quantitative link between the RFS and LUC. For example, EPA (2018a) points out that the U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS) data indicate increases in corn crops but in the absence of comprehensive land classification "*it is impossible to know whether these increases came from existing*

[1] EPA (2018a) at page xi

[2] EPA (2018a) at page 22

[3] EPA (2018b) at page 16

agricultural lands or new lands that were not recently in cultivation".[4] EPA (2018a) additionally notes weaknesses in empirical approaches in general, including difficulty in comparing observations and differences in how measured attributes are defined. Consequently, EPA (2018a) acknowledges that it is difficult to attribute the causes of land use changes, including where such changes are coincident with the passage of the EISA.

Several authors have examined LUC from the standpoint of decisions made at the individual farm level. Wang et al. (2017) conducted surveys of 3,000 randomly selected farmers in 37 counties in South Dakota and 20 counties in North Dakota to gain an understanding of the relative importance of different factors affecting land use decisions, and how that relative importance changes with operator and farm characteristics. The results of their survey indicated that the importance of crop output and input prices, innovations in cropping equipment, and weather patterns all increase closer to the economic margin. The authors also found that highly sloped areas are more sensitive to crop prices and crop insurance policies than less sloped land and that as farm size increases, farmers are more sensitive to policy issues and technological innovations (Wang et al. 2017).

Claassen et al. (2011) assessed the effect of farm policy on LUC and found that crop insurance, disaster assistance, and marketing loans contributed to a 2.9 percent increase in cropland acreage between 1998 and 2007 in the northern plains (Claassen et al. 2011). Miao et al. (2015) found that crop insurance reduced the effective cost of land conversion by stabilizing crop revenues (Miao et al. 2016).

Efroymson et al. (2016) use classical causal analysis to elucidate shortcomings of existing studies of the relationship between biofuels policy and LUC. The authors point out that such studies are often based on assumptions that the production of feedstock for biofuels results in the increase in demand for food crops, which in turn, results in an increase in crop prices and expansion of the total area devoted to agriculture; and that this cascading process results in the loss of areas of natural vegetation, including grasslands. EPA (2018a) acknowledges the general premise by Efroymson et al. (2016), describes the methods the authors used, but does not describe the authors' principal conclusion that for LUC, single lines of evidence considered individually are insufficient to demonstrate probable cause. Many of the studies cited by EPA (2018a) in describing a putative relationship between the RFS and LUC indeed focus on single lines of evidence such as the temporal association between LUC and the enactment of the RFS, correlations between LUC and farm proximity to ethanol plants, or LUC and increased production of corn.

Fausti (2015) explored the causal linkages among genetically modified corn, ethanol production, and corn production, hypothesizing that genetically modified corn allowed for the expansion of corn acreage, increased corn production incentivized increased ethanol production, and the RFS allowed this economic feedback mechanism to intensity (Fausti 2015). The author examined pre-RFS data (1996-2000) as well as post-RFS data (2009-2013) and found that the policy-induced [RFS] increase in ethanol production after 2006 had a statistically significant and positive effect on change in corn acres planted. However, although this relationship was statistically significant, Fausti (2015) found that the "policy-induced" change was responsible for only 0.69% to 0.88% percent of the change in corn acres planted.

One line of evidence for a link between RFS and LUC that has been explored by several authors is the relationship between increased acres in corn or LUC and proximity to ethanol

[4] EPA (2018a) at page 21

plants. EPA (2018a) asserts that "*The finding of higher rates of conversion closer to the biorefineries is important and suggests a causal link*".[5] In support of this assertion, EPA (2018a) cites "Motamed and Williams (2016)".[6] EPA (2018a) also states that "*for instance* [Motamed et al. 2016]*, estimated that for every 1% increase in an area's ethanol refining capacity, its corn acreage and total agricultural acreage increased by 1.5% and 1.7%, respectively".*[7] *However, EPA (2018a) ignores the authors' own caveats about interpretation of this finding.* In particular, the authors implicate the observed spatial linkages to food and animal feed, as well as ethanol production, conceding that "*[t]hese outcomes may reflect the efficient response of different producers to new economic incentives, but any externalities associated with these evolving arrangements remain unknown*".[8] In other words, no causal link to the RFS was established.

Wright et al. (2017) is cited several times by EPA (2018a) to provide evidence of the association between land use change (loss of grasslands) and refinery location. In particular, Wright et al. (2017) note that approximately 2 million acres of grassland was converted to row crops within 50 miles of a refinery between 2008 and 2012. However, EPA (2018a) again does not acknowledge a major shortcoming of the study, namely, the authors' admission that their study "*did not consider potential effects of other explanatory variables".*[9] The paper also discussed the errors in the data itself, stating that the "*conversion of non-cropland to cropland was mapped correctly over 70% of the time* " which means that it was mapped incorrectly 30% of the time, a considerable percentage.[10]

Li et al. (2018) examine the determinants of change in corn acreage and aggregate crop acreage as a function of the establishment of ethanol plants and changes in crop prices in the United States between 2003 and 2014. In this nationwide study, the authors report that corn acreage is fairly inelastic with respect to both changes in nearby ethanol refining capacity as well as changes in crop prices (Li et al. 2018). Unlike previous studies of the relationship between LUC and ethanol refinery location that have regional focus, Li et al. (2018) base their findings on the analysis of data for 2,535 counties in the contiguous United States. Li et al. (2018) found that a 1% increase in ethanol capacity in a county was associated with approximately 0.03% to 0.1% increase in corn acreage in that county and a 1% increase in corn price was associated with an approximately 0.18% to 0.29% increase in corn acreage in a county. The authors conclude that previous studies may have overestimated the effect of the proximity of ethanol refineries on planting of corn. The authors did find that the expansion in corn ethanol alone, all else being equal, resulted in a 2.9-million-acre increase in acres planted in corn in 2012 relative to 2008. Critically, however, they noted that most of the increase came from conversion of other crops to corn rather than LUC to corn from a non-agricultural land use. Li et al. (2018) also refute previous studies that purported to show considerable and irreversible LUC to corn, and they recognize that the overall effect of corn ethanol production on total crop acreage was negligible (Stein 2018).

[5] EPA (2018a) at page 35

[6] This study is mis-cited by EPA and should have been Motamed et al (2016). See Section 8 *References* of this report for full citation.

[7] EPA (2018a) Box 3 at page 53

[8] Motamed et al. (2016) at page 741

[9] Wright et al. (2017) at page 9

[10] Wright et al. (2017) at page 3

A review of the above studies indicates that a causal relationship between the RFS and LUC has not been definitively established, and to the extent there is a causal linkage, the relationship is likely weak. These studies as well as EPA (2018a) do not consider in a quantitative way, the potential role of agricultural land loss on extensification. Although EPA (2018a) present some information on agricultural land loss, these studies are not discussed in any detail nor is the potential relationship to extensification.[11] American Farmland Trust estimates that between 1992 and 2012, almost 31 million acres of agricultural land were lost to development—an average rate of loss of 1.55 million acres/year (Sorensen et al. 2018). By comparison, Li et al. (2018) in their nationwide study noted an increase of 2.9 million acres in 2012 as compared to 2008 (an average increase of 725,000 acres per year). It is clear that farmland loss is considerable and very likely affects extensification.

3.3 Studies Relied Upon by EPA (2018a) to Quantify LUC Around the Time of Enactment of the RFS Are Based on Unreliable Data and Likely Overestimate LUC

One of the most pervasive issues in many studies of LUC around the time of the enactment of the RFS is reliance on data sets that have proven to be inaccurate. Some of the key publications that present estimates of LUC post-2007 and were relied on by EPA (2018a) include the following:

- Wright and Wimberley (2013) reported that between 2006 and 2011, based on an analysis of USDA's National Agricultural Statistics Service's Cropland Data Layer (CDL), there was a 1.0-5.4% annual increase in the rate of change of WCB grasslands to corn and soy with total LUC of 530,000 ha (Wright and Wimberly 2013).
- Johnston (2013) assessed wetland to row-crop transition rates in the Dakotas by geographical information system analysis of the intersection of CDL with US Fish & Wildlife's National Wetlands Inventory (NWI) and the U.S. Geological Survey's National Land Cover Database (NLCD) and reported an annualized loss rate of 0.28% (5,203 ha./yr. over a 25-32 year period for NWI data) to 0.35% (6,223 ha./yr. over a 10 year period for NLCD data) (Johnston 2013).
- Lark et al. (2015) analyzed LUC nationwide during the period 2008-2012 using CDL, calibrated with ground-based data from USDA's Farm Service Agency (FSA), and further refined using data from the NLCD. They reported that 7.34 million acres (2.97 million ha.) of previously-uncultivated lands became utilized in crop production while during the same period 4.36 million acres (1.76 million ha.) of existing cropland were abandoned with most of this being land enrolled in the CRP. They also reported that 1.94 million acres (785,000 ha.) of converted lands were planted in corn as a "first crop."
- Morefield et al. (2016) studied LUC using the USDA's CDL over the 12-state Midwest Region and report that between 2010 and 2013, 530,000 ha. (1.3 million ac.) of land formerly in the CRP were converted to row crops with the "vast majority" of these lands converted to soy and corn (Morefield et al. 2016). Of this 530,000 ha., 360,000 ha. (890,000 ac.) were grassland, 76,000 ha. (188,000 ac.) were wildlife habitat, and 53,000 ha. (131,000 ac.) were wetland. They further report that areas in the Dakotas, Nebraska and southern Iowa were hotspots for LUC.
- Mladenoff et al. (2016) assessed LUC in the Lakes States (MN, WI, and MI) and determined that during the period 2008-2013, 836,000 ha. (2,066,000 ac.) of non-agricultural open lands were converted to agricultural use, with conversion to corn

[11] EPA (2018a) Figure 14 at page 33

accounting for 480,000 ha (1,186,000 ac.) (Mladenoff et al. 2016). The authors used USDA's CDL data but combined shrubland and grass/pasture classifications into a single "open land" classification and combined wetland/forest into a single class.

- Wright et al (2017) assessed grassland losses as a function of proximity to ethanol refineries over the period 2008-2012 using USDA's CDL and found that almost 4.2 million acres (1.7 million ha.) of arable non-cropland was converted to crops within 100 miles of refinery locations, including 3.6 million ac. (1.46 million ha.) of converted grassland. Their analysis was based on applying a bias correction factor as per Lark et al. (2015) and making other adjustments.

A major shortcoming of these studies is that the primary data set relied on (CDL) is poor at differentiating between non-crop land classifications. Some authors acknowledged and attempted to correct for this problem to varying degrees. These shortcomings limit the confidence of conclusions regarding the form of the conversion, and even whether actual land use conversion has occurred in some areas.

An illustration of the effect of CDL data uncertainties on many studies relied upon by EPA (2018a) is a paper by Dunn et al. (2017). These authors examined data for 2006-2014 in 20 counties in the PPR using the CDL, a modified CDL dataset, data from the National Agricultural Imagery Program, and in-person ground-truthing, and conclude that analyses relying on CDL returned the largest amount of LUC by a wide margin. They further conclude that errors associated with CDL-based analyses are a major limitation of conclusions drawn from such analyses. In fact, the authors conclude that "*the amount of hectares in the potential error associated with CDL-derived results is generally greater than the number of hectares the CDL-based analysis determined had undergone a transition from grassland, forested land, or wetland to agricultural land".*[12] This suggests that errors in classification inherent in the CDL can result in uncertainty bounds that are of a larger magnitude than the estimates of LUC.

As an example, Dunn et al. (2017) point out that the findings reported by Lark et al. (2015) contradict USDA data indicating that cropland area has remained almost constant during the period 2008-2012. Dunn et al. (2017) is of particular interest because the study focused on the PPR, which has received the greatest attention due to documented ecosystem impacts from habitat loss and wildlife impacts to sensitive species, including population declines of prairie-dependent birds. It is interesting to note that EPA (2018a) acknowledges the specific conclusions reported by Dunn et al. (2017) by stating that adjustments to data made by Dunn et al. (2017) "*led to much lower estimates of land use than either unadjusted CDL and the NAIP for almost all counties examined* [*in the PPR*]".[13] Despite this explicit acknowledgment, EPA goes on to state that "*Nevertheless, these earlier studies* [referring to the studies critiqued by Dunn at al. (2017)] *qualitatively agree with patterns reported in more recent national studies".*[14] EPA's use of the term "qualitatively agree with patterns" in the context of studies that are attempting to quantify LUC after 2007 has little meaning and is misleading to the extent it suggests agreement between studies where little to no such agreement exists.

Table 1 presents a summary of selected results on the analysis conducted by Dunn et al. (2017).

[12] Dunn et al. (2017) at pages 8 and 9

[13] EPA (2018a) at page 35

[14] EPA (2018a) at page 35

Table 1: Summary of Selected Results as Reported by Dunn et al (2017).

	Forest to Cropland (1000 ha.)			Wetland to Cropland (1000 ha.)		
	Dunn et al. (2017)		Lark et al. (2015)	Dunn et al. (2017)		Lark et al. (2015)
State	NAIP (2013)	CDL	modified-CDL	NAIP (2013)	CDL	modified-CDL
MN[a]	1.7	249	5.6	0	38	10
ND	0.83	222	0.44	0.01	25	7.4
SD	1.2	94	0.47	0	47	5.1
TOTAL	3.73	565	6.51	0.01	110	22.5

[a]Includes forest and grassland that was converted to cropland.

CDL data has 30 m resolution and is tested for inaccuracy each year. The accuracy of the CDL data varies yearly and regionally, which is why authors like Lark et al. (2015) make modifications to the data in an attempt to make it more accurate. Dunn et al. (2017) tested the accuracy of the modifications used by Lark et al. (2015) using NAIP data (see **Table 1**). NAIP data are images that are have 1 to 2-meter resolution and allow side-by-side viewing across years with high levels of accuracy. Dunn et al. (2017) found that even with the corrections that Lark et al. (2015) made to the CDL data, the modifications produced "*less land flagged as undergoing LUC but the result may not be any more accurate than a result produced without any modification".*[15] These results suggest that for the areas assessed, estimates using only uncorrected CDL data may overestimate actual LUC by a factor of 150 for forests and a factor of 11,000 for wetlands.

Further, EPA (2018a) mischaracterizes the accuracy of the CDL data[16], as the Agency states that CDL accuracies are generally > 90% for corn and soy and cites a study by Reitsma et al. (2016) in support of that assertion; however the accuracies found in the article were actually much lower than 90% for croplands (Reitsma et al. 2016). Reitsma et al (2016) used high resolution imagery to distinguish between cropland, grassland, non-agricultural, habitat, and water body land uses based on data from 2006 and 2012 in South Dakota. They found that cropland accuracy ranged from 89.2% to 42.6% depending on whether there was more cropland than grassland or the reverse. The authors chose data from South Dakota because the state represents a climate transition such that row crops predominate in the eastern portion of the state and grasslands predominate in the western portion of the state; the change in the dominant vegetation allowed them to examine how the surrounding habitat affected accuracy (Reitsma et al. 2016). The authors state that CDL errors that are inherent to the data sets introduce uncertainty into land-use change calculations. EPA's (2018a) failure to recognize the difference in CDL accuracy is especially important since many authors have documented that most of the observed LUC since 2007 has occurred at the margins of cropland/grassland transition areas. While EPA (2018a) falls short of addressing those specific data set concerns, EPA (2018b) recognizes that although satellite imagery can provide information on the types of crops grown on a given parcel of land in a given year, there is no nationwide system for tracking how crops from a particular parcel of land are used, whether for domestically or internationally consumed biofuels or feed or other uses. Thus, as EPA determined, its Triennial Report "did not purport to establish any causal link between the RFS . . . and increased crop cultivation."

15 Dunn et al. (2017) at page 10

16 EPA (2018a) at page 32

3.4 Recently Released Research Purporting to Establish a Quantitative Link Between the RFS and LUC is Poorly Documented and Flawed

A recent presentation of research results by Lark et al. (Lark et al. 2019) appears to be an ambitious effort to establish quantitative causal linkages between enactment of the RFS as a policy to a variety of environmental outcomes using a series of interlinked models. However, their approach rests on the assumption that the price of corn is heavily influenced by increased demand for ethanol due to the RFS, yet the authors ignore other important factors that could be equally or more important. Nor can they differentiate between price drivers associated with global vs. domestic ethanol demand.

The modeling effort begins with estimates of increased demand for corn for ethanol and effects of the increased demand on the price of corn. The authors then model the effect of this increased demand on crop intensification and extensification and abandonment. The authors then apply a "suite" of models, including what they describe as "causal economic models" to evaluate the resultant land use changes as well as the following environmental outcomes: NO_2 emissions, carbon emissions, and consumptive water use.

With respect to the effect of RFS implementation in 2007 on LUC, the authors conclude that during the period 2008-2016, the RFS resulted in an annual average increase of 6.9 million acres of corn planted on existing cropland. In addition, the authors conclude that during the same period, the RFS resulted in an annual average increase of 2.8 million acres of corn planted on new cropland (i.e., cropland converted from other land cover types), or 43% of the total increase in new cropland observed over the period. The authors attribute these changes to a 30% increase in price of corn attributable to ethanol demand created by the RFS.

The authors attempted to construct the counterfactual case; that is, simulate what the world would have looked like without the RFS (called the "Business as Usual" scenario) and then compare it to existing conditions in order to obtain and isolate the effects of the RFS. However, when a counterfactual is posed that is too far from the real-world data, conclusions drawn from even well-specified statistical analyses become based on speculation and indefensible model assumptions, rather than empirical evidence. Unfortunately, standard statistical approaches assume the veracity of the model rather than revealing the degree of model-dependence, so this problem can be hard to detect. It is well understood that the greater the distance from the counterfactual to the closest reasonably sized portion of available data, the more the counterfactual depends upon model assumptions and inferences. The seemingly large effects of the RFS reported by the authors are simply their comparison between reality and a manufactured counterfactual situation which may or may not reflect a realistic alternative state.

The authors' entire analysis rests on estimating price increases attributable to RFS, and that is the primary weakness evident in the work. The pricing model drives the rest of the analysis. By not examining other model specifications, the inherent assumption regarding the association of prices to the RFS remains speculative. In fact, corn prices over the period of analysis were affected by a variety of other factors. For example, rapid economic growth in developing countries led to growing food demand and a dietary transition from cereals toward more animal protein. As a result, global consumption of agricultural commodities has been growing rapidly. Further, most of the increase in corn prices has been driven by higher oil prices. **Figures 6 and 7** show nominal prices of West Texas Intermediate crude ($/bbl) and corn ($/bu) for the latest 20-year period. The shaded areas reflect US recessions.

Figure 6: West Texas Intermediate Crude Prices ($/barrel).

(Source: Macrotrends. n.d.)

Figure 7: US Corn Prices ($/bushel).

(Source: Macrotrends. n.d.)

Regarding the ability to "measure" land use change, Lark et al. (2019) explicitly recognize many problems with spatial data interpretation and state that land use change was mapped at the field level using the updated recommended practices by Lark et al (Lark et al. 2015). However, the specific data sets used are not disclosed, and there is no description of how the "recommended practices" were applied. The authors also do not provide an assessment of whether and how the "recommended practices" improved estimates of LUC; rather they simply present the results of their analysis. In addition to not presenting a full description of the methods used, the authors rely on at least some data sets that are not publicly available, therefore limiting the ability of a third party to replicate their work. For example, the authors state that their analysis relies on a database built using field boundary data from the 2008 USDA Common Land Unit (CLU) among other data sources. The CLU database is compiled by the USDA FSA and is not in the public domain.[17]

3.5 EPA (2018a) Failed to Adequately Account for the Role of Cropping Practices and Production of Distillers Dried Grains with Solubles (DDGS) at Ethanol Refineries as Important LUC Offsetting Factors

Numerous authors cited by EPA (2018a) who have researched LUC or increasing corn production, and the relationship of these two phenomena to ethanol production have acknowledged that much of the observed change (either LUC to agriculture or increasing corn) may be attributable to cropping practices rather than conversion of non-agricultural land to corn production. The primary cropping practices that may contribute to increased production of corn, without implicating conversion of noncropland to row crops, are switching fields to corn from other crops and double cropping of corn. The use of DDGS also reduces the need for additional acreage of corn, which is often overlooked in analysis of LUC. Similarly, EPA (2018a) fails to discuss the role of DDGS in potentially offsetting market forces that may contribute to LUC occurring to meet demand for corn for ethanol.

3.5.1 Cropping Practices Have a Major Role in Meeting Increased Demand for Corn

EPA (2018a) acknowledges the potential significance of cropping practices by citing, among other studies, a study by Ren et al. (2016) in eastern Iowa that examined changes in corn and soybean rotations around 2017 and found that the most common rotation over the period 2002-2007 was corn/soy, but this rotation was not evident in 2007 and 2012 (with 59% of the area that had been in rotation prior to 2007 was in two or more years of continuous corn after 2007). The most important conclusion reached by Ren at al. (2016) is ignored by EPA (2018a): "*From our analysis, it is clear that the expansion of corn production after 2007 was realized by altering crop rotation patterns* " (Ren et al. 2016).[18] Although this study pertains to eastern Iowa it is of particular importance since Iowa is the largest producer of corn in the US (17.4% in 2018; USDA-NASS, 2019).[19]

EPA also refers to a study by Plourde et al. (2013) when discussing intensification, but EPA does not underscore the primary conclusion of these authors (Plourde et al. 2013). In assessing data for two distinct time periods (2003–2006 and 2007–2010) in a nine state "Central United States" area (states of AR, IL, IN, IA, MS, MO, NE, ND, and WS) these authors found that the total area impacted by corn production only increased slightly between the two periods, while there was a much greater increase in the intensity of continuous corn rotation patterns. Similarly, in discussion about corn acres increasing mostly on farms that were previously soy over the period 2006-2008, EPA cites Beckman (2013) "…*that increases in corn acreage from 2001-2012 resulted in a net decrease in barley, oats, and sorghum* " (Beckman et al. 2013).[20]

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[17] In fact, the FSA website states the following:
CLU is not in the public domain. Section 1619 of the Food, Conservation, and Energy Act of 2008 (Farm Bill), only allows the sharing of this data to individuals or organizations (governmental or non-governmental) certified by FSA as working in cooperation with the Secretary of Agriculture. Users of the data must be providing assistance to USDA programs, and must require access to CLU data to complete that work (USDA 2012).

[18] Ren et al. (2016) at page 157

[19] Calculated from p. 11 in USDA-NASS 2019

[20] EPA (2018a) at page 40

Although EPA (2018a) acknowledges that changes in cropping practices "could be significant," they do not provide a quantitative or even qualitative assessment of how significant cropping might be in meeting increased demand for corn for ethanol. Inadequate accounting of the role of cropping practices in discussion of ethanol and LUC contributes to the misperception that the increase in corn production to fulfill demand for corn for ethanol necessarily results in adverse LUC.

3.5.2 Production of DDGS Has Offset a Substantial Amount of Demand for Corn as Livestock Feed But this was Not Adequately Acknowledged by EPA (2018a)

EPA (2018a) states that approximately 12% of the total corn production from 2014-2016 was returned to the feed market in the form of DDGS which is produced during the distillation of corn for ethanol. EPA (2018a) also acknowledges a study by Mumm et al. (2014)(Mumm et al. 2014) who conclude that although 40% of corn grown in 2011 was estimated to be utilized in ethanol production, when the offsetting effect of DDGS is accounted for, this acreage is reduced to 25%.[21] Although EPA (2018a) cites some of the findings reported by Mumm et al. (2014), they fail to acknowledge some very important conclusions of these authors regarding potential future projections. Mumm et al. (2014) evaluate four scenarios considering the impact of technological advances on corn grain production, two scenarios focused on improved efficiencies in ethanol processing, and one scenario reflected greater use of DDGS. For each scenario, Mumm et al. (2014) estimate the land area attributed to corn ethanol. Assuming reasonable increases in corn grain yield with anticipated new yield technologies coming into play between 2011 and 2026, the authors estimate that the percentage of land devoted to corn for ethanol will be reduced from the 25% estimated for 2011 to 13% in 2026.

Irwin and Good (2013) reported that DDGS account for much of the decline in feeding of whole corn to livestock since 2007-2008. According to the National Corn Growers Association, between 1,013 and 1,222 million bushels of corn were displaced by DDGS and Corn Gluten Feed (CGF; produced by wet milling at ethanol refineries) between 2009 and 2016 (National Corn Growers Association 2019). For illustration purposes, if we assume an average yield of corn per acre per year of 125 bushels (USDA-NIFA n.d.), then over the period 2009 to 2016_DDG/CGF may have displaced ~8.1 – 9.8 million acres of corn production per year that otherwise would have gone for livestock feed. This offsetting factor is more than the 6.9 million acres (yearly average) of corn planted on existing cropland and the 2.8 million acres (yearly average) of new cropland alleged by Lark et al. (2019) to be attributable to the RFS for the period 2008-2015.

[21] Mumm et al. (2014) Box 3 at page 53

4. CHANGES IN AGRICULTURAL PRACTICES REDUCE THE LIKELIHOOD OF ENVIRONMENTAL IMPACTS TO WATER RESOURCE AVAILABILITY AND QUALITY

The relationship between corn production and water resource availability and water quality varies geographically and temporally. What is clear but not quantitatively recognized by EPA (2018a), is that advancements in farming practices and technology have reduced the negative impact of farming on the environment. Recent technological advances have resulted in considerable improvements in water use in agriculture in general, and for corn growing, as well as reducing the use of agrochemicals such as fertilizers and pesticides. These improvements have the effect of reducing the likelihood of adverse impacts to water resource availability and quality.

There is no dispute that all agricultural production is strongly tied to the availability and quality of fresh water. Farming practice is based on local and regional climatic and soil conditions which determine whether crops are grown using irrigation from surface water or groundwater sources or are non-irrigated and rely solely on precipitation. Approximately one-quarter of US cropland is irrigated (NAS 2019). The total US irrigation withdrawals for all crops in 2010 averaged approximately 115 billion gallons per day (NAS 2019). The availability of sustainable water sources, more so than any other issue, poses the greatest threat to crop productivity into the future. Corn is a water intensive crop; however, most corn grown in the US is non-irrigated, and this is recognized by EPA (2018a). Over the past decade, there has been increased use of modern and precision agriculture methods (for both water use and agrochemical application) which retain soil moisture and reduce tilling. This trend is expected to continue into the future, with increasing efficiency and effectiveness of resource use, which will result in reducing water and fertilizer needs.

4.1 The Triennial Report's Discussion of Water Use and Water Quality

Key conclusions in EPA (2018a) relevant to the RFS reset discussion include:

- The environmental impacts of increased biofuel production on water resource use and water quality were likely negative in the past **but limited in impact**.
- A potential exists for both **positive** and negative impacts in the future with respect to water resource use and availability, and impact to water quality both locally and regionally.
- Environmental goals for biofuels production could be achieved with **minimal environmental impacts** (including water and fertilizer/pesticide use) **if best practices were used** and if technologies advanced to facilitate the use of second-generation biofuels feedstocks.

These messages are consistent with our findings that the environmentally protective goals for biofuel production are highly achievable as best management practices and technological advances in farming continue to be adopted by the farming community. While challenges for fully distributing and implementing these approaches will remain in certain areas (e.g., NAS 2019), the economic drivers for implementing best practices such as increased productivity and savings derived from resource conservation, will undoubtedly continue to steer the farming community toward greater implementation of modern approaches.

The most important statements presented by EPA (2018a) are the forward-looking considerations that biofuel production can (and will) achieve environmental goals by using modern practices. EPA (2018a), however, paints a picture of negative impacts from biofuels feedstock production without using specific and conclusive data to support the claims. For example EPA (2018a):

- Asserts that increased intensity of corn production on existing cultivated land and expansion of crop land negatively impacts water quality but presents no direct evidence of a causal link.
- Does not rely on direct analysis to assess the magnitude of potential water quality impacts but instead makes general statements with no quantitative analysis that connects the water quality impact to specific areas, land, or conditions.
- Recognizes that quantitative assessments are necessary to evaluate whether increases in water demands can be directly attributed to feedstock production. However, EPA (2018a) does not provide the studies or backup to support this evaluation, rather merely speculates that negative impacts must exist.

EPA (2018a) suggests that growing corn for ethanol feedstock is a major contributor to eutrophication and hypoxic conditions in the northern Gulf of Mexico and eutrophication in western Lake Erie. EPA (2018a) attributes these conditions to substantial nutrient loading from agricultural runoff. However, the impact, if any, from corn grown for ethanol production on water quality and availability is not substantiated with data. For example, the attribution by EPA (2018a) that biofuel feedstock production is a contributing factor to these conditions appears to rely on models such as those presented by Michalak et al. (2013) that state corn production "could" be a contributing factor and LaBeau, et al. (2014) that speculate biofuel production "could" contribute to increased nutrient loading to surface water (Michalak et al. 2013, LaBeau et al. 2014).

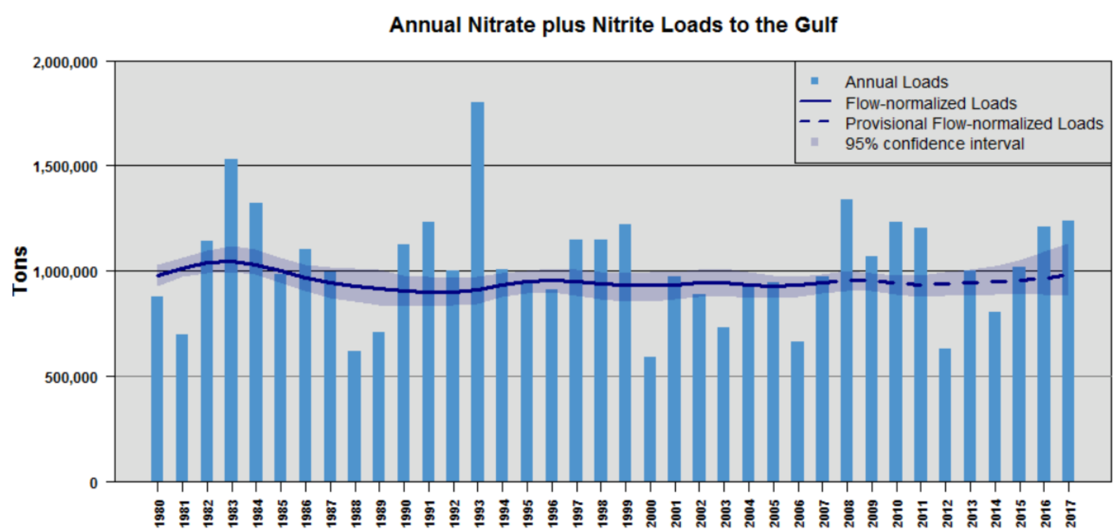
There may be no dispute that excess nutrient loading from the key watersheds that discharge into western Lake Erie and the northern Gulf of Mexico contribute to eutrophication and hypoxia; however, the watersheds are composed of a complex mix of urban and rural uses and wastewater discharges. Agricultural runoff should be considered an important component; however, the direct causal link to corn grown for ethanol production (compared to all other uses and compared to all other agricultural activities) is not substantiated. Indeed, no studies reviewed by Ramboll convincingly link increases in biofuel production to regional hypoxic conditions in surface water bodies. Such conditions have been increasing in frequency and severity since the 1950s, long before ethanol production increased.

EPA (2018a) also fails to acknowledge the importance of regional weather on the occurrence and severity of large-scale hypoxia events. For example, one major variable determining the size of the hypoxic zone (colloquially known as the "dead zone") in the Gulf of Mexico is the rate of flow in the Mississippi River, which may be highly-variable on an annual basis. The National Oceanic and Atmospheric Administration (NOAA) is predicting that the 2019 dead zone in the Gulf of Mexico will cover an area of 7,829 square miles which is close to the record size of 8,776 square miles in 2017 and more than one third larger than the 5-year average size of 5,770 square miles (NOAA 2019). NOAA states that a major factor contributing to the dead zone in 2019 is the abnormally high amount of spring rainfall that has resulted in flows in the Mississippi and Atchafalaya Rivers that are 67% above the average flows over the last 38 years. Data collected by the United States Geological Survey (USGS) indicate that because of these high flows, nitrate loads are about 18% above the long-term average, and phosphorus loads are approximately 49% above the long-term average (USGS 2019).

Finally, EPA (2018a) also fails to recognize that changes in flood-control and navigation improvements in the Mississippi River watershed during the first part of the 20th century dramatically affected the amount of flow from the upper Midwest watersheds that would enter the Gulf of Mexico without environmental buffering from natural tributaries (NOAA 2000). The higher flow rates allowed greater unimpeded flow of water containing nutrients to the Gulf of Mexico than would otherwise have occurred (NOAA 2000).

It is interesting that while EPA (2018a) relies on speculation and qualitative studies to associate corn grown for ethanol to hypoxia in western Lake Erie and the Gulf of Mexico, EPA (2018a) also reports that there has been a reduction in total nitrogen concentrations in surface water bodies in Iowa (the highest corn producing state and an area of corn growth intensification). We note that nutrient loading to the Gulf of Mexico has been relatively stable on average since at least 1980 – an important consideration as corn yield has increased during this time period (USGS n.d.) even as farmed acreage has been stable. This indicates that even during the increased use of corn for ethanol, there has been no net change to nutrient loading to the Gulf of Mexico and thus there is no support for the assertion of a direct relationship between ethanol production on the hypoxia conditions in the Gulf of Mexico. This evidence refutes claims made to the contrary by EPA (2018a).

Figure 8: Annual Nitrate and Nitrite Loading to the Gulf of Mexico 1980-2017.



(Source: USGS n.d.)

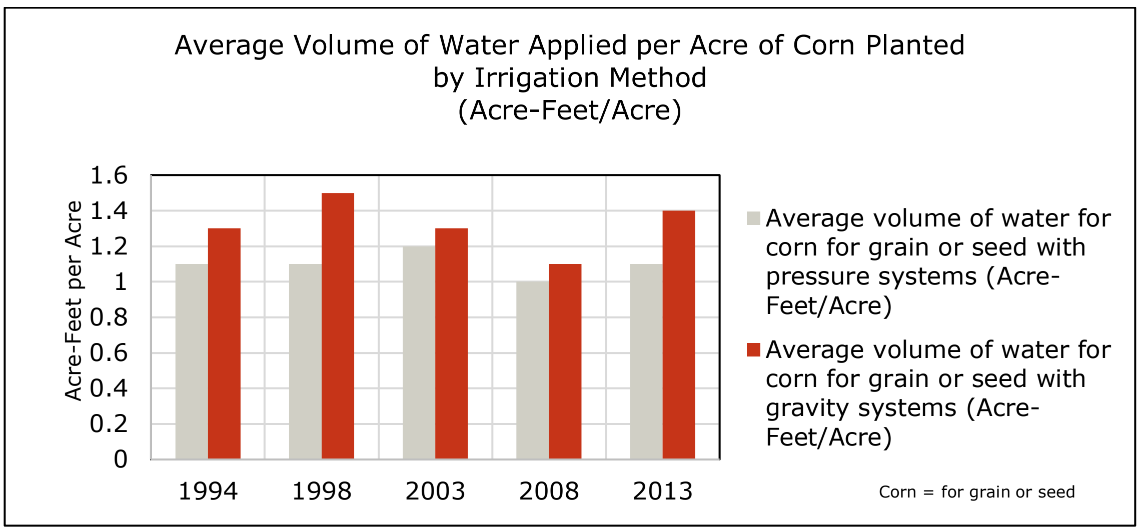
The fact that agricultural practices in general can result in nutrient runoff is acknowledged, although modern efficiencies and conservation methods have improved over time. Modern practices apply technology for increased efficiency and harness continuously improving data analysis to develop and implement best management practices. There is strong evidence that the agricultural community, including biofuel feedstock producers, are adopting modern agricultural practices (Vuran et al. 2018). EPA (2010 and 2018a) acknowledge and strongly advocate for these modern practices and note that negative impacts to environmental resources will be reduced with the use of modern approaches to tilling, fertilizer use, water use, and precision agriculture. If these practices were not being implemented, the expectation is that nutrient loading, and thus hypoxic conditions, should have been increasing along with the increased yield over the past several decades. However, the data from NOAA and the USGS show stability in nutrient loading, which would thus indicate that the net flux of nutrients has not been increasing even while crop yields may have been increasing.

4.2 Agricultural Improvements in Irrigation are Reducing Water Use

The trend of increasing yield per acre farmed extends to both irrigated and unirrigated corn crops, indicating that changes in yield are not likely attributed to irrigation alone. According to the 2012 statistics from the USDA (USDA-ERS 2018a) irrigated corn acreage represented about 25% of all irrigated acreage in western states, and about 24% of all irrigated acreage in the eastern states. Additionally, the USDA has shown that irrigation for all crops, including corn, has decreased even as the farming acreage has essentially been stable over the past 35 years. The USDA attributes this trend to improvements in physical irrigation systems and water management. The USDA also notes that significant capital investments in on-farm irrigation is continuing, particularly in the western states, where most of the irrigated farm-land is concentrated. As an indication of a positive trend in irrigation reduction, the University of Nebraska, Lincoln reports that in Nebraska (as a bell-weather of other dry western states), the percentage of all corn acreage that is irrigated has declined from a high of 72% in 1981 to 56% in 2017 (University of Nebraska 2018).

USDA data indicate that there has been no substantial change in the volume of water applied to corn crops (for grain or seed) since the 1990s (**Figure 9)** (USDA-NASS 2013). This stability in the average volume of water applied to corn crops, combined with the plateau in area of corn planted, suggests that the quantity of water applied to corn crops has not substantially increased since at least the 1990s, despite intensification.

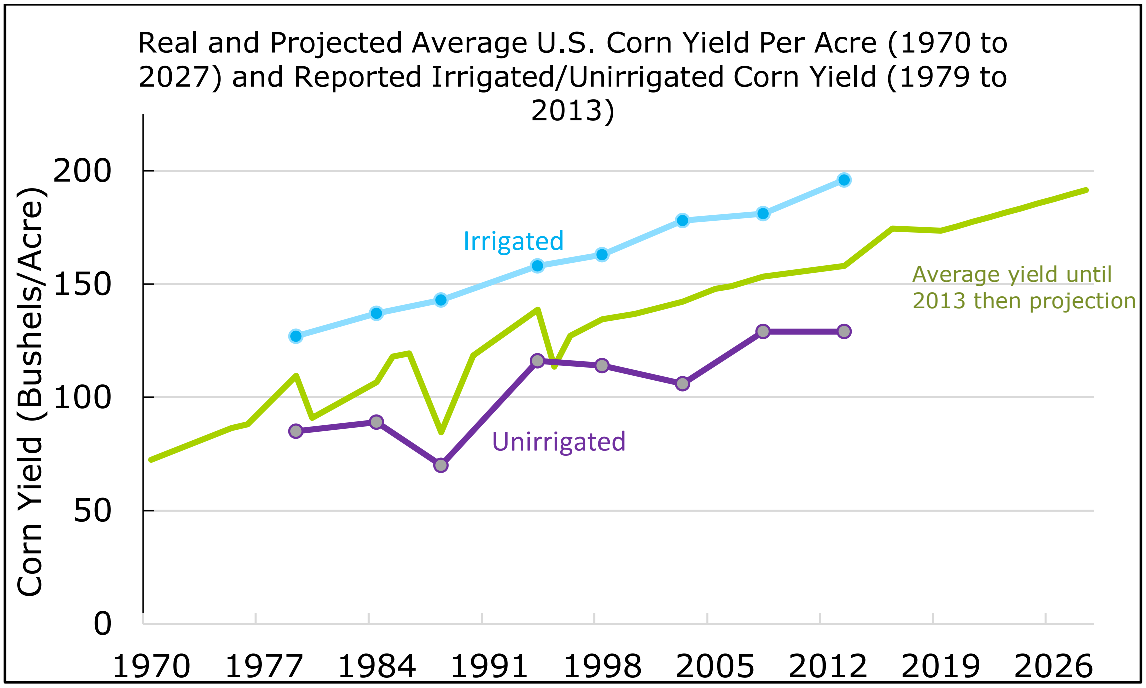
Figure 9: Volume of Water Applied to Irrigated Corn Crops Since 1994, by Irrigation Method.



(Source: USDA-NASS 2013)

Because irrigation provides a stable water resource to the farmed field (assuming the water source that supplied irrigation is also stable), crop yields on irrigated land are generally more regular (e.g., less variable and often more substantial) than for non-irrigated land (**Figure 10)**. Note, however, that from at least 1979 to 2013, increases in yield also have been observed in unirrigated corn crops (USDA Farm and Ranch Irrigation Survey). Specifically, in 1979, irrigated land produced 127 bushels per acre on average, versus 85 for unirrigated land. By 2013, irrigated land produced 196 bushels per acre on average, versus 129 bushels per acre for unirrigated land, representing a 54% and 52% increase, respectively.

Figure 10: While Irrigated and Unirrigated Corn Crops Have Both Experienced General Increases in Yield, Irrigated Crops More Reliably Produce Higher Yields.



(Source: USDA-NASS 2013)

Regions of greatest corn production are moving eastward away from the regions of greatest irrigated water use, providing further evidence that year-to-year changes in corn planting have little to negligible impact on total U.S. water supply. For example, in 2016, the five leading states in annual corn production (Illinois, Nebraska, Iowa, Minnesota, and South Dakota) produced over 60% of the corn grown in the U.S. (USDA-ERS 2016). This statistic is a change from the 2010s when the irrigation of corn crops was even more concentrated in the drier Northern Plains (Colorado, Montana, Nebraska, Wyoming, and North and South Dakota) and dry Southern Plains (Kansas, Oklahoma, Texas) regions. In 2007, the USDA reported that the thirteen leading states in total irrigated acres for all crops of farmland, accounted for nearly 80% of all U.S. irrigated land, but that they were concentrated in arid western states (USDA-ERS 2018a). Of the top five corn-producing states, none made up more than 15% of the total U.S. irrigated acreage. The increased growth in wetter states such as Illinois and Minnesota eases the water supply demand for the total yield of all irrigated corn acres.

USDA anticipates that changes in corn production will result in appreciable yield increases (e.g., 16.1 more bushels per acre by 2028) (USDA-NASS 2017). It is therefore reasonable to expect that technological and methodological changes to farming will continue to result in significant reductions in water use per unit of corn production. **Table 2** presents an overview of prevailing opportunities for water savings in irrigated agriculture.

Table 2: Technological and Methodological Improvements to Irrigation of Corn Crops.

Technological Advancement	Approximate water savings factor	Baseline scenario	Demonstrated potential yield increase	Notes
Subsurface drip irrigation	**25-35%**	vs. center pivot system	**15-33%**	Costs 40-50% higher than center pivot systems but returns on investment can accrue within 2—5 years. In 2007, only 0.1% of irrigated corn farms used this.
Rain water harvesting and storage	**50+%**	vs. natural soil runoff	**20-52%**	Includes 1) harvesting of surface runoff from roads; 2) field micro-catchment to increase fallow efficiency in rain.
Precision agriculture	**13%**	vs. without government-run weather network	**8%**	Includes use of global positioning system, geographical information systems, in situ soil testing, remote sensing crop and soil status, real-time weather info. Adoption rate slightly higher in corn belt.
Conservation structures	**18%**	vs. conventional agriculture	**27%**	Examples include grass vegetation strips. Adoption is higher in areas of highly erodible land.

(Sources: Netafim n.d., Gowing et al. 1999, Shangguan et al. 2002, National Research Council 2008, Biazin et al. 2012, Allen 2013, Barton and Elizabeth Clark 2014, Center for Urban Education about Sustainable Agriculture (CUESA) 2014, Qin et al. 2015)

Subsidized government programs offer farmers incentives to implement water conservation strategies. For example, because of prolonged drought conditions, California recently installed a network of 145 automated statewide weather stations, so that farmers could manage their water resources more efficiently (CIMIS 2019).

With the focus on drought and long-term reductions in supplied water in some states (such as California), more farms are moving away from "traditional, less-efficient application systems" (USDA-ERS 2018a). For example, the number of farms using inefficient gravity irrigation systems decreased from 62% in 1984 to 34% in 2013, converting mostly to pressure-sprinkler irrigation which is more efficient than gravity irrigation, but which still leaves room for improvement. Currently, almost 10% of farms use soil-moisture or plant-moisture sensing devices or commercial irrigation scheduling services. Sensor technology can optimize irrigation scheduling and hence increase water use efficiency. Though less than 2% of farms use simulation models right now (USDA-ERS 2018a), the anticipation is that additional large industrial farms (which make up a large volume of total yield) also will employ water use simulation models that are based on corn growth patterns and weather conditions. Adoption of these technologies will continue to grow in the U.S., and particularly in the west, where 72% of water irrigation investment takes place and farmers have recent experience with low water supply following the 2012-2016 drought.

Barriers to implementing these measures are lessening but it is recognized that issues relating to the following are still at play: (1) farmer concerns about the impact of new practices on yields; (2) tenant or lease issues that discourage the installation or use of new equipment; (3) institutional issues related to Federal Crop Insurance Program; (4) irrigation water rights laws like "use it or lose it;" and (5) cost of implementation. The Great Plains area had traditionally been risk-averse to implementing subsurface drip irrigation techniques because of the upfront costs and uncertain lifespan of the systems; however, there have been improvements in the technology and irrigators are increasingly aware of the additional incentives for water conservation and protecting water quality (Lamm and Trooien 2003).

Genetic engineering or selection for improved drought tolerant corn cultivars has also contributed to increases in corn crop productivity. Additionally, genetic breeding has shown that yields can be maintained with lower water requirements (nearly 25% reduction), in addition to studies that suggest corn crops can forego the initial irrigation without significant adverse effects to the harvest (Xue, Marek, et al., 2017). Mcfadden et al. (2019) reported that with drought being among the most significant cause of crop yield reduction, the spike in use of irrigation water to reduce such losses can be a major negative impact to water resource availability particularly in the drier western states. Even though many water-intensive crops, including corn, are grown on non-irrigated land, the use of drought-tolerant corn, which was commercially introduced in 2011, had increased to over 22 percent of the total U.S. planted corn acreage by 2016 (Mcfadden et al. 2019). More important, this percent of use was greatest in the driest corn-producing states of Nebraska (42 percent) and Kansas (39 percent). Even the less severe drought-impacted though important corn-growing states of Minnesota, Wisconsin, and Michigan saw drought-tolerant corn planting ranging between 14 and 20 percent of total acreage. There is no guarantee that drought-tolerant crops will be effective against the most severe droughts; however, this use can be seen as similar to the use of crop-insurance to protect farmers against loss while still providing product for use during low-water years. The longer-term advantage is that less irrigation water would be required even under normal water years.

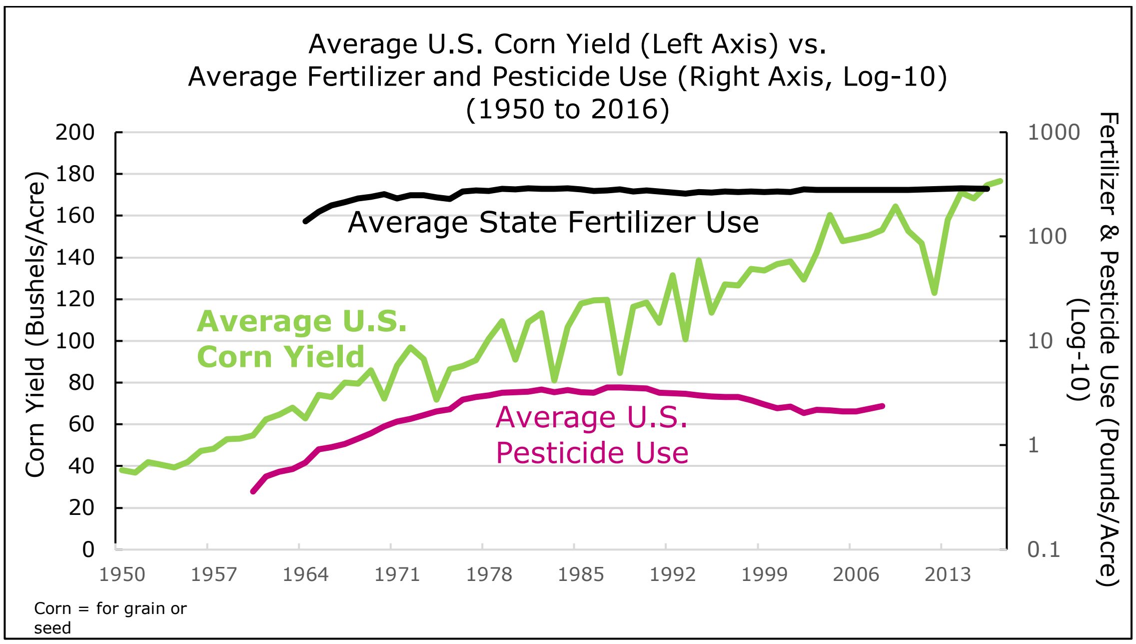
Liu, et al (2018) states that best management practices for reducing agricultural non-point source pollution are widely available even with the challenges related to the large number of agricultural producers and the spatially variable and temporally dynamic nature of the nutrient loading cycles. Greater adoption of the improved practices will rely on: (1) better identification of the higher risk areas; (2) a commitment from local, state and federal authorities to assist the farming community in applying the new approaches by allowing innovations to be implemented without unnecessary regulatory impediments; and (3) better financial incentives. Liu, et al (2018) also note that lack of information and misdirected communications can negatively impact the adoption of new techniques and encourages government, consumers, and farmers to work together to more consistently communicate the advantages of technology adoption.

4.3 Technological Improvements in Agriculture Translate to Reductions in Potential Water Quality Impacts

Government institutions including USDA and academic institutions such as California State University, Fresno have promoted research into the use of precision agriculture to reduce the need for both nutrient and pesticide use (as well as supplied water) because in addition to a reduced environmental impact, the techniques result in cost savings for farmers by improving yield per acre. In addition, the greater use of area-wide databases that provide better information and awareness of water quality conditions helps to identify areas where additional best management practices can be applied. For example, utilization of the USGS water quality mapping reports (e.g., USGS 2017) helps provide data for surface water chemistry trends (i.e., nutrients, pesticides, sediment, carbon, salinity) and aquatic ecology from 1972 to the current editions.

Recent advancement in technology for fertilizers and pesticides have reduced the use of agricultural chemicals while increases in crop yield continue. While use of fertilizer on corn typically accounts for more than 40% of commercial fertilizer used in the U.S. since the 1980s (USDA-National Resources Conservation Service [NRCS] 2006, EPA 2018c), there has been a plateau in the mass of fertilizer applied to corn crops (on average on a state-by-state basis), as well as an overall decrease in the mass of pesticide applied to corn crops (see **Figure 11**;(USDA-NASS 2013, Fernandez-Cornejo et al. 2014, USDA-ERS 2018c). In 1987, the average mass of pesticide active ingredient application per area of corn planted in the U.S. peaked at approximately 3.58 pounds per acre. In 1984, fertilizer use peaked at approximately 290 pounds per acre. The USDA and EPA report similar trends; for example, U.S. spending on pesticides for all crops peaked in 1998, and consumption of commercial fertilizers peaked in 1981 (Fernandez-Cornejo et al. 2014, EPA 2018c).

Figure 11: Both Pesticide and Fertilizer Use on U.S. Corn Crops Appear to Have Peaked in the 1980s



(Source: USDA [ibid.])

The application of slow released (or controlled) nitrogen fertilizer during peak uptake is one key to improving nutrient efficiency and utilization (Lal, R. (Ed.), Stewart 2018). Under optimum moisture and temperature conditions, use of slow released nitrogen fertilizer can greatly reduce leaching of nutrients. However, further research is necessary to discern the best slow release fertilizer for a given crop species (Rose 2002). Other advanced chemical technologies such as use of bioreactors, can offer additional reductions in pesticide and fertilizer in corn production. Bioreactors such as those that redirect water in farm fields through tiles to underground woodchips where nitrate is removed by microorganisms, can reduce nitrogen in run-off by 15% to 90% (Iowa Corn n.d., Christianson 2016).

Recent surveys and data from the use of the modern and technology-based agricultural management systems have shown reduced resource needs and significant cost savings (NAS

2019; Liu, et al. 2018). The USDA also has shown that a “guidance-based” system for corn production can save thousands of dollars each year with a return of investment of two to three years for this technology (USDA-NRCS 2006). Furthermore, the USDA reports that “…precision agriculture reduces environmental pollution and improves water quality by reducing nutrient runoff [while] other benefits include: improved crop yield; reduced compaction [of fields]; labor savings; and more accurate farming records.” Finally, there are fewer barriers to nearly all farmers in using precision technologies because of grants that are available for purchasing equipment and free public access to the Federal Global Position System that makes it economically possible for producers to use the new precision tools to save energy and reduce costs by improving or implementing the following: (a) yield monitoring, (b) grid soil sampling, (c) precision and variable-rate nutrient application; and (d) soil moisture monitoring. Precision agriculture technologies are quickly adopted by farmers in the United States; the rate of adoption for all precision technologies was 72.47 percent in 2010, as compared to just 17.29% in 1997 (Vuran et al. 2018). USDA found that if guidance-based farming was used on just 10 percent of planted acres in the U.S., fuel use would be cut by 16 million gallons, herbicide use would be reduced by 2 million quarts and pesticide use would lower by 4 million pounds per year(USDA-NRCS 2006). The results would be better environmental conditions and substantial increase in financial savings for the farmer/producer.

4.4 Reduction in Water Usage for Ethanol Processing

Opportunities exist for implementing water reduction programs during biofuel production. Excluding the non-fuel component, the primary processes that require water consumption in ethanol production include heating and cooling. Water losses occur through: (1) evaporation, drift, and blow down from cooling towers; and (2) blow down from boilers. Losses vary with both the ambient temperature of the production plant, and the degree of boiler condensate and blow down water reuse and recycling. Generally, dry mills use less water than wet mills. In a 2007 Renewable Fuels Association survey of 22 ethanol production facilities (representing 37% of the 2006 volume produced), dry mills used an average of 3.45 gallons of water per gallon of ethanol produced and wet mills used an average of 3.92 gallons of water per gallon of ethanol produced. Efforts to use recycled waste water are increasing and will reduce the need for using supplied water during the conversion process.

Keeney and Muller (2006) report that in Minnesota, water use by dry mill ethanol refineries ranged between approximately 3.5 and 6.0 gallons of water per gallon of ethanol in 2005 which followed a 21% reduction in water use by dry mill ethanol refineries from 1998 to 2005 (representing an annual reduction of approximately 3%). More recently, Dr. Steffen Mueller of the University of Illinois (Chicago) Energy Resources Center notes that water consumption by ethanol plants is continuing to decrease and dramatically so. Mueller (2016) documents a reduction of approximately 5.8 to 2.7 gallons of water per gallon of ethanol produced between 1998 and 2012 in dry mills.

Wu and Chiu (2011) noted additional trends that suggest decreases in the water demands of existing and new ethanol plants. Freshwater consumption in existing dry mill plants had, in a production-weighted average, dropped 48% in less than 10 years to water use rates that are 17% lower than typical mill values. Water use can be minimized even further through process optimization, capture of the water vapor from dryers, and boiler condensate recycling to reduce boiler makeup rates.

5. RECENT ESTIMATES OF HEALTH DAMAGES FROM CORN PRODUCTION ARE UNRELIABLE AND MISLEADING

A recent publication in *Nature Sustainability* (Hill et al., 2019) estimates US annual health damages caused by particulate air quality degradation from all direct farm and indirect supply chain activities and sectors associated with corn production. Although the authors do not reference the RFS, they do mention corn grown for ethanol, and the publication has been referenced by third parties in a manner suggesting that corn grown for ethanol may be associated with adverse health outcomes. Ramboll's review indicates that the conclusions presented by Hill et al. (2019) are unsubstantiated and likely overestimate adverse health impacts if any.

These "life-cycle" activities and sectors examined by Hill et al. (2019) include air emissions from farms and upstream processes that produce the chemical and energy inputs used in corn crop production: fuel, electricity, agrichemical production, transportation and distribution. Downstream activities such as corn distribution and food/fuel processing are not considered in the study. The authors develop an annual county-level emissions inventory of air pollutants for all related sectors, then apply a specific "reduced form model" (RFM) that converts those emissions into spatial distributions of annual fine particulate air concentrations (or $PM_{2.5}$) and resulting human exposure, premature mortality, and monetized health damages.

$PM_{2.5}$ comprises microscopic particles smaller than 2.5 microns in diameter, with chemical constituents that include direct (primary) emissions (dust and smoke) along with the several secondary compounds chemically formed in the atmosphere from gas precursor emissions: nitrate from nitrogen oxide (NOx) emissions, ammonium from ammonia emissions, sulfate from sulfur oxide (SOx) emissions, and secondary organic aerosols (SOA) from volatile organic compound (VOC) emissions. $PM_{2.5}$ is a concern for human health because particles of this size can penetrate deep into the lungs and enter the bloodstream, which can potentially result in both acute and chronic effects to the respiratory and cardiovascular systems. Epidemiological studies have found associations between $PM_{2.5}$ exposure and mortality and these associations are used by Hill et al. (2019) to calculate health impacts from corn production. The authors find that impacts to annual-average $PM_{2.5}$ concentrations from corn production are primarily driven by emissions of ammonia from nitrogen fertilizer.

Ramboll reviewed details of the specific RFM used by Hill et al. (2019), called the Intervention Model for Air Pollution (InMAP; Tessum, Hill, et al., 2017) to calculate ambient $PM_{2.5}$ impacts from corn production. InMAP calculates atmospheric dispersion, chemistry and removal (deposition) from direct $PM_{2.5}$ and precursor gas emissions. It then converts resulting annual $PM_{2.5}$ concentrations to human exposure metrics from which premature mortality and associated damages are determined. Hill et al. (2019) provide only an overview of the process to develop emission inventories, which limits our capacity to review. However, given the importance of ammonia emissions to the results reported by Hill et al. (2019), we enumerate well-known uncertainties involved in estimating emissions from agricultural activities. In addition, although Hill et al. (2019) did not provide explicit details on the impact assessment, we provide a summary of the key uncertainties associated with estimating health and associated costs from $PM_{2.5}$ exposures. It is noteworthy that the authors do not provide any uncertainty or sensitivity analyses that can provide important context for the interpretation of the results and conclusions.

Based on our review of Hill et al. (2019) and of Tessum et al. (2017), we draw the following conclusions:

- InMAP uses annual-average data for emissions, meteorology, and chemical/removal rates to estimate annual-average $PM_{2.5}$ impacts. Use of annual averages is inappropriate for representing processes that operate over shorter time scales ranging from minutes to several months (e.g., atmospheric dispersion and chemical formation of $PM_{2.5}$). The authors acknowledge that this weakness in their approach results in spatial errors in annual average $PM_{2.5}$ calculations. These spatial errors can significantly impact the resulting exposure and mortality estimates. The authors, however, do not present sensitivity analyses to assess the impact of the model assumptions, nor do they include any plausible range of uncertainty or variability with their modeled $PM_{2.5}$ concentration or mortality estimates.
- The 2005 modeling year upon which InMAP is based is not representative of more recent chemical conditions of the atmosphere in the U.S. because there have been significant reductions in precursor emissions that directly reduce the capacity to form $PM_{2.5}$. We estimate that this leads to an overestimate of the $PM_{2.5}$ contributions from corn production by more than a factor of 2. Therefore, resulting health and economic damages are likely overestimated.
- Ammonia emission estimates, which are the largest driver of mortality in the Hill et al. (2019) analysis, are the most uncertain aspects in any air quality modeling exercise because: (1) emissions are largely from agricultural sources that vary both spatially and temporally due to weather and farming practices; (2) many different methods are used to estimate ammonia emissions, and each can yield very different rates and exhibit a high degree of error; (3) annual average ammonia emission inventories fail to account for important seasonal variations and related complex interactions with sulfate and nitrate chemistry; (4) ignoring diurnal and intra-daily ammonia emission variations have been shown in the literature to overestimate ambient ammonia concentrations by as much as a factor of 2. These numerous uncertainties and compounding error rates call into question the estimates of emissions that drive the rest of the Hill analysis.

Based on our review, InMAP is not typically able to reproduce $PM_{2.5}$ impacts estimated by more complex state-of-the-science air quality models. In fact, its performance is worst for the very $PM_{2.5}$ component (ammonium) that Hill et al. (2019) model indicates is the highest contributor to PM mortality from corn production. This renders InMAP especially unreliable for this key PM component.

In addition to the number of significant uncertainties in all modeling aspects of the Hill et al. (2019) analysis, including the emissions estimates and the RFM InMAP modeling, there is also a significant amount of uncertainty associated with estimating health impacts from air pollution concentrations and from quantifying the costs of these health impacts.

The health impact assessment is based on a single epidemiological study that found associations between $PM_{2.5}$ concentrations and mortality. While these studies suggest that such an association exists, there remains uncertainty regarding a clear causal link. This uncertainty stems from the limitations of epidemiological studies to establish causality because these studies are based on inadequate exposure estimates and these studies cannot control for many factors that could explain the associations between $PM_{2.5}$ and mortality – which, for example, may not be related to $PM_{2.5}$. from the source being investigated (e.g., lifestyle factors like smoking). In fact, the components of $PM_{2.5}$ that may be associated with adverse health effects are yet unknown, but evidence suggests that carbonaceous particles are more toxic, than inorganic particles such as those derived from ammonia and nitrate or sulfate.

Overall, the uncertainties enumerated above result in unreliable estimates of $PM_{2.5}$ exposure, mortality and related costs associated with corn production, each associated with a large range of variability.

6. ENVIRONMENTAL IMPACTS ASSOCIATED WITH ETHANOL PRODUCTION CANNOT BE VIEWED IN A VACUUM, WITHOUT CONSIDERATION OF SUCH IMPACTS ASSOCIATED WITH GASOLINE PRODUCTION.

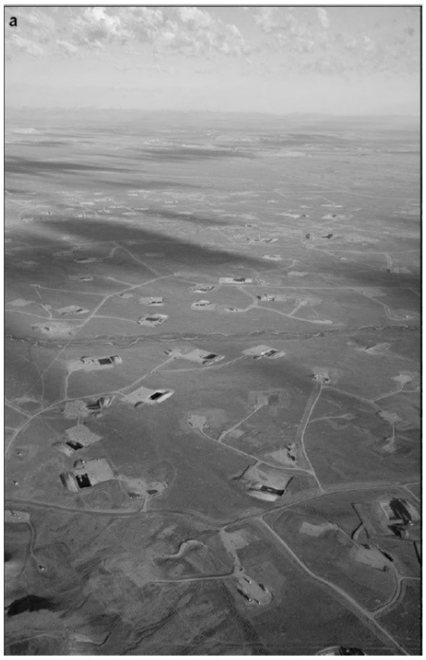
EPA (2018a) acknowledges that it fails to address environmental impacts associated with gasoline production. Spills of petroleum, gasoline, and a wide range of other fluids used in the exploration, production, and refining processes as well as land use change to support those activities all have adverse effect on water quality, ecosystems (including wetlands), and wildlife. Additionally, both conventional and unconventional oil and gas extraction place demands on water supply. Failure to address impacts associated with gasoline production relative to impacts from ethanol production does not present a balanced view of alternative energy sources and casts a negative bias on ethanol production. Parish et al. (2013) recognize the importance of understanding differences in environmental effects of alternative fuel production so that the relative sustainability of alternatives can be adequately assessed in policy-making and regulatory decisions. Parish et al. (2013) assessed negative environmental impacts through the supply chain for ethanol production and gasoline production and found that impacts from ethanol production are more spatially limited, are of shorter duration, and are more easily reversed than those associated with gasoline production. It was beyond the scope of this report to expand upon the work of Parish et al. (2013) or other comparative studies, rather this Section presents a brief description of the wide range of potential impacts associated with petroleum production stemming from land use changes as well water use and impacts to water quality.

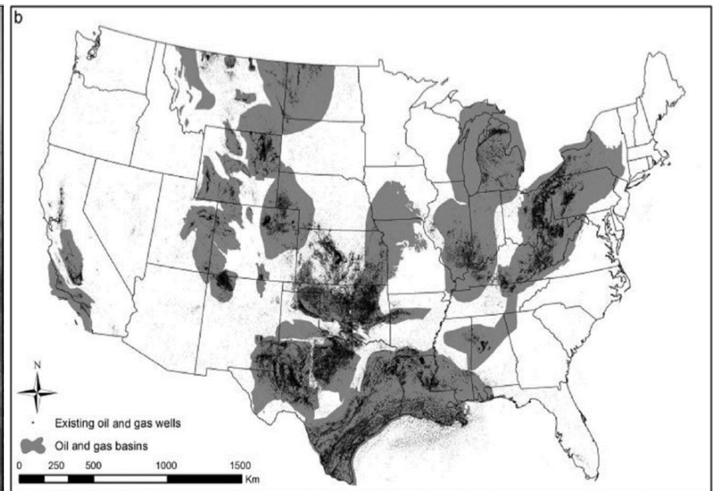
6.1 Impacts of Gasoline Production Associated with Land Use Change

Oil and gas can be extracted using conventional or unconventional (i.e., hydraulic fracturing) methods, with some resultant variability in associated land use change impacts. Both methods require the construction and maintenance of a well pad and placement of pumping machinery. To install any onshore well pad, the land must be cleared and leveled, which requires the construction of access roads in most cases. A water well to provide water to the site and a reserve pit for cuttings and used drilling mud may also be necessary. Once this infrastructure is in place, the oil rig can be assembled on site. Diesel engines and electrical generators provide the power for the rig. Once the oil has been reached, for a conventional well, a pump is installed and much of the rig and other machinery can be removed and some altered areas can be restored. However, the pad area and some access roads and pipelines must remain throughout the life of the well. A typical lease area has many different oil wells and pads that are connected by roads and utilities which fragment the surrounding habitat. In Texas, well pad density may be over 55 pads per square mile (Hibbitts et al. 2013). The typical lifespan of an oil or gas well is 20-30 years, though this varies due to geology and the amount and type of oil present (Encana Natural Gas 2011). Once the well and pad have reached the end of their life, they may be removed, and the area can be restored. However, restoration does not eliminate the environmental damage the well caused; research has shown that local biodiversity loss can have cascading effects on ecosystem productivity and function (Butt et al. 2013).

In the United States, the land use change caused by wells is considerable due to the high numbers of wells in many locations (**Figure 12**).

Figure 12: Oil and gas field in Wyoming; Areas with Suitable Resources for Future Extraction.





Both panels reproduced from Jones *et al*. 2015. a) Oil and gas field in Wyoming; Photo by David Stubs. b) Current oil and gas wells (dots) and areas with suitable resources for future extraction (shading).

In 2017, there were 990,677 onshore and offshore oil wells in the US, down from 1,038,698 in 2014 (U.S. EIA 2018a). The average size of an onshore unconventional well pad is 3.5 acres (Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences n.d.), while an onshore conventional well pad in Texas is about the same, or roughly 3.4 acres (Young et al. 2018a). When only the direct footprint of onshore domestic wells is considered, the US had over 1,429,999 acres of well pad infrastructure in 2011 (Trainor et al. 2016). Trainor et al. 2016 predicted that by the year 2040, the direct footprint of oil and gas land use could increase to 15,891,100 acres. The actual landscape impacts are almost double the footprint, due to the spacing requirements of wells (Trainor et al. 2016). Thus, the full landscape impact of oil and gas estimated for 2040 is roughly 31,782,200 acres. The large landscape effects of oil and gas have implications for environmental effects.

Conventional and unconventional wells require roads and other impermeable infrastructure that result in highly altered landscapes (Jones et al. 2015, Garman 2018). The land use change to altered landscapes has direct effects on habitats and wildlife (Butt et al. 2013, Garman 2018, Young et al. 2018b). Land use change for well construction increases habitat fragmentation, pollution, noise and visual disturbance, and causes local habitat destruction; all of which can decrease biodiversity (Butt et al. 2013, Garman 2018, Young et al. 2018b). Some of these disturbances, such as fragmentation, are not unique to oil and gas extraction, and research on their effects is explained in other literature (Brittingham et al. 2014). For example, it is well known that fragmentation can split breeding populations and reduce genetic variability within each population, potentially making them less adaptable to other disturbances (Keller and Largiadèr 2003, Langlois et al. 2017).

Wildlife populations have been shown to decrease near areas with oil and gas production due to habitat fragmentation, density of wells, human activity, noise and light pollution, avoidance, and other factors (Jones et al. 2015). For example, habitat fragmentation by well pads reduced the use of preferred habitats of lizards in Texas, which is likely to decrease the populations of habitat specialist species (Hibbitts et al. 2013). Density of well pads has been shown to decrease the population size of several species of songbirds in Wyoming (Gilbert and Chalfoun 2011). Greater sage-grouse (*Centrocercus urophasianus*) in Montana and Wyoming were found to avoid sagebrush habitats that would otherwise be high quality when those areas are near natural gas development (Doherty et al. 2008). Threatened woodland caribou (*Rangifer tarandus caribou*) avoid areas within 1000 m of oil and gas wells and 250 m of roads in northern Alberta, Canada, especially during calving season (Dyer et al. 2001). This avoidance reduces available habitat and can decrease caribou population size (Hervieux et al. 2005). Direct mortality from contact with infrastructure is also a problem; an average of 8.4 birds die in each uncovered reserve pit each year (Trail 2006), thousands more birds die due to gas flare stack emissions (Bjorge 1987), and many more may die due to the gas flare stacks and gas compressors on well sites (Jones et al. 2015).

Development of areas for oil and gas production causes secondary land use conversion as more people move into the production area. If the well is in a remote area the increase in population size can cause other cascading negative effects such as illegal hunting and the increase in introduction of exotic species of plants and animals. Both direct and cascading environmental impacts can be especially harmful in delicate ecosystems, such as the Prairie Pothole Region (Gleason and Tangen 2014).

The United States is composed of many different habitats that energy development affect (McDonald et al. 2009), as shown in **Figure 13**. When comparing **Figure 12** and **Figure 13**, it is clear that oil and gas resources and well locations fall into many habitat categories, although temperate grassland and temperate forest may be the most highly affected.

Figure 13: Major Habitat Types in the United States.

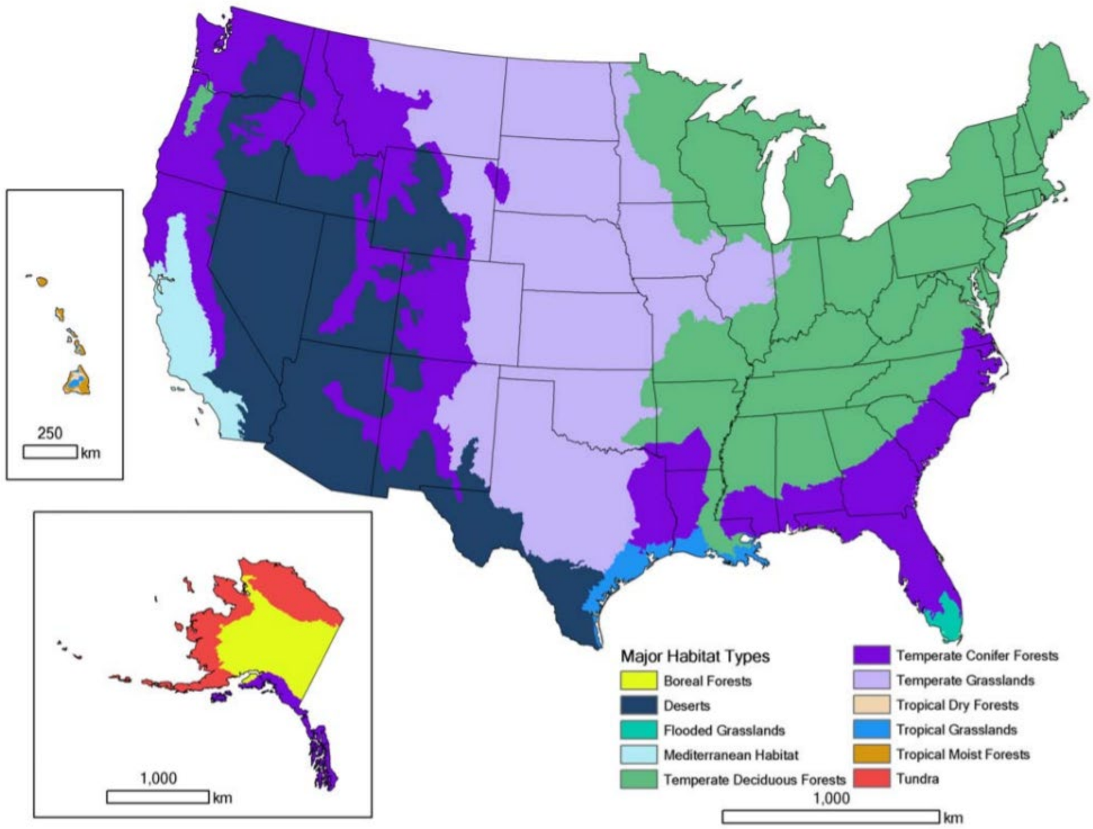


Figure reproduced from McDonald et al. 2009

6.2 Water Quality Impacts Associated with Spills

6.2.1 Unconventional Oil and Gas (UOG)

The most common UOG production method in the U.S. is hydraulic fracturing. A study of UOG wells sites in Colorado, New Mexico, North Dakota, and Pennsylvania estimated 55 spills per 1,000 well-years (where a well-year is a unit denoting the operation of one well for a period of one year; Patterson, Konschnik, et al., 2017). Actual spill rate varied by state, from about 1% (Colorado) to 12% (North Dakota). Median spill size by state varied from 120 gallons (0.5 m^3, Pennsylvania) to 1,302 gallons (4.9 m^3, New Mexico). Total spill volume over ten years (2005 to 2014) was estimated to range from 1,447 m^3 (380 thousand gallons; Pennsylvania) to 33,937 m^3 (9 million gallons; North Dakota). The study found that over 75 percent of UOG production sites spills occur during the first three years of a well's life. It also found that wells with one spill have a higher probability of future spills (Patterson et al. 2017).

Relative to total oilfield spills, the number of spills at UOG production sites is relatively small. EPA (2015) associates only 1% of spills (457 of 36,000 spills across nine states) with hydraulic fracturing. Of the 457 spills assessed by EPA (2015), 300 were reported to reach soil, surface water, or groundwater. The total reported spill volume includes an estimated 540,000 gallons released to soil, 200,000 gallons released to surface water, and 130 gallons reaching groundwater (EPA 2015). Patterson et al. estimate of 6,648 spills associated with all stages of UOG production covering ten years (2005 to 2014). By contrast, the estimate by EPA (2015) focuses only on hydraulic fracturing and covered seven years (2006 to 2012).

6.2.2 Conventional Oil and Gas

The movement of raw petroleum and petroleum products consists of a complex distribution and storage system, which has many chances for accidents, spills, leaks, and losses from volatilization. Consistent national statistics are lacking for many stages in the overall oil distribution and storage system. (ATSDR 1999). Statistics from the American Petroleum Institute (API) based on U.S. Coast Guard data exist for U.S. Navigable waters, but these are limited primarily to coastal areas and large rivers but can include lakes and estuaries.

Data were readily available for the period 1997-2006 from API (API 2009) and are presented for illustration purposes. API reported approximately 10.8 million gallons of oil was spilled into U.S. Navigable Waters from 1997-2006. This includes spills by vessels and facilities (onshore and offshore). The amount spilled per year varied from 466,000 (2005) to 2.7 million (2004). Of the 10.8 million gallons of oil spilled over the period:

- 3.7 million gallons were from onshore facilities;
- Just over 620,000 gallons were from pipelines;
- 226,000 gallons were from offshore facilities;
- 36,000 gallons were from railroads, tank trucks, and passenger cars;
- And most of the remaining spills (5.7 million gallons) were from vessels.

The figures above do not include the Exxon Valdez spill in Alaska in 1989 of 10.8 million gallons (API 1998 as cited in ATSDR 1999) or the Deepwater Horizon spill in 2010 (which post-dated the API study) where EPA reports that 4 million barrels (approximately 168 million gallons) spilled during the 87-day period of the incident (EPA n.d.).

6.3 Toxicity and Other Ecological Impacts of Oil and Associated Products

Total petroleum hydrocarbon (TPH) toxicity to ecological receptors depends on the hydrocarbon composition, exposure pathway, and exposure duration (i.e., acute or chronic). Additionally, TPH in the form of product (e.g., crude oil) can cause physical and chemical toxicity. Acute exposure typically occurs following an accidental release, which causes immediate exposure to high concentrations of petroleum products. Chronic exposures are typically associated with low-level releases over long periods of time, such as from a leaking underground storage tanks and groundwater contamination. Acute exposure following a large oil spill has both physical and chemical impacts and can have immediate ecosystem impacts. In contrast, chronic low-level releases have more subtle impacts typically related to chemical toxicity (Interstate Technology & Regulatory Council [ITRC] 2018).

EPA (1999) describes oil toxicity effects on wildlife according to four categories: physical contact, chemical toxicity, reproductive problems, and destruction of food resources and habitats. These categories of toxicity are described relative to acute and chronic exposures below.

6.3.1 Physical Contact

Terrestrial plants, invertebrates, small animals (mammals, amphibians, reptiles) and birds can become smothered by oil and aquatic organisms can similarly become smothered and lose their ability to uptake oxygen. When fur or feathers of larger mammals or birds contact oil, they get matted down, causing the fur and feathers to lose their insulating properties, placing animals at risk of freezing to death. Additionally, in the case of birds, the complex structure of feathers that allow birds to float or to fly can become damaged, resulting in drowning for aquatic birds (EPA 1999).

6.3.2 Chemical Toxicity

Toxicity to the central nervous system is the major mechanism of toxicity to ecological receptors. Early life-stage aquatic invertebrates and fish can also exhibit phototoxicity (ITRC 2018). These and other toxicological effects are summarized below. Chemical toxicity is typically associated with chronic exposures, however, if petroleum products are present in high enough concentrations, negative health effects, including mortality can occur from acute exposure.

Oil vapors may be inhaled by wildlife, which can cause damage to some species' central nervous system, liver, and lungs. Animals are also at risk from ingesting oil, which can cause red blood cell, intestinal tract, liver, and kidney damage. Skin and eye irritation can also occur from direct contact with oil (EPA 1999). Fish that are exposed to oil may suffer from changes in heart and respiratory rate, enlarged livers, reduced growth, fin erosion, a variety of biochemical and cellular changes, and reproductive and behavioral responses. Chronic exposure to some chemicals found in oil may cause genetic abnormalities or cancer in sensitive species (EPA 1999).

6.3.3 Reproductive Effects

Oil can be transferred from birds' plumage to the eggs they are hatching. Oil can smother eggs by sealing pores in the eggs and preventing gas exchange. Also, the number of breeding animals and the number of nesting habitats can be reduced by a spill.

Scientists have observed developmental effects in bird embryos that were exposed to oil. Long-term reproductive problems have also been shown in some studies in animals that have been exposed to oil (EPA 1999).

6.3.4 Destruction of Food Resources and Habitats

Species that do not directly contact oil can be harmed by a spill. Predators may refuse to eat their prey because oil contamination gives fish and other animals unpleasant tastes and smells, which can lead to starvation. Alternatively, a local population of prey organisms may be destroyed, leaving no food resources for predators. Predators that consume contaminated prey can be exposed to oil through ingestion. This causes bioaccumulation of oil compounds in the food chain. Depending on the environmental conditions, the spilled oil may linger in the environment for long periods of time, adding to the detrimental effects. In freshwater lentic systems, oil that interacts with rocks or sediments can remain in the environment indefinitely, leading to persistent ecological impacts (EPA 1999)

6.4 Additional Water Quality Impacts Associated with Petroleum Production

Production water and fluids used in conventional and unconventional oil and gas production are an additional source of potential contaminants and may have negative impacts on the environment. In the U.S., an estimated 21 billion barrels of produced water is generated each year (Aqwatec n.d.). Production water can be highly saline (up to 15 times saltier than seawater) and can contain elevated levels of chemicals and radioactive elements. This water can kill vegetation and prevent plants from growing in contaminated soil (Miller and Pesaran 1980, Miller et al. 1980, Adams 2011, Pichtel 2016). Hydraulic fracturing fluids contain numerous chemicals to enhance gas and oil extraction. EPA identified 1,173 chemicals associated with hydraulic fracturing activities and chronic oral toxicity values are available for 147 of the chemicals identified (Yost et al. 2016). The potential for toxicity to wildlife and ecosystems depends on the quality of the production water, which varies by production site.

6.5 Additional Water Quality and Supply Impacts Associated with Exploration, Production, and Refining

Water is necessary for both conventional and unconventional oil and gas extraction as well as refining with unconventional oil and gas exploration and production having the higher water demand requirements. This makes oil and gas development a competitor for limited water resources with nearby populations and agriculture, in a time when water rights are often hotly contested (Strzepek and Boehlert 2010). High source water consumption can alter stream flows and affect aquatic ecosystem function, including declines in specific fish species around production sites (Dauwalter 2013, Jones et al. 2015). Additionally, produced water, especially from unconventional oil and gas development, has high total dissolved solids and may be contaminated with other chemicals, making it a pollutant that is expensive and difficult to treat (Gregory et al. 2011, Gleason and Tangen 2014).

There are 135 petroleum refineries in the United States (U.S. Energy Information Administration [USEIA] 2018b, 2019). Over time, the number of petroleum refineries has decreased, but the capacity per refinery has increased (ATSDR, 1999; USEIA 2018b). Gross crude oil inputs to refineries averaged 16.6 million barrels per day in 2017 (USEIA 2018c). An estimated 2.3% of total refinery output is released to the environment through spills or leaks (ATSDR 1999).

Petroleum refinery wastewaters are made up of many different chemicals which include oil and greases, phenols (creosols and xylenols), sulfides, ammonia, suspended solids, cyanides, nitrogen compounds and heavy metals. Refinery effluents tend to have fewer of the lighter hydrocarbons than crude oil but more polycyclic aromatic hydrocarbons, which are generally more toxic and more persistent in the environment (Anderson et al. 1974, Wake 2005). Aquatic ecosystems around refinery discharges are often found to have low biodiversity and a low abundance of fauna. Often the impacted area is limited to a specific distance from the discharge point. This distance varies depending on the site and the effluent. Studies have estimated the impacted range to be 200 m to 1.6 km from the effluent site (Petpiroon & Dicks, 1982; Wharfe 1975 as cited in Wake, 2005). Refinery effluent has also been attributed as the cause of lack in recruitment in some areas, that it may either kill early life stages of aquatic organisms (e.g., settling larvae) or deter them from settling near discharges (Wake 2005).

7. LIMITATIONS

The conclusions, opinions and recommendations presented herein represent Ramboll's professional judgment based upon reasonably available information and are products of and limited by Ramboll's assigned and agreed upon scope of work. In preparing this report, Ramboll relied upon information provided by its client and/or third parties, and also relied upon certain additional publicly available information. Ramboll, however, did not conduct an exhaustive search or review/analysis of all potentially relevant information. The conclusions, opinions and recommendations presented herein, and all other information contained in this report, necessarily are valid only to the extent that the information reviewed by Ramboll was accurate and complete. Ramboll reserves the right to revise this report if/when additional relevant information is brought to its attention. In addition, Ramboll did not consider matters outside of its limited scope of work. Accordingly, the conclusions, opinions, recommendations and other information contained herein may not adequately address the needs of all potential users of this report, and any reliance upon this report by anyone other than Growth Energy, or use of a nature, or for purposes not within Ramboll's scope of work is at the sole risk of the person/entity so relying upon or otherwise using this report. Ramboll makes no representations or warranties (express or implied) regarding this report beyond those made expressly to its client, and Ramboll's liability in relation to this report and its related scope of work is limited under its client contract.

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Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 4

ENVIRONMENTAL RESEARCH
LETTERS

Carbon intensity of corn ethanol in the United States: state of the science

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CARBON INTENSITY OF CORN ETHANOL IN THE UNITED STATES: STATE OF THE SCIENCE

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ABSTRACT

The carbon intensity of corn ethanol, the primary renewable fuel used in transportation, has been actively researched and quantified over the last three decades. Reliable estimates of greenhouse gas emissions for corn ethanol are important since these values help determine significant policy and market decisions on state, national, and international levels. We reviewed well-to-wheel greenhouse gas life cycle analyses for corn ethanol and evaluated models, input data, and results for farming, fuel production, co-product credit, land use change, transport of feedstock and fuel, tailpipe, and denaturant. Compared to earlier analyses, recent life cycle analyses for corn ethanol contain updates to modeling systems and data that reflect: (1) market-driven changes in corn production that lowered the intensity of fertilizer and fossil fuel use on farms; (2) more efficient use of natural gas and recent electric generation mix data for energy consumed at ethanol refineries, and (3) land use change analyses based on hybrid economic-biophysical models that account for land conversion, land productivity, and land intensification. LCAs that include these latest developments yield a central best estimate of carbon intensity for corn ethanol of 51.4 gCO_2e/MJ (range of 37.6 to 65.1 gCO_2e/MJ) which is 46% lower than the average carbon intensity for neat gasoline. The largest components of total carbon intensity are ethanol production (29.6 gCO_2e/MJ, 58% of total) and farming practices net of co-product credit (13.2 gCO_2e/MJ, 26%), while land use change is a minor contributor (3.9 gCO_2e/MJ, 7%). Market conditions that favor greater adoption of precision agriculture systems, retention of soil organic carbon, and demand for co-products from ethanol production may lower the carbon intensity of corn ethanol further. Continued refinement of models to account for co-products, conservation of soil carbon, and direct and indirect land use change is expected to produce ever more accurate estimates in the future.

1. INTRODUCTION

The Renewable Fuel Standard (RFS) program, authorized by the Energy Policy Act of 2005, aims to reduce greenhouse gas (GHG) emissions, expand the nation's renewable fuels sector, and reduce reliance on imported oil (1). The RFS required that transportation fuels sold in the United States contain 7.5 billion gallons (BG) of renewable fuels by 2012 (2). In 2007, the Energy Independence Security Act expanded the RFS (referred to as RFS2) and required transportation fuels to contain 36 BG by 2022, with 15 BG coming from conventional biofuels and 21 BG from advanced biofuels (3).

Ethanol produced from corn starch (hereafter "corn ethanol") is currently the primary conventional renewable fuel used in transportation fuels (4). Ethanol demand in the US increased from 3.6 BG in 2004 to 14.4 BG in 2019 (5). Given this significant expansion, accurate characterization of the GHG profile of corn ethanol is important for evaluating impacts of the RFS and related low carbon fuel initiatives. Estimates for the carbon intensity (CI) of corn ethanol over the past three decades range from approximately 105 gram carbon dioxide equivalent emission per megajoule (gCO_2e/MJ) in 2009 to approximately 52 gCO_2e/MJ in more recent years (2, 6-14). The estimates published since 2010 represent a reduction of approximately 20% to 40% in GHG emissions relative to conventional 2005 gasoline, the benchmark comparison in life cycle analyses (LCA) published by EPA and USDA (2, 7). Identifying the basis of these estimates and reasons for the differences among them is important because the CI values are used to inform significant policy and market decisions on state, national, and international levels.

To address this need, we conducted a state-of-the-science review of the CI for corn ethanol in the US and derived an evidence-based central CI estimate and credible range as of 2020. We compared our result to CI values for corn ethanol reported in generally accepted, widely used LCAs published as of 2010 and identified the principal reasons for any notable differences observed. This review of CI for corn ethanol is intended to inform analyses of the role for corn ethanol as a transportation fuel in the decarbonization of the US economy and to facilitate communications on biofuel production, policy, and use.

2. METHODS

We searched the peer-reviewed and grey literature to identify existing well-to-wheel LCA analyses, models, parameter values, and data on overall corn ethanol CI and its components for the US. We focused on well-to-wheel LCAs because they use a generally accepted approach for assessing GHG impacts of a transportation fuel and examine each stage of corn ethanol production and use (15). We also focused on stand-alone analyses of LCA components to capture the latest developments in LCA models and the associated input parameters. To supplement the literature review, we interviewed over two dozen biofuel LCA experts in academia, government, not-for-profit, and commercial organizations in the US and Canada. This search strategy yielded 23 LCA models (2, 7-14, 16-26) and over 30 supporting publications that we used to develop a structure for subsequent critical review and analysis.

We consolidated the numerous LCA components into nine emission categories: farming, co-product credit, fuel production, land use change (LUC), rice methane, livestock, fuel and feedstock transport, denaturant, and tailpipe. Preliminary review of the data showed that farming and co-product credits, fuel production, and LUC account for over 90% of the CI of corn ethanol. For each of those major categories we: (1) critically reviewed previously developed CI estimates; (2) evaluated and recalibrated inputs and assumptions to reflect the current state-of-the-science; and (3) selected models and parameters deemed to provide the most reliable results based on our analysis of their strengths and weaknesses (described in the results). The screening process generally produced fewer than 10 CI values for each emission parameter, all of which we considered equally likely and valid. We defined the minimum and maximum values as the range of credible values for each parameter and the midpoint between the minimum and maximum values as the central best estimate. Information on methods employed for each of the major categories is provided next.

For farming, we primarily drew upon analyses and data in the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model, the most widely used tool and database over the prior 10 years for assessing GHG emissions from corn ethanol in the US (27). We reviewed recent GREET-based assessments (7, 9, 10, 12-14) and compared their emission estimates to calibrated data from the Ecoinvent database version 3.5 (28). We selected Ecoinvent as a useful and transparent database to thoroughly assess farming emissions because: (1) its data sources and assumptions are well documented; (2) it is publicly available; and (3) when used in conjunction with LCA software, it allows for assessment of process contributions, identification of key drivers of emissions, determination of the impact of assumptions and parameters on the analysis, and scenario analysis. We calibrated the Ecoinvent data to reflect current farming practices more accurately. We determined the range and central estimate of farming emissions from the parameter values in GREET and Ecoinvent. To account for farming co-product credits, we followed methods in accordance with the ISO 14044 standard for LCAs and determined a credible range and central estimate (29).

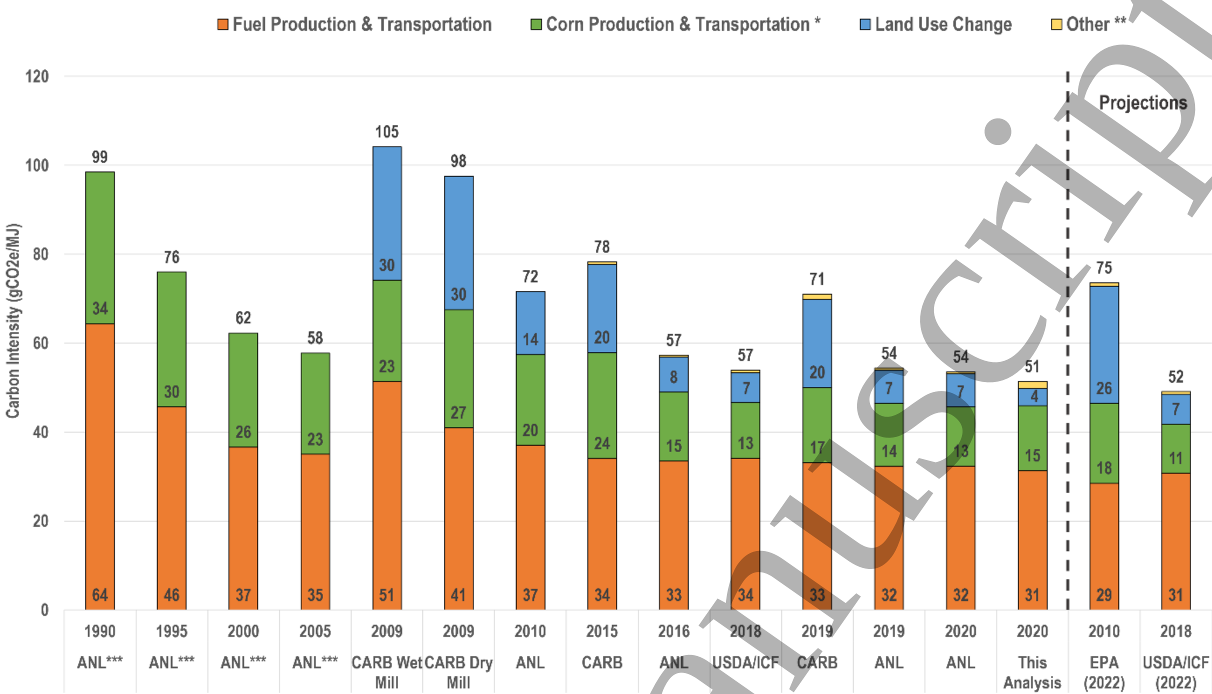
For ethanol production, we relied upon documented energy emissions factors and assumptions about the mixture of sources that provide energy for refining, electricity demand, and production of process fuels. We evaluated fuel production model assumptions used in well-to-wheel LCAs and compared them to current processes of the US corn ethanol refining industry. Following the model evaluation, we derived a range and central estimate for fuel production emissions and validated our estimates using data from an ANL 2018 survey that collected responses from 65 corn ethanol dry mill facilities located across 17 states in the US (30).

For LUC, we critically reviewed 26 CI values published since 2008 and evaluated the underlying agro-economic model, economic data year, yield price elasticity (YDEL), and incorporation of land intensification (2, 7-10, 12-14, 31-44). We assigned a binary indicator of current best practice (yes or no) to each LUC model or parameter using criteria informed by peer-reviewed literature, empirical analysis, and input from our panel of external experts. Next, we selected the CI outputs for international LUC (iLUC), domestic LUC (dLUC), and total LUC from the sources that met our criteria for best practice. We also calculated an updated dLUC emission value using the recently released 2020 ANL Carbon Calculator for Land Use Change from Biofuels Production (CCLUB) model. We summed the values for iLUC and dLUC to develop a central estimate and credible range for total LUC.

For the remaining direct GHG emissions categories (fuel and feedstock transport, tailpipe, and denaturant emissions), we derived a range and central estimate from the information provided in the selected attributional and consequential LCAs included in our analysis. Attributional LCAs consider the direct emissions associated with the full supply chain of corn ethanol production and its consumption (2). Consequential LCAs consider direct as well as indirect emissions from potential changes to resources (e.g., rice and livestock) expected to result from changes in the production or consumption of corn ethanol (2). To calculate the CI of corn ethanol in our study, we considered an attributional approach (i.e., included direct emissions), with the addition of consequential LUC emissions, since those emissions have been historically considered as large contributors to the CI of corn ethanol (2, 7, 10, 31). Thus, we calculated the total CI of corn ethanol by summing the central estimates for seven emission categories (LUC, farming, co-product credit, fuel production, fuel and feedstock transport, tailpipe, and denaturant), as well as the upper and lower bounds of the credible ranges.

3. RESULTS

All well-to-wheel GHG LCAs identified by our literature search were produced by government organizations or investigators, while studies on specific components of LCAs, such as LUC and farming emissions, were primarily published by academic-based investigators. Of the former, we identified three LCAs issued by CARB (8-10); one by EPA (2); two by USDA (7, 26); and annual reports from ANL for 2010 – 2020 (11-14, 16-25). The total CI values for corn ethanol from most of those LCAs are presented as a time series in Figure 1, along with contributions from the three principal components: corn production and transportation (i.e., farming), ethanol production and transportation, and land use change. The plot demonstrates two-fold variability among CI values for corn ethanol over the 20-year period, but also convergence toward lower CI values for corn ethanol in total and each of its principal components.



* Corn Production & Transportation includes farming, feedstock transport, and co-product credit.
** Other less significant emission categories account for fewer than 2 gCO_2e/MJ.
*** Models did not incorporate land use change.

Figure 1. Timeline of estimated corn ethanol life cycle greenhouse gas emissions for 1990 through 2020 with projections out to 2022.

Examination of Figure 1 shows that some of the variability among estimates of total CI over time is explained by differences in system boundaries of the LCAs. The LCAs released by ANL from 1990 through 2005 only consider GHG emissions arising directly from the life cycle of corn ethanol, i.e., from farming and ethanol production, whereas LCAs published after 2005 also consider emissions that could occur indirectly in response to changes in corn ethanol production and demand (2). Expanding the system boundary to include LUC increases the CARB and EPA estimates of total CI for corn ethanol by 40% to 55% over the combined CI of farming and ethanol production (2, 8-10). In comparison, the ANL and USDA estimates of CI associated with LUC are lower and equivalent to approximately 15% to 25% of the combined CI for farming and ethanol production (7, 11-14). Estimates for LUC CI are reviewed in Section 3.1.

Further examination of Figure 1 shows a consistent, but not monotonic, decrease in CI for farming and ethanol production which also explains a portion of the variability in total CI values over time. Estimates of the CI for both farming and ethanol production decreased by approximately 50% from peaks of 64 gCO_2e/MJ and 34 gCO2e/MJ in 1990, respectively (6). The decrease in farming emissions is primarily a result of practice improvements, such as a 35% reduction in nitrogen fertilizer use and 40% reduction in fossil fuel consumption from 1990 – 2005 (44). The reduction in GHG emissions at corn ethanol plants stems primarily from more efficient use of energy at corn ethanol plants with energy use intensity dropping by approximately 50% (15 to 7.5 GJ per m^3 of ethanol) in 1990 to 7.5 from 1990 to 2010 (44). Except for analysis by CARB in 2015, CI estimates published after 2010 have converged on approximately 30 gCO_2e/MJ for ethanol production and 13 gCO_2e/MJ for farming, with the latter including a co-product credit from displacement of conventional animal feeds such as corn, soybean meal, and urea by distillers grain solubles (DGS) generated as a by-product of ethanol production.

We review variability of the CI estimates for LUC, farming, ethanol production, and remaining categories in the remainder of this paper. Those evaluations focus on LCA analyses published as of 2010 and relevant peer-reviewed papers. These inclusion criteria exclude earlier LCAs from ANL and CARB that are superseded by more recent analyses, while capturing the only LCA published by EPA and key publications on LUC and petroleum-based gasoline.

Results from the LCAs as of 2010 are summarized in Table 1. Aggregate CI scores for corn ethanol range from 52.1 to 78.3 gCO_2e/MJ, including the two projections for 2022. The net CI for farming, ethanol production, and co-product credits comprise approximately 70% of the total CI in each analysis. Transportation of feedstock and ethanol as well as tailpipe emissions from end-user vehicles were also similar across the LCAs and together account for about 4 gCO_2e/MJ and 7% of total CI. The LCAs differed in the remaining emissions categories. LUC CI varied 4-fold among individual analyses, from 6.7 to 26.3 gCO_2e/MJ. Emissions associated with addition of a denaturant to ethanol were considered in only two of the LCAs and indirect effects on rice methane emissions and livestock emissions were considered in only three of the LCAs. We examine these emission categories in the following sections, beginning with LUC.

Table 1. Greenhouse Gas Emissions (gCO_2e/MJ) Reported by Life Cycle Analyses for Corn Ethanol Produced in the United States

Model	CARB 2015	ANL 2016	USDA 2018	CARB 2019	ANL 2019	ANL 2020	EPA 2010 Projection for 2022	USDA 2018 Projection for 2022
GREET Model	CA-GREET 2.0 (GREET1_2013)	GREET1_2016	GREET1_2015	CA-GREET 3.0 (GREET1_2016)	GREET1_2019	GREET1_2020	GREET_1.89c (2009)	GREET1_2015
GHG Emission Categories								
Fuel Production	30.2	32.3	32.7	30.7	31.3	31.4	26.5	29.4
Farming (domestic and international*, including chemicals)	34.4	27.7	22.8	28.0	26.0	25.6	16.0	21.3
Co-product credit	-12.6	-12.2	-12.1	-12.6	-13.4	-13.5	Included in farming emissions	-11.4
Fuel and Feedstock Transport	5.9	2.7	3.3	3.9	2.5	2.2	4.0	2.5
Tailpipe	0.0	0.5	0.6	0.1	0.5	0.5	0.8	0.6
Total Land-use Change (domestic and international)	19.8	7.9	6.7	19.8	7.5	7.4	26.3	6.7
Rice Methane (domestic & international)	--	--	1.4	--	--	--	1.8	1.4
Livestock (domestic & international)	--	--	1.6	--	--	--	-0.3	1.6
Denaturant	0.6	--	--	1.1	--	--	--	--
Total CI in gCO_2e/MJ	78.3	58.9	57.0	71.0	54.4	53.6	75.1	52.1

*International farming only considered by USDA and EPA.

ANL Argonne National Lab
CARB California Air Resources Board
EPA United States Environmental Protection Agency
GREET The Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model
GHG greenhouse gas emissions
USDA United States Department of Agriculture
CI Carbon Intensity
gCO_2e/MJ Gram carbon dioxide equivalent emission per megajoule

References: (2, 7, 9, 10, 12-14)

3.1 LAND USE CHANGE (LUC)

We identified 26 CI values for LUC of corn ethanol published since 2008. As shown in Figure 2, these values decreased from 104 gCO_2e/MJ to generally less than 10 gCO_2e/MJ from 2008 - 2020 (2, 7-10, 12-14, 31-44). The LUC values appear to be converging although a moderate degree of variability remains among models and analyses. Variability among the LUC estimates stem primarily from differences in the four major elements that comprise these CI values: the agro-economic model, economic data year, yield price elasticity, and land intensification. Our evaluation of these elements is presented next and details are provided in Tables S.1 to S.4 in the Supplemental materials.

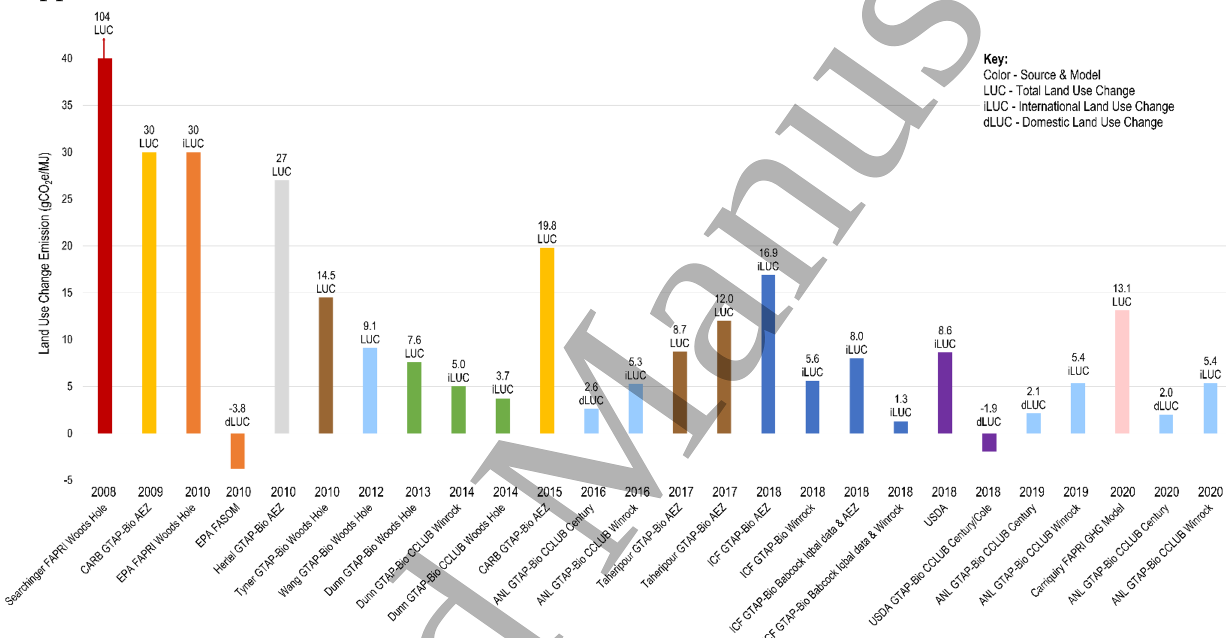


Figure 2. Timeline of estimated greenhouse gas emissions associated with corn ethanol-related land use change, 2008-2020.

Agro-economic Models

Agro-economic models predict demand for agricultural commodities globally in response to changes in supply and are used to assess LUC following increases in production of biofuels (45). The LCAs for corn ethanol that we reviewed rely upon one of three agro-economic models: FASOM (Forestry and Agricultural Sector Optimization Model), FAPRI (Food and Agriculture Policy Research Institute), and GTAP-BIO (Global Trade Analysis Project-Biofuels). While having a common endpoint, these models differ in their geographic scope, method used to predict land conversion, and consideration of land cover categories. These characteristics and others translate to comparative strengths and weaknesses of the three models.
As shown in Table S.1, EPA (2010) relied upon FASOM to characterize LUC within the United States (dLUC) and FAPRI elsewhere in the world (iLUC) (2). FASOM was developed with a focus on dLUC and has not been widely adopted in LCAs for corn ethanol (46, 47). Further

examination of Table S.1 shows that FAPRI was used in three analyses that we reviewed, one for iLUC only and for total LUC in the other two. GTAP-BIO was used to estimate total LUC in the remaining 22 analyses.

For land conversion, FAPRI predicts changes in crop acres by country globally, but does not have land type interactions built into the model (2). To predict land specific crop acres, FAPRI relies upon MODIS satellite imagery data which has been demonstrated to misclassify agricultural and non-agricultural lands, resulting in inaccurate predictions of land types that convert to cropland and unreliable emission estimates associated with LUC (2, 47). In contrast, land conversion in GTAP-BIO is based upon hybrid economic-biophysical models that account for both the quantity and quality of available agricultural land to predict how much land of each land cover category is actively used in production and how much land is idle during a specific time period (45, 48). GTAP-BIO accounts for climate-specific crop yields and three soil quality indicators to generate land productivity and land supply curves that are calibrated to historical crop productivity figures (49). GTAP-BIO also considers multiple categories of land use, including idle cropland and cropland pasture, that allow for application of land use-specific GHG emission factors. This feature is particularly important for simulating return to production of land in the USDA Conservation Reserve Program (50).

Based on our review of the literature, GTAP-BIO appears to be the field-leading model for LUC because it addresses both domestic and international LUC, predicts LUC for specific land types using both economic and physical data, is incorporated into the generally accepted GREET model from ANL, and has been adopted for use in LUC analyses for the California Low Carbon Fuel Standard (51). For these reasons, we marked LUC estimates derived from the GTAP-BIO model as meeting our best practice criteria (Table S.1).

Economic Data Year

The economic data year is the baseline point in time used in agro-economic models for estimating LUC of corn ethanol. The year of the economic data is significant because the agro-economic model is “shocked” with an expansion of a specified volume of corn ethanol. The volumes which shock the model are determined by the difference between 15 BG, the RFS2 mandated volume target for conventional biofuels, and the volume of ethanol produced in the US during the specific economic data year (1, 52). Three world economic data years were used in the analyses that we reviewed: 2001, 2004, and 2011. The modeled expansion in production volume of corn ethanol is approximately 13.25 BG for economic data year 2001, 11.6 BG for 2004, and 1.1 BG for 2011. Eighteen of the 26 LUC analyses that we reviewed used 2004 as the economic data year, while four used 2001, and one used 2011. We selected 2004 as the most appropriate economic data year for this review, because it captures the largest period of corn ethanol volume expansion in the US and is relied upon the most frequently. We marked analyses models using 2004 as meeting our best practice criteria (Table S.1).

Yield Price Elasticity

Yield price elasticity, or YDEL, describes the percentage change in crop yield per unit of land per percentage change in price for the crop and is a key driver of LUC outputs from agro-economic models (53). The CARB Low Carbon Fuel Standard (LCFS) expert workgroup recommended a YDEL of 0.25 for the US and 0.3 for Brazil and Argentina, where multiple cropping is likely to occur, and 0.175 for countries that do not practice multiple cropping (54). Multiple cropping is defined as growing two or more crops on the same land in the same season or year (55). Taheripour et al. (2017) reviewed crop yield data from 19 regions around the world and derived a recommended range of 0.175 – 0.325 (39, 56). We examined YDEL for corn reported in 20 studies published from 1976 – 2017 and calculated a simple average of 0.23 (Table S.2) (2, 32, 38, 39, 57-66). From these data, we determined a YDEL central best estimate of 0.25 and credible range of 0.175-0.325. Eighteen analyses that we reviewed had YDEL values within this range and we marked them as meeting our best practice criteria (Table S.1).

Land Intensification

Land intensification is the practice of using existing cropland more efficiently and is defined as activities undertaken with the intention of enhancing the productivity or profitability per unit area of land (67). Examples of land intensification include yield improvement, multiple cropping, reduction of agricultural land in fallow, conversion of other unused cropland to crop production, and reduction in temporary or mowed pasture (68). According to an empirical analysis of agricultural land use across the globe, land intensification accounted for two thirds (49.1/73.1 million hectares) of the observed increase in harvests from the period 2004-2006 to 2010-2012 rather than conversion of timberland and pasture to farm land (68), while US corn ethanol production increased over 3-fold during that period (4.0 to 13.5 BG) (5). Similarly, an empirical analysis of agricultural land from 2003 to 2013 found the ratio of harvested area over available land area increased in 17 of the 19 worldwide regions, indicating that land intensification increased globally rather than only in a minor fraction of locations (56). Another empirical study found that from 2002 to 2017, agricultural land area in the US declined by 38 million acres while land intensification increased harvested area by 17 million acres and annual ethanol production increased by 13.8 BG (5, 69). These studies indicate that land intensification is an important and common response to increased demand for corn ethanol production. Only five of 26 analyses that we reviewed considered land intensification and we marked them as meeting our best practice criteria (Table S.1).

In addition to reviewing previously developed LUC estimates, we calculated an updated dLUC CI value to incorporate the recently released 2020 CCLUB model developed by ANL into this review and apply land transformation parameters (37). The land transformation parameters considered regionally specific land transformation elasticities and land-specific costs of converting pasture or forest to cropland (37). We set 2004 as the economic data year and ran the "Corn Ethanol 2013" feedstock to fuel pathway which was calibrated with land transformation parameters. Additional inputs for the CCLUB run are provided in the Table S.3. Our analysis returned a CI for dLUC of -2.3 gCO_2e/MJ.

The dLUC, iLUC, and total LUC CI values identified as meeting our best practice criteria are shown in Table 2. We summed the two dLUC values with the iLUC values selected from our critical review to determine an overall credible range of range for LUC of -1 to 8.7 gCO_2e/MJ from which we calculated a central best estimate of 3.9 gCO_2e/MJ.

Table 2. Land Use Change Analyses, Models and Outputs Identified as Meeting Current Best Practice for Life Cycle Analysis of Corn Ethanol

Study	Year	Parameter	LUC Value (gCO_2e/MJ)	Merits
USDA – 2018 – ICF	2018	dLUC	-1.9	• GTAP-BIO model calibrated with land transformation parameters • 2004 economic data year • Land-specific conversions • Acceptable YDEL
This analysis	2020	dLUC	-2.3	• GTAP-BIO model • 2004 economic data year • Land-specific conversions • Acceptable YDEL; based on empirical data • 2020 Carbon Calculator for Land Use Change from Biofuels Production
USDA – 2018 – ICF	2013	iLUC	8.0	• GTAP-BIO model • 2004 economic data year • Land specific conversions • Acceptable YDEL • Calibrated output with empirical data that included land intensification
USDA – 2018 – ICF	2013	iLUC	1.3	• GTAP-BIO model • 2004 economic data year • Land-specific conversions • Acceptable YDEL • Calibrated output with empirical data that included land intensification
Taheripour	2017	LUC	8.7	• GTAP-BIO model • 2004 economic data year • Land-specific conversions • Acceptable YDEL; based on empirical data • Included land intensification parameter based on empirical data

ICF ICF International
dLUC Domestic Land Use Change
iLUC International Land Use Change
LUC Total Land Use Change
GTAP-BIO Global Trade Analysis Project-Biofuels
gCO_2e/MJ Gram carbon dioxide equivalent emission per megajoule

References: (7, 37, 39)

3.2 FARMING AND CO-PRODUCT CREDITS

LCAs for corn adopt a cradle-to-gate scope, including both on-farm emissions as well as those from the full supply chains associated with on-farm processes including fertilizer and chemical use, disturbance of farming soils, and fossil fuel and electrical energy use. LCAs published since 2010 estimate the CI for farming differ by as much as a factor of 2 and range from 16.0 to 34.4 gCO_2e/MJ. These estimates are based upon versions of the GREET model released from 2013 – 2020, as shown in Table 1, and user-specified values for selected model parameters. We examined the farming components of these versions of GREET and the modeling scenarios to determine whether they meet our criteria for characterizing CI of corn ethanol as of 2020.

Examination of Table 1 shows that the most recent estimate of farming CI from CARB is 6.4 gCO_2e/MJ lower than CARB's prior estimate and the largest difference among all CI estimates within a category other than LUC. Based on information from CARB, the decrease is primarily attributable to adoption of lower energy intensity for farming (6,924 Btu per bushel in the 2019 estimate compared to 9,608 for the 2015 estimate) and lower fertilizer intensity (383 gallons of nitrogen fertilizer per bushel for 2019 compared to 423 gallons per bushel for 2015) (70). For its 2019 analysis, CARB adopted the default values that are in GREET1_2016 for these inputs (70). According to the developers of GREET, the default values in GREET1_2016 are significant updates to earlier versions of GREET and are based upon new analyses of fertilizer intensity and farming energy data from the USDA Agricultural Resource Management Survey in 2010 and 2012 (71, 72). Changes to these inputs will necessarily influence the overall CI results for farming because emissions of nitrous oxide (N_2O) from cycling of nitrogen fertilizer in corn fields, production of fertilizer, and direct energy use for fuel and electricity are the largest components of GHG emissions for growing and harvesting corn (44). Based on this information, we determined the CARB 2015 CI value for farming does not meet our best practice criteria and omitted it from further analysis. For similar reasons, we also omitted the EPA 2010 projection for farming emissions of 16 gCO_2e/MJ projected to occur in 2022. And lastly, we omitted the USDA projection for farming emissions in 2022 of 21.3 gCO_2e/MJ because it assumes numerous farming practice improvement that have yet been demonstrated to be widely adopted, including residue and tillage management, nutrient management, and cover crops.

To further evaluate the reliability of the farming results from these LCAs, we evaluated farming CI using a source of data independent of GREET, the Ecoinvent database of GHG emissions (28). Table 3 shows the GREET and Ecoinvent farming model parameters ranked according to their contribution to the overall farming emissions. The major contributors to farming emissions are chemical supply chain, N_2O emissions from nitrogen fertilizer and nitrogen in crop biomass, and co-product credits.

Table 3. Farming Parameters Ranked by Magnitude of Impact on Farming Emissions

Category *	Farming Model Parameters	Emissions (gCO_2e/MJ) Default Ecoinvent	Adjusted Ecoinvent	GREET Models
Small (1-5 gCO_2e/MJ)	Soil CO_2 from urea and lime	0**	0**	0** – 2.8
	Irrigation energy	4.2	0.8	0**
	Harvest drying	16.7	2.0	0**
	Seed drying	4.5	3.3	0**
	On-farm fossil fuel use	3.3	3.3	2.7 –
Large (5-15 gCO_2e/MJ) to Very Large (>15 gCO_2e/MJ)	Chemicals, supply chain	8.7	8.7	7.9 – 11.2
	N_2O emissions from soils	11.1	11.1	10.2 – 13.9
	Co-product credit	--	--	-12.1 – -13.5 ***

* Categories are based on adjusted Ecoinvent and GREET models.
** 0 indicates that at least one source either omitted this model parameter or reported it as part of on-farm fossil fuel use.
*** Included the default method use in GREET
-- Ecoinvent does not specify a co-product credit
gCO_2e/MJ Gram carbon dioxide equivalent emission per megajoule

References: (6, 7, 9, 10, 12-14, 28)

Ecoinvent uses data from studies by the National Renewable Energy Lab (NREL) and USDA as inputs for modeling US corn production (73-75). Ecoinvent contains the central estimates of average quantities of input per unit of output from the NREL and USDA studies, with two exceptions: irrigation and on-farm drying of corn grain after harvest. We evaluated both of those model inputs using current data on average US corn farming practices.

The Ecoinvent dataset reflected full use of irrigation, with a water use intensity of 0.24 m^3 water per kg of corn produced. However, not all US farms use irrigation and national average water use intensity varies from year to year. We analyzed data from the USDA's Agricultural Resource Management Survey (ARMS) database for all available survey years since 1996 (76). The fraction of irrigated corn acres ranged from 11.5% to 15.7% across these years. We combined ARMS data on water inputs with data on annual corn production from the USDA Feed Grains database (77) to generate water use intensities of 0.03 to 0.06 m^3/kg since 2000. We observed a declining trend during that period. The central estimate of this range, 0.045 m^3/kg, represents 20% of the irrigation intensity input (0.24 m^3/kg) used in Ecoinvent. Using our updated water use intensity estimate, we calculated the adjusted Ecoinvent CI contribution of irrigation to be 0.84 gCO_2e/MJ instead of the original estimate of 4.2 gCO_2e/MJ.

Analogous to its treatment of irrigation, the Ecoinvent model assumed that 100% of corn grain required active fuel-based drying plus fans to lower grain moisture content from 39% at harvest to 14% at storage (28). Farmers may also use passive drying (without fuel) in the field prior to harvest, which yields a lower starting moisture content. We compared the assumption of 39% moisture at harvest with historical data on corn moisture at harvest for the US from 2010-2017 (78). Annual averages in the US ranged from 16.3% in 2010 to a high of 19.7% in 2013, with an 18% average over the entire period. A target moisture level of 14% for storage is also conservatively low; CARB and EPA cite storage moisture content levels of 15% and 15.5%, respectively (79, 80). We adjusted the model to reflect the measured harvest moisture level of 18%, and a target moisture content of 15%, and retain the conservative assumption that 100% of farmers pursue active drying to achieve this moisture reduction. The result is an adjustment of drying's CI contribution from 16.7 gCO_2e/MJ to 2 gCO_2e/MJ.

The Ecoinvent database is transparent at the unit process level, with over 1,000 separately examinable processes contributing to the full supply chain for US corn production. Upon examination of the models we detected that the supply chain for seed included a duplicate instance of seed drying; drying with the same amount of fuel use and emissions appeared both prior to, and then after, aggregation of the seeds at market. Removing this error caused a minor adjustment to the CI contribution of seed drying, from 4.54 gCO_2e/MJ to 3.27 gCO_2e/MJ.

After updating data in Ecoinvent to reflect current US corn farming practices in relation to irrigation harvest drying, and seed drying, the CI for corn farming decreased by nearly 20 gCO_2e/MJ (Figure 3). The resulting adjusted Ecoinvent CI of 29.2 CO_2e/MJ was within +/-6 gCO_2e/MJ of the recent GREET-based CIs (Figure 4).

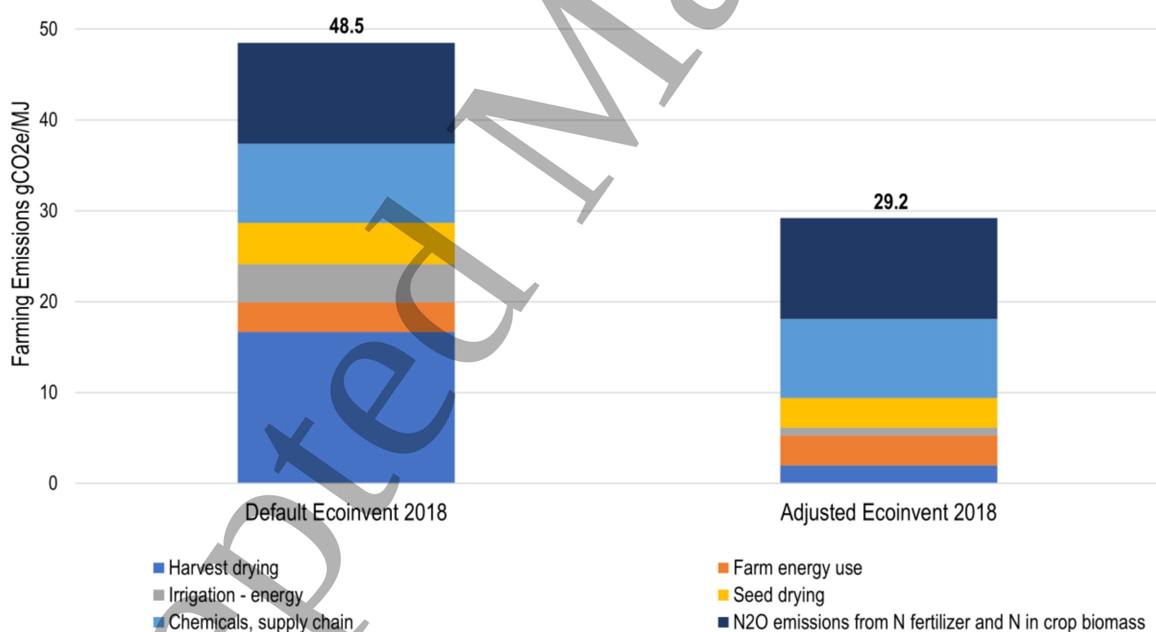


Figure 3. Comparison of farming emissions produced from the default and adjusted Ecoinvent 2018.

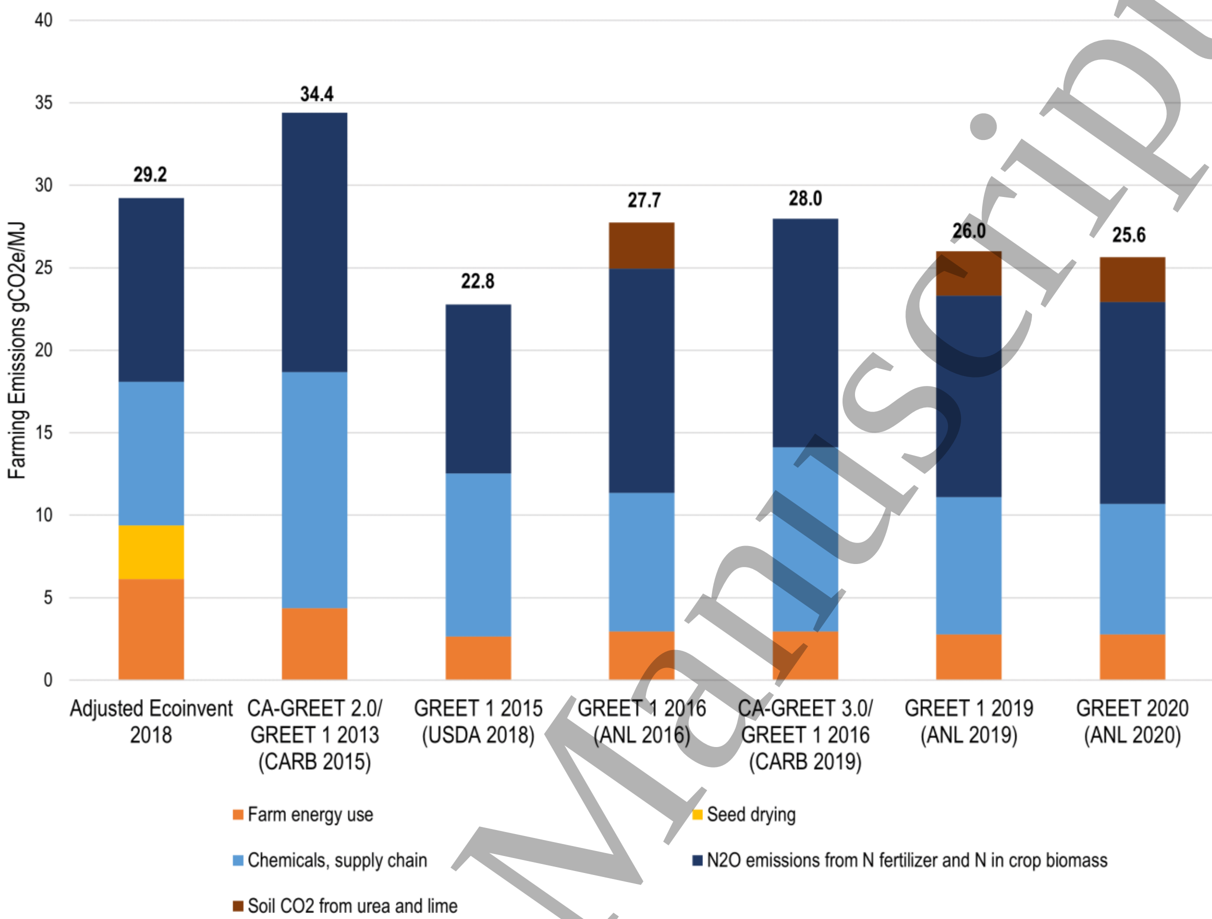


Figure 4. Comparison of sources of farming emissions across models produced from adjusted Ecoinvent and GREET.

To account for farming co-product credits, we followed methods used in the well-to-wheel LCAs and determined a credible range and central estimate in accordance with the ISO 14044 standard for LCA (29).

We also considered the emission co-product credit from distillers' grains solubles (DGS) in our analysis, since DGS is a co-product of corn ethanol production and is sold to the animal feed market. The method selected for allocating co-product credits in LCAs can make a major difference on the CI estimates of co-product credits. A recent comparison found that co-product credits ranged from -8 to -24 g CO2e/MJ based on the allocation method used (6). The ISO 14044 standard for LCAs recommends a hierarchy of methods for addressing co-product credits (29). The preferred approach is the system expansion or displacement method followed by causal modeling, and then by allocation of process burdens among co-products based on parameters such as the co-product shares of process revenues.

Even when using the preferred method (i.e., the displacement method), there will still be some variability in co-product credits for the corn-based ethanol life cycle for two reasons; first, because the DGS can be used to displace a variety of products, whose corresponding footprints (and thus co-product credits to the ethanol system) vary considerably; and second because corn ethanol production also yields co-products which can displace alternative production. DGS sold as animal feed can displace urea, and corn and soybean meal in different quantities depending on which type of livestock is being fed (9, 10, 12-14). Ecoinvent data show the carbon footprint of soybean meal to be 0.07 kg CO2e/kg, which is more than twice the value of 0.032 kg CO2e/kg given for corn meal as energy feed (28). In addition, corn ethanol production yields at least two additional byproducts: food grade CO_2, which can displace alternative production of food grade CO_2 (81); and corn oil, which can substitute for other vegetable oils (82) or can replace fossil-fuel-based inputs in applications such as asphalt paving (83, 84).

In this analysis, we conservatively focus on the displacement of feed products by the DGS co-product, and we follow the displacement ratios given in the GREET model for a mix of beef, dairy, swine, and poultry feed. ANL, CARB, and USDA rely upon the GREET displacement method ratios. EPA did not include information on their negative emissions associated with the DGS co-product. The negative emissions associated with displacement of feed products by the DGS co-product produced by ANL, CARB, and USDA using GREET range from -13.5 to -12.1 gCO_2e/MJ (a maximum absolute difference of 1.3 gCO_2e/MJ), with a central estimate of -12.8 gCO_2e/MJ (Table 3). We adopt the value of -12.8 gCO_2e/MJ which is based on the livestock-specific displacement ratios for soybean meal, corn and urea, for a mix of primarily beef and dairy feed, plus 13% swine and 6% poultry (9, 10, 12-14).

In summary, our review and analysis generated an overall range for farming emissions from 22.8 to 29.2 gCO_2e/MJ with a central estimate of 26.0 gCO_2e/MJ, derived from recent GREET-based analyses and our independent analysis using data in Ecoinvent. We also considered the emission co-product credit from DGS in our analysis and generated a central estimate of -12.8 gCO_2e/MJ with range of -13.5 to -12.1 gCO_2e/MJ based on analyses from ANL, CARB, and USDA using GREET that conform with the ISO 14044 standard for addressing co-product credits in LCAs.

3.3 ETHANOL PRODUCTION

LCAs for corn ethanol published since 2010 estimate the CI of corn ethanol production to range from 26.5 to 32.7 gCO_2e/MJ (Table 1). GHG emissions associated with biofuel production depend on the types of refining processes used to make ethanol from corn, the energy use intensity of those processes, and the sources and types of fuel used to provide the power.

There are two prominent refining processes for producing corn ethanol: dry milling and wet milling. In dry milling, the grain kernel is ground into meal which is followed by the starch hydrolysis and fermentation processes (45). Dry milling refineries produce ethanol, DGS, and when incorporated into operations, the extraction of corn oil (82). In contrast, the first step in wet milling is to soak grain kernel to separate the kernels from the hulls after which the kernels are further separated into fiber, gluten, and starch (85). Wet milling refineries produce ethanol, and the resulting fiber and gluten are processed separately to produce feed products (85). According to data from USDA, approximately 91% of US refineries are dry milling plants and 9% are wet milling plants (86). Wet milling provides higher ethanol fuel yields than dry milling (12-14), but requires more capital investment and is estimated to be over 75% more energy intensive (12-14, 20, 22, 87).

As shown in Table S.4 in the Supplemental materials, most of the analyses shown in Table 1 assumed that 89% of refineries were dry mills which is consistent with the distribution of dry mill facilities in the U.S (86, 87). Other models, such as CARB 2015, EPA 2010, and USDA 2018 (projected for 2022) estimated the CI for corn ethanol production assuming 100% dry milling. According to the models, electricity consumed from the grid accounts for approximately 10% of energy needs at the refineries with the remaining 90% powered by process fuels (2, 7, 9-14, 88, 89). The primary process fuel is natural gas, with a share of 72.5% to 100% of process fuel energy use among refineries (2, 7, 9-14, 88, 89). Coal accounts for 0% to 27.5% of energy from process fuels among refineries (2, 7, 9-14, 88, 89). Both natural gas and biomass are more energy efficient than coal; however, biomass is not widely used due to high fuel and capital costs (90).

The fuel production emissions produced by ANL, CARB, USDA, and EPA are consistent with one another with a maximum difference of approximately 6 gCO_2e/MJ. To evaluate those values further, we calculated production CI using data from the recently published ANL 2018 survey of 65 corn ethanol dry mill facilities located across 17 states in the US and compared the result to the ethanol production values in Table 1 (30). The facilities surveyed reported average consumption of 24,310 British thermal units (BTU) of natural gas per gallon of ethanol, 0.747 kilowatt-hour (kWh) of electricity per gallon of ethanol, and no use of coal (30). These rates correspond to 27.8 gCO_2e/MJ of fuel production emissions at an average dry mill corn ethanol facility, a value that is in the lower end of the range of estimates produced by ANL, CARB, USDA, and EPA. The facilities in the survey sample may not be representative of the entire population of corn ethanol producers given that they are all dry mill facilities and none of them reported use of coal. Nonetheless, these recently available survey data corroborate the inputs on energy use intensity and energy type for the models that we reviewed. Based on these observations, we find a reasonable central estimate and credible range of CI for corn ethanol production of 29.6 gCO_2e/MJ and 26.5 to 32.7 gCO_2e/MJ, respectively.

3.4 OTHER DIRECT EMISSION CATEGORIES

The remaining GHG emission categories reviewed and updated were fuel and feedstock transport, tailpipe, and denaturant emissions. The fuel and feedstock transport category consists of emissions associated with the combustion of gasoline and diesel fuels during the transport of corn from farm to refinery and corn ethanol from refinery to retail station. The tailpipe category consists of emissions from the combustion of corn ethanol in transportation vehicles. Corn ethanol-based CO_2 emissions from tailpipes are assumed to be biogenic and offset by carbon uptake during new biomass growth (7). Corn ethanol combustion also emits methane (CH_4), nitrous oxide (N_2O), and volatile organic compounds (VOCs), which are included in modeling of corn ethanol tailpipe emissions.

CI values for fuel and feedstock transport and tailpipe emissions across the ANL, CARB, EPA, and USDA models average 3.4 and 0.5 gCO_2e/MJ, respectively (Table 4). Together, these two categories represent about 6% of the overall CI score for most of the analyses. Although only a modest contributor to overall CI, the CI estimates vary by nearly 3-fold for transport of feedstock and fuel (2.2 to 6.0 gCO_2e/MJ) and 9-fold for tailpipe emissions (0.09 to 0.83 gCO_2e/MJ). The variation across those ranges primarily reflects two factors: updates to the national input parameters and CA-specific versus national input parameters. We first address transport emissions and then tailpipe emissions.

Table 4. Other Direct Emission Modeling Produced by ANL, CARB, USDA, and EPA

	CARB 2015	ANL 2016	USDA 2018*	CARB 2019	ANL 2019	ANL 2020	EPA 2010 (2022)	USDA 2018 (2022) *
GREET Model	CA-GREET 2.0 (GREET1_2013)	GREET1_2016	GREET1_2015	CA-GREET 3.0 (GREET1_2016)	GREET1_2019	GREET1_2020	GREET_1.89c (2009)	GREET1_2015
Fuel & Feedstock Transport								
Feedstock transport (gCO_2e/MJ)	2.06	1.49	1.86	1.5	1.55	1.2	--	1.16
Fuel transport (gCO_2e/MJ)	3.86	1.19	1.39	2.6	0.99	0.98	--	1.34
Feedstock & Fuel Transport (gCO_2e/MJ)	6.0	2.7	3.3	4.1	2.5	2.2	4.0	2.5
Tailpipe								
CH_4 Emissions (gCO_2e/MJ)	--	0.06	0.29	--	0.06	0.06	0.25	0.29
N_2O Emissions (gCO_2e/MJ)	--	0.47	0.26	--	0.47	0.47	0.58	0.26
Tailpipe Emissions (gCO_2e/MJ)	0	0.52	0.55	0.09	0.52	0.52	0.83	0.55

*USDA values include emissions associated with transport of fuel, feedstock, distillers grains, and corn oil.
gCO_2e/MJ Gram carbon dioxide equivalent emission per megajoule
CARB California Air Resources Board
USDA United States Department of Agriculture
EPA United Stated Environmental Protection Agency
CH4 Methane
N2O Nitrous Oxide

References: (7, 9, 10, 12-14, 91)

Inspection of Table 4 shows that feedstock and fuel transport emissions in the GREET models decreased by 15% to 25% with the release of GREET1_2016. The changes in GREET reflected a new analysis that accounted for closer proximity of corn farms to ethanol plants resulting from a five-fold increase in the number of production facilities in the Midwest corn-growing states and a shift from truck-dominated to rail-dominated delivery of ethanol (71). The rapid expansion of ethanol in gasoline across the US as of 2010 was the driving force for both the proximity effect and rail effect cited in the new analysis (72). The difference between the CARB 2019 value of 4.1 gCO_2e/MJ and the values from ANL of 2.2 – 2.7 gCO_2e/MJ stem from adjustments made by CARB to fuel economy and cargo payload of trucks, tankers, and barges that convey ethanol (70). In consideration of these updates to GREET, we adopt a credible range of 2.2 to 4.1 gCO_2e/MJ and central value of 3.1 gCO_2e/MJ for CI of fuel and feedstock transport.

Additional inspection of Table 4 shows that CI for tailpipe emissions in the CARB 2015 and CARB 2019 LCAs are approximately 5-fold lower than corresponding CI from ANL, EPA, and USDA. This difference reflects the lower emission standards in California compared to US standards according to CARB (70). The projection for 2022 made by EPA in 2010 is an outlier compared to the relatively consistent estimates issued by ANL since 2016, therefore we omitted the EPA value from further consideration. Given these results, we adopted a credible range of 0.09 to 0.55 gCO_2e/MJ with a central value of 0.3 gCO_2e/MJ for tailpipe emissions.

The final emission category that we assessed is the small amount of denaturant added to ethanol, approximately 2% by volume, to render it undrinkable (2, 92). Denaturant was considered by CARB in its 2015 and 2019 LCAs but has yet to be included in LCAs from EPA, ANL, or USDA. CARB calculates the emissions associated with denaturant using a formula with inputs that include farming, co-product credit, fuel production, and fuel and feedstock transport. The calculated denaturant value is inversely related to the CI of the other emission categories. The California GREET 2.0 model estimated a denaturant CI of 0.55 gCO_2e/MJ (9) and the CA-GREET 3.0 model estimated a denaturant value of 1.12 gCO_2e/MJ (10). We used the CA-GREET 3.0 approach to estimate CI for denaturant associated with the central estimate CI values from our analysis and computed a value of 2.0 gCO_2e/MJ. We used the minimum and maximum of these three values to define the credible range for denaturant CI as 0.55 to 2.0 gCO_2e/MJ with a central estimate of 1.3 gCO_2e/MJ.

3.5 CARBON INTENSITY OF CORN ETHANOL

Using the central estimates and ranges of LUC, farming, co-product credit, fuel production, fuel and feedstock transport, tailpipe, and denaturant emissions described in the preceding sections, we estimate the CI of corn ethanol to be 51.4 gCO_2e/MJ, with an overall range of 37.6 to 65.1 gCO_2e/MJ (Figure 5). Our findings for fuel and corn production and transportation are consistent with the decreasing and converging trend of GHG emission estimates that is apparent in the scientific literature (Figure 1).

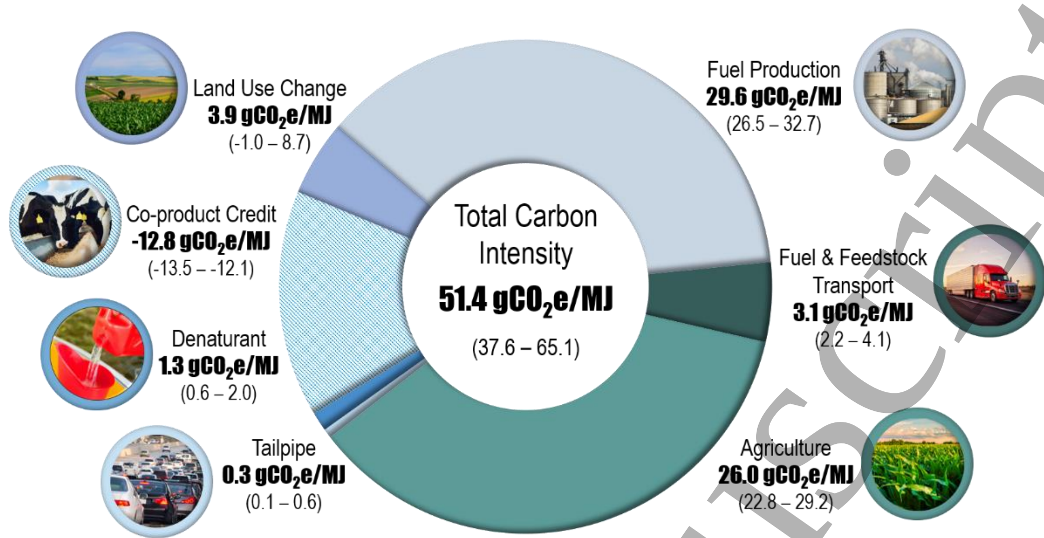


Figure 5. Greenhouse gas emission categories and total carbon intensity of corn ethanol.

4. DISCUSSION

We reviewed peer-reviewed publications and grey literature reports on well-to-wheel GHG LCAs and studies on specific components of LCAs that characterize CI for corn ethanol produced in the United States. ANL, CARB, USDA, and EPA are the four major organizations that produce LCAs for corn ethanol. Their estimates of corn ethanol CI decreased by approximately 50% over the prior 30 years although not uniformly. Estimates for GHG emissions from farming and production of ethanol fall within 20% of each other among the organizations. In addition, estimates of CI for farming and ethanol production that we produced from two independent sources of information corroborated the results from the four government organizations. However, treatment of LUC is less consistent among the organizations, with variability of approximately 70% among organizations. Our review indicates that estimates for CI of LUC from ANL and USDA are based upon more reliable methods and data than those from EPA and CARB. Those estimates of CI converge to a central best estimate of approximately 55 gCO_2e/MJ. Notably, some authors have generated lower and higher estimates of CI for corn ethanol than those evaluated here, but those assessments are for specific combinations of regions and technologies while our aim was to characterize emissions for the US (93, 94).

Modeled emissions from corn production and transport (including farming, feedstock transport, and co-product credit) decreased by approximately 14 gCO_2e/MJ between 1990 and 2010 and stabilized in the last decade, with all recent estimates from CARB, ANL, USDA, and EPA in the range of 10.5 to 24.4 gCO_2e/MJ (Figure 1). The downward trend of corn production emissions is explained by improvements in farming practices and LCA methods. In the past few decades, corn yield has increased and fertilizer application per bushel of corn has decreased as a result of crop and nutrient management strategies, such as use of nitrogen inhibitors and precision agriculture (7, 76, 95). According to USDA National Agriculture Statistics Service, the use of nitrogen fertilizer in grams per bushel of corn decreased by over 20% in the majority of "US Corn Belt" states (Illinois, Indiana, Iowa, Nebraska) between 2000-2018 (96). Farm energy use decreased by approximately 8% on a per bushel basis from 2005 to 2010, a downward trend that is likely to have continued since 2010 (97). The GREET model used to characterize farming emissions has also improved to quantitatively account for soil organic carbon, which tends to lower GHG emissions from corn farming (98). Inclusion of co-product credit associated with corn oil as a biodiesel feedstock contributed to the downward trend of corn production and transport emissions as well (99).

GHG emissions associated with farming practices net of co-product credit constitute a relatively large share (26%) of the total CI for corn ethanol, therefore, additional improvements that reduce the cradle-to-gate footprint of corn production would improve the CI of corn ethanol further. Greater adoption of techniques for precision-based application of fertilizers offer significant economic as well as environmental benefits (100, 101). The total cradle-to-farmgate CI for corn produced from states in the upper Midwest, which supply the bulk of corn to ethanol production, could be reduced in the region by up to 74% by adopting conservation tillage, reducing nitrogen fertilizer use, and implementing cover crops (102). The implementation of land management practices such as cover crops and manure application have been found to increase soil organic carbon (103). Results of improved management practices have been shown to depend on regionally variable factors including climate and soil characteristics, indicating the need and opportunity to pursue improvement management practices on a regionally-tailored basis (103). Biofuel policies should give farmers and corn ethanol producers full incentive and credit for adopting environmentally beneficial practices, which will in turn increase the economic incentives and result in wider use of those practices. We also recommend that future GREET models update inputs on energy sources used in corn production, since the current GREET model relies upon a 2015 USDA study that used farming data from 2010 (97). One other recommendation arising from our review is that Ecoinvent update its dataset on US corn production to reflect current average practice and more recent data, particularly for irrigation and grain drying.

Modeled emissions from ethanol production and transport decreased by approximately 27 gCO_2e/MJ between 1990 and 2010 and stabilized in the last decade, with all recent estimates from CARB, ANL, USDA, and EPA falling within 28.5 to 34.1 gCO_2e/MJ (Figure 1). Models used to estimate fuel production emissions have also been updated to include more current inputs for electrical generation mix data and more accurate distribution of plant types. However, the latest fuel production models still use electrical generation mix datasets that are either dated or based on estimated projections; and assume the distribution of fuel types (e.g., natural gas, coal) and plant types (e.g., dry mill, wet mill) are either 100% dry mill and natural gas or have remained static since 2016 (Table S.4). We recommend future studies validate the energy input and plant distribution data as they play a significant role in the determination of fuel production GHG emissions.

Since GHG emissions associated with producing ethanol account for 58% of the total CI for corn ethanol, additional production improvements related to co-products (DGS, CO_2, and corn oil) and alternative energy sources (biomass, biogas, and wind and solar energy) can play a significant role in reducing the overall CI of corn ethanol. Transitioning to 100% wet DGS can result in about -10 gCO_2e/MJ, due to savings in avoided energy associated with drying DGS (104). Carbon dioxide, a co-product from the corn ethanol fermentation process, can be sequestered or captured and sold for uses elsewhere, such as in the beverage industry, and could result in up to -30 gCO_2e/MJ by avoiding CO_2 emissions being released or generated (81, 104). Corn oil as a co-product can also lead to carbon credits if it displaces soy oil and if it is used as a pavement additive, which could extend the useful life of asphalt pavements (83, 84). The use of alternative energy sources such as biomass, dairy or swine biogas, and solar or wind energy can result in up to approximately -20 gCO_2e/M (13), -65 gCO_2e/MJ (105), and -5 gCO_2e/MJ (79) CI credits, respectively. We estimated the maximum potential CI credit for biomass by substituting natural gas as the energy source used for fuel processing and drying of DGS in GREET (106). We assumed biomass to be biogenic and its emissions as negligible, and did not consider the emissions associated with the processing and transport of biomass, nor the impact of corn stover as biomass on fertilizer use. We estimated the potential CI credit associated with biogas using 2019 LCFS pathways submitted to CARB for review (105), but did not consider logistical concerns regarding the supply and transport of sufficient biogas to refineries. We determined the CI potential of wind or solar power using CA-GREET (79), which includes wind and solar as emission free energy source options. The use of wind and solar power is not a feasible option to replace major energy sources such as natural gas but could be applied to specific refinery processes. We recommend continued research on the feasibility and impact of alternative co-product production processes, energy sources, and process fuels such as biomass, biogas, and wind and solar energy.

Modeled emissions from LUC decreased from 30.0 to 14.0 gCO_2e/MJ between 1990 and 2010 and have continued to decrease for LCAs from USDA and ANL (Figure 1), due to modeling and land management improvements. Modeling improvements include refinements to GTAP-BIO, the field-leading agroeconomic model, use of appropriate YDEL values (0.175-0.35), and inclusion of land intensification. Data-driven improvements to the GTAP over the years include updated regional YDELs, land transformation elasticities, land intensification parameters, and yield improvements; and the inclusion of cropland pasture as a land type for the US, Brazil, and Canada (39). Models with these improvements have resulted in lower LUC values (7, 39). For example, an adjustment to the land transformation parameter was made to account for the costliness associated with converting forest to cropland, relative to converting grassland (48, 107, 108). The costs and resources associated with transforming forest to cropland, tend to deter farmers and result in the conversion of more feasible land types such as pasture. Including this realistic and logical observation in land transformation parameters results in a decreased likelihood of converting forest to cropland, ultimately lowering modeled LUC values (107). ANL's domestic LUC model, CCLUB, has also been modified to include land management practices related to tillage and selection of soil depth, which influence SOC, and county-specific corn yield records of the modern agricultural period (37, 109). Incorporating domestic land management practices that increase SOC and actual yield data play a role in lowering GHG emissions associated with LUC.

LUC emission estimates from ANL and USDA (including a prediction for 2022) from the last decade fall within our estimated range of -1.0 to 8.7 gCO_2e/MJ. Estimates from CARB (19.8 gCO_2e/MJ) and EPA (26.3 gCO_2e/MJ predicted for 2022) fall outside our range, resembling LUC values from LCAs prior to 2011 (Figure 1), and are based on modeling approaches that do not represent current best practices. EPA used two different models that have limitations compared to GTAP-BIO: (1) FASOM, which focuses on dLUC and has not been widely adopted in LCAs for corn ethanol; and (2) FAPRI, which predicts non-specific changes in crop acres and requires external input of MODIS satellite data to assign land types, resulting in unreliable emission estimates associated with LUC (47). CARB used the GTAP-BIO model, but three out of five YDELs used for modeling (0.05, 0.10, 0.35) (53) fall outside our determined best practice range (0.175 to 0.325), and may not be representative of actual corn crop yields in response to price change. CARB also used an Agro-ecological Zone Emission Factor (AEZ-EF) model, which tends to generate higher LUC emissions primarily because of its treatment of cropland pasture. Emission factors in LUC modeling are used to assign carbon stock changes and emissions associated with reported land use changes. AEZ-EF assumes emissions from converting cropland pasture to cropland release 50% of the emissions associated with converting pasture to cropland (110). However, emissions associated with conversion of cropland pasture to cropland are likely to be lower due to periodic tilling since cropland pasture typically "shifts back and forth between cropland and grassland depending on the net returns (111)." Additional emission factor models used in LUC modeling are Woods Hole, Winrock International, and CCLUB (37, 112, 113). In conducting our review, we did not identify a comprehensive analysis which focused on the evaluation and utility of different LUC emission factors. To improve the characterization of LUC, we recommend future studies conduct a thorough review of the various emissions factors to assess the validity of their assumptions and functions.

Compared to estimates in earlier LCAs, more recent analyses indicate that LUC accounts for a small percentage (7%) of the overall CI of corn ethanol. A limitation of the current approach for predicting LUC in LCAs is that the resulting GHG emissions are presented as a static number. In reality, changes in land use, such as clearing of forest for farmland used for biofuel, create a carbon debt that can be repaid over time as biofuel displaces petroleum or other fossil fuels (114). The payback period is determined by the magnitude of the original debt and the size of the carbon dividend from the biofuel. In this context, the LUC carbon impact is a dynamic property that starts out as a large source, and eventually becomes a net carbon sink. The original analyses based upon this 'debt-dividend' framework suggested a payback period for corn ethanol of 48 – 167 years based upon a relatively small biofuel dividend (114). The latest LUC estimates described here suggest that the current biofuel dividend has increased since those early analyses. Thus, we recommend future research to update earlier analyses of carbon debt and dividend for corn ethanol as the timescale for ethanol production to become a net carbon sink from land use considerations may be considerably shorter than prior estimates. The updated analyses should incorporate recent data on the carbon content of Midwest prairie land and the net CI of corn ethanol farming and production relative to gasoline refined from petroleum.

Our analysis reviewed LCAs and LCA components conducted by researchers that primarily relied upon the GREET model, or a version of the GREET model (e.g. CA-GREET). It is important to acknowledge other international modeling tools that are available for developing a GHG emissions profile for corn ethanol, such as GaBi (115), GHGenius (116), and RenovCalc (117). A comparative analysis of international LCA modeling tools would strengthen understanding of the CI for corn ethanol. Additionally, our findings pertain to the impacts from current and modest increases in production and consumption of corn ethanol on a gCO_2e/MJ basis. A full consequential analysis is necessary to assess the effect of major increases in production and consumption (e.g. increasing the percent volume of ethanol in gasoline from 10% to 20%). A full consequential analysis would address constraints in the production system including land use availability, farming efficiencies (e.g. yield elasticity), and resources (e.g. water), as well as additional indirect emissions from changes in rice crop and livestock production and management. EPA and USDA estimated those two categories to contribute between 1.5 and 2.7 gCO_2e/MJ (2, 7). As part of a sensitivity analysis, we determined that including those two emission categories would increase our CI estimate by approximately 4%.

LCAs should also expand upon the latest empirical analyses of land use over time and across regions to characterize potential indirect land use change more accurately (56, 68, 69, 118). The most comprehensive study we drew upon was conducted by Babcock and Iqbal in 2014 (68). We recommend additional empirical LUC studies conducted that rely on recent and updated data sources, such as the Food and Agriculture Organization of the United Nations (119) and satellite data.

Our analysis on the state of the science of GHG emissions associated with the well-to-wheel life cycle of corn ethanol yielded a CI central estimate of 51.4 gCO_2e/MJ. We compared our central estimate to the average CI of neat gasoline, which ranges from 93 to 101 gCO_2e/MJ (2, 120, 121), with an average of approximately 96 gCO_2e/MJ. Relative to the average CI of conventional gasoline, our central estimate for corn ethanol is 46% lower. These results are relevant to policy and commerce because CI estimates generated from LCAs are used to make significant biofuel policy and market decisions on state, national, and international levels. We recommend that comparative analyses of the CI for transportation fuels clearly note the system boundaries of the respective analyses as our review demonstrates that the consequential components of a LCA can strongly influence the resulting CI estimates.

5. CONCLUSION

Assessments of GHG intensity for corn ethanol have decreased by approximately 50% over the prior 30 years and converged on a current central estimate value of approximately 55 gCO_2e/MJ which is over 40% lower on an energy equivalent basis than gasoline produced from crude oil. The decrease in GHG intensity is attributable to updates in modeling systems and input data that reflect market-driven changes in farming practices that lowered the use of fertilizer and fossil fuel on a per bushel basis, more efficient use of natural gas and more recent electric generation mix data for energy consumed at ethanol refineries, and market-based analyses of land use change. Current estimates from US organizations are primarily based upon the GREET modeling system and show that direct emissions associated with production of corn and ethanol from corn, including co-product credits for animal feed and corn oil, account for approximately 80% of total carbon intensity. Two independent sets of information that we examined corroborate the results from GREET. Compared to farming and ethanol production, estimates of CI associated with LUC are more variable among recent LCAs, however, the most comprehensive evaluations indicate emissions are lower than 10 gCO_2e/MJ. Recent research indicates that market conditions that favor greater adoption of precision agriculture systems, retention of organic carbon in soil, and demand for co-products from ethanol production have the potential to reduce the CI of corn ethanol. Continued development and refinement of models to account for co-products, farming practices such as conservation of soil carbon, and direct and indirect land use change is expected to improve the accuracy of CI estimates in the future.

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DATA AVAILABILITY

The data that support the findings of this study are available upon request from the authors.

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Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 5

EPA Proposed Renewable Fuel Standards for 2018: Estimated Increase in National GHG Emissions if EPA Reduces the Conventional Fuel Volume

Prepared for Growth Energy by Air Improvement Resource, Inc.

August 31, 2017

The U.S. Environmental Protection Agency's (EPA's) proposed Renewable Fuel Standard (RFS) volumes for 2018 proposes 15 bgy of conventional biofuel. This is consistent with the statutory implied minimum volume requirement for conventional biofuel.

The purpose of this study is to estimate the GHG emission benefits that would result from finalizing the implied conventional fuel requirement lower than 15 bgy. We find that for every 100 million gallons of reduced conventional biofuel, annual GHG emissions in the U.S. would increase by 322,876 metric tons.

Analysis

Conventional biofuels have much lower lifecycle GHGs than the gasoline they replace. As a consequence, using less conventional biofuels results in a corresponding increase in GHG emissions. GHG emission increases can be estimated with the following expression:

GHG = Gallons * 76,330 btu/gal * 1MMBtu/1,000,000 btu * [98 Kg/MMBtu – 55.7 Kg/MMBtu] * 1 metric ton/1000kg

Where

GHG = GHG emission increase in metric tons
Gallons = conventional fuel volume reduction from 15 bgy
76,330 Btu/gallon is energy content of ethanol [1]
98 Kg/MMBtu = lifecycle GHG of gasoline per MMBtu
55.7Kg/MMBtu = lifecycle GHG of dry mill ethanol plant in 2014 in MMBtu according to recent report for USDA

The 98 Kg/MMBtu is EPA's estimate of the lifecycle GHG emissions of gasoline, which ethanol replaces.[2] USDA's recent analysis of the lifecycle emissions

[1] *See* http://cta.ornl.gov/bedb/appendix_a/Lower_and_Higher_Heating_Values_of_Gas_Liquid_and_Solid_Fuels.pdf
[2] *See* 75 Fed. Reg. 14788, Table V.C-1 (March 26, 2010).

of a typical natural gas dry mill in 2014 producing ethanol is 55.7 Kg/MMBtu.[3] Thus, the GHG benefit of the conventional ethanol over gasoline is 42.3 Kg/MMBtu.

Using the expression described above and 100 million gallons, the result is 322,876 metric tons of GHG per 100 million gallons. Thus, for every 100 million gallons reduction in conventional biofuel from 15 bgy, the increase in GHG is 322,876 metric tons.

[3] *A Lifecycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol*, ICF, for the Department of Agriculture, January 12, 2017.

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 6

Emissions Reductions from Current Natural Gas Corn Ethanol Plants

Prepared for Growth Energy by Air Improvement Resource, Inc.

July 27, 2015

This analysis relies on U.S. Environmental Protection Agency (EPA) emissions data, supplemented with the most reliable and broadly used modeling data and land use change estimates, to assess current greenhouse gas (GHG) emissions from existing corn ethanol plants. Based on this data, current GHG emissions from corn ethanol plants are between 28% and 41% lower than current emissions from gasoline plants.

Table 1, which is drawn directly from the 2010 Renewable Fuel Standard final rule (RFS2), shows EPA's assessment of anticipated lifecycle GHG emissions for a natural gas dry mill corn ethanol facility for 2022.[1] The second column shows GHG emissions broken down by several stages of lifecycle impacts.

Table 1: Lifecycle GHG Emissions For Corn Ethanol, 2022
(average natural gas dry mill producing 37% wet DGs, 66% dry DGs)[2]

Lifecycle Component	*(Kg CO2e/MMBtu)*
Net Domestic Agriculture	4
Net International Agriculture	12
Domestic Land Use Change	-2
International Land Use Change	32
Fuel Production	28
Fuel and Feedstock Transport	4
Tailpipe	1
Total (mean)	**79**

As shown in Table 1, EPA estimated 2022 total emissions — including land use — to be an average of 79 Kg/MMBtu. EPA compared these projected corn ethanol emissions against baseline gasoline emissions of 98 Kg/MMBtu and concluded that ethanol emissions from natural gas facilities would be approximately 20% lower than gasoline facilities in 2022.

[1] *See* 75 Fed. Reg. 14788, Table V.C-1 (March 26, 2010).

[2] Distillers grains, or DGs, are a co-product of a corn ethanol dry mill plant. Some plants dry the DGs, primarily for ease of transport, while other plants keep them wet. Drying the DGs necessarily uses more energy than not drying the DGs.

The analysis in this report draws on the data from EPA's 2010 RFS2 final rule, as found in Table 1, but replaces the projected 2022 fuel production and land use change data with actual data from 2014 in order to assess *current* GHG emissions from natural gas ethanol facilities. To conduct this analysis, fuel production data was obtained from the recently released Argonne National Lab GREET 2014 model, which is a current and broadly used source of emissions data.[3] GREET is updated annually, and ethanol plant input information is sourced from a periodic, independent survey of actual natural gas ethanol plants.[4] We evaluated fuel production emissions for a dry mill plant using natural gas and producing both wet and dry distillers grains. Results are shown in Table 2. The results are shown in both g CO2e/MJ and Kg/MMBtu. For comparison to Table 1, we also weight the wet DGs emissions by 37% and the dry DGs emissions by 63%.

The weighted average emissions for 2014 are 29 Kg/MMBtu, which is very close to the 28 Kg/MMBtu estimated by EPA for the 2022 timeframe. This is indicates that many natural gas dry mill plants have adopted technologies improving yield and reducing process fuel consumption earlier than predicted by EPA. These technologies include sophisticated heat integration, combined heat and power strategies, variable frequency drives, advanced grinding technologies, various combinations of front and back-end oil separation, and innovative ethanol and dry DGs recovery.[5]

Table 2. Dry Mill Natural Gas Plant with 100% wet DGs and 100% dry DGs using GREET2014

Type	Production Emissions, g CO2e/MJ	Production Emissions, Kg/MMBtu
Wet DGs	22.72	23.86
Dry DGs	30.72	32.25
37% wet, 63% Dry DGs	27.76	29.14

For updated land use change data, this analysis draws on two sources. The first source is information from the California Air Resources Board (CARB) assessment of domestic and international land use change. CARB currently estimates the combined domestic and international land use change of corn ethanol

[3] GREET2014 and all documentation are located at https://greet.es.anl.gov/.

[4] *Updates to the Corn Ethanol Pathway and Development of an Integrated Corn and Corn Stover Ethanol Pathway in the GREET Model*, October 3, 2014, *available at* https://greet.es.anl.gov/publication-update-corn-ethanol-2014.

[5] S. Mueller and J. Kwik, Univ. of Illinois Chicago Energy Resources Center, *2012 Corn Ethanol: Emerging Plant Energy and Environmental Technologies* (April 29, 2013).

at 19.8 gCO2e/MJ.[6] When converted to Kg/MMBtu—the units used in EPA's data in Table 1—the combined land use change totals 20.9 Kg/MMBtu.

A second recent estimate of potential land use change emissions for corn ethanol was made by a group of authors from Argonne National Lab, the University of Illinois, the University of Illinois at Chicago, and the International Food Policy Research Institute.[7] The land use change emissions for corn ethanol in this analysis was a much lower 7.6 gCO2e/MJ. When converted to Kg/MMBtu, the value is 7.98 Kg/MMBtu. These two widely-differing estimates of the potential land use change emissions due to corn ethanol illustrate that the science of estimating land use change emissions for biofuels is far from mature. Nonetheless, both of these estimates for corn ethanol are more current than EPA's assessment, and provide the best estimate of the range of emissions from a current natural gas dry mill corn ethanol plant.

The summary of 2014 ethanol emissions, relying on this data from the GREET model, CARB and Argonne, is shown in Table 3. Items bolded are the only items modified from Table 1.

Table 3: Lifecycle GHG Emissions For Corn Ethanol, 2014
(natural gas dry mill, 37% wet DGs, 63% dry DGs)

Lifecycle Component	*Kg CO2e/MMBtu)*
Net Domestic Agriculture	4
Net International Agriculture	12
Land Use Change	**7.98–20.9**
Fuel Production	**29**
Fuel and Feedstock Transport	4
Tailpipe	1
Total (mean)	**57.98–70.9**

As reflected in Table 3, current GHG emissions for a 100% dry distillers grain ethanol plant total between 61.1 and 75.6 KG/MMBtu. These total ethanol emissions are in the range of 28%–41% lower than EPA's baseline gasoline

[6] *Staff Report: Initial Statement of Reasons, Proposed Re-adoption of Low Carbon Fuel Standard* (Dec. 2014), available at http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs2015.htm

[7] Dunn J., Qin, Z., Mueller, S. Kown, H., Wander, M., Wang, M., Argonne National Laboratory, *Carbon Calculator for Land Use Change from Biofuels Production*, ANL/ESD/12-5 (Jan 23, 2014).

emissions of 98 Kg/MMBtu, as reported in the agency's 2010 RFS2 final rule.[8,9] The reduced emissions from current corn ethanol facilities can be attributed to improved efficiencies and faster-than-expected adoption of new technologies at ethanol facilities.

At least one alternative analysis, published in 2011, contends that GHG emissions from corn ethanol in 2012 are instead 36% *higher* than baseline lifecycle gasoline emissions.[10] That analysis, however, which purports to use EPA information on the types of corn ethanol plants in the U.S., is fundamentally flawed, because it (1) assumes all U.S. corn ethanol plants produce 100% dry distillers grains, (2) assumes all dry mill plants producing 100% dry distillers grains have the same carbon intensity, (3) does not weight the percent change in emissions by ethanol volume, and (4) does not use a much more recent corn ethanol land use values.

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[8] 75 Fed. Reg. 14788, Table V.C-1 (March 26, 2010). The comparative emissions reduction from ethanol facilities would be even lower if the data included a mix of wet distillers' grains, as EPA assumed in its 2010 RFS2.

[9] We were unable to identify a 2014 value for gasoline from EPA to compare with the 2014 corn ethanol level. However, CARB has changed their gasoline estimate, between the current Low Carbon Fuel Standard (LCFS) and the proposed re-adoption of the LCFS. The current CARBOB (California Reformulated Gasoline Blendstock for Oxygenate Blending) CI level is 99.18 gCO2e/MJ. *See* CARB, Proposed Second 15-Day Regulation Order, p. 59 Table 6, *available at* http://www.arb.ca.gov/regact/2015/lcfs2015/lcfsmodregorder.pdf, at Attachment A, p. 59 Table 6 (showing both the current and proposed CARBOB CI values, with strikeouts through the old regulation order). Thus, the CARBOB CI has *increased* by 0.6% since EPA published its RFS2 in 2010.

[10] Kate McMahon and Victoria Witting, *Corn ethanol and climate change* (July 2011).

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 7

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ARTICLE

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Reduced ultrafine particle levels in São Paulo's atmosphere during shifts from gasoline to ethanol use

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Despite ethanol's penetration into urban transportation, observational evidence quantifying the consequence for the atmospheric particulate burden during actual, not hypothetical, fuel-fleet shifts, has been lacking. Here we analyze aerosol, meteorological, traffic, and consumer behavior data and find, empirically, that ambient number concentrations of 7–100-nm diameter particles rise by one-third during the morning commute when higher ethanol prices induce 2 million drivers in the real-world megacity of São Paulo to substitute to gasoline use (95% confidence intervals: +4,154 to +13,272 cm^{-3}). Similarly, concentrations fall when consumers return to ethanol. Changes in larger particle concentrations, including US-regulated PM2.5, are statistically indistinguishable from zero. The prospect of increased biofuel use and mounting evidence on ultrafines' health effects make our result acutely policy relevant, to be weighed against possible ozone increases. The finding motivates further studies in real-world environments. We innovate in using econometrics to quantify a key source of urban ultrafine particles.

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Vehicular emissions are main contributors to urban air pollution within megacities[1]. Of key relevance to both health[2–5] and climate change[6, 7] policies is particulate matter (PM), a broadly defined class of ambient air pollutants[8, 9]. Around the world, gasoline is the typical fuel source for the passenger-car and motorcycle fleets that circulate in urban areas, outnumbering heavy-duty diesel vehicles by an order of magnitude or so. With the introduction of biofuel ethanol to the fuel mix witnessed in countries, such as Brazil, Sweden and the United States, as both a substitute for gasoline and as a fuel additive, it is timely to assess the effect such changes have on ambient particle levels across the size range[10]. Some controlled emissions studies show improved combustion efficiency and lower tailpipe emissions as the ethanol fraction in gasoline increases and, in particular, research in the laboratory indicates that gasoline combustion can lead to larger amounts of ultrafine particles (<100 nm in diameter) when compared to ethanol combustion[11–19]. Beyond the tailpipe and the lab, a few modeling studies have focused on ambient air, attempting to predict the impact on PM2.5 levels (PM up to 2.5 μm in diameter) of the adoption of E20 or E85[20–22], yet such studies are based on hypothetical fuel shifts, and ignore the currently unregulated health-relevant ultrafine range[23–27]. The variation in PM concentrations in ambient air during actual fuel shifts, in the real-world setting of a major metropolitan area undergoing a period of large-scale fluctuations in gasoline vs. ethanol use, has not been assessed, nor has the particle size dependence on the fuel mix been evaluated until now.

The one location that features episodes of large-scale shifts in fuel mix as well as well-maintained monitoring networks for air, weather and road traffic is the subtropical megacity of São Paulo. Urban São Paulo is home to about 20 million people and 6 million passenger cars, with gasoline-ethanol "flex-fuel" vehicles accounting for over half of vehicle miles traveled. Due to significant investment into sugarcane ethanol supply and demand[28], ethanol prices that fluctuate with the world sugar market, and government-controlled gasoline prices, there has been large-scale switching by consumers between ethanol (E100) and gasoline (a E20 blend typically), fuels that are ubiquitous at retail[29, 30].

In this study, we combine aerosol size distribution measurements between 7 and 800 nm and mass concentration measurements for black carbon (BC) and PM2.5 with an econometric approach to evaluate how the gasoline-ethanol fuel mix impacts ambient particle levels in urban São Paulo across a wide range of sizes. The method incorporates consumer responses to price movements at the pump and examines pollutant concentration, meteorology and road traffic observations at the street-hour level. The longest sample period among the data sets that we use is November 1, 2008 to May 31, 2013, excluding the colder months of June to September. This sample period includes two episodes of large variation in ethanol prices and subdued movement in gasoline prices, over the spring to fall 2009–2010 and again over the spring to fall 2010–2011. These large fluctuations in the price of ethanol relative to gasoline, and the induced shifts in consumer choice at the pump between ethanol and gasoline, were driven by developments in world food and energy markets,[31, 32] and not concerns about air quality in São Paulo. Short-run fluctuations in relative fuel prices, while shifting consumers' choice of fuels, did not impact price-inelastic demand for driving or travel behavior[33]. Tunnel studies in the area attribute particle sizes below 100 nm to direct emissions from both light and heavy vehicles[34], and diesel combustion, used exclusively in a fleet of 0.3 million heavy vehicles, was invariant to movements in the ethanol-to-gasoline price ratio. Given this background, we determine how particle concentrations across PM2.5 to ultrafines varied in the real-world setting of São Paulo as the metropolis underwent periods of increased—followed by decreased—gasoline relative to ethanol use, once potential confounding factors are accounted for, including temperature, wind, boundary layer height, precipitation, the spatial distribution of traffic, and even drifts.

A previous application of the econometric method to these price-induced natural experiments addressed only regulated gaseous pollutants routinely measured by the environmental authority[33], compared to the field-derived particle size distribution measurements we now examine[35, 36]. That study found that shifts from gasoline to ethanol use increased ozone concentrations, countering the reduction in ambient number concentrations of <50 nm diameter nanoparticles that we now report. Our "purely empirical"[37] approach provides a concrete benchmark for alternative approaches used to evaluate urban air pollution, specifically those based on emissions inventories, the analysis of exhaust emissions or smog chambers, source apportionment studies and chemical modeling[38, 39]. Motivated by a recent modeling study associating PM with higher mortality when compared to ozone[3], a proposed next step in this research agenda is to evaluate how public health outcomes co-varied with the ethanol fraction relative to gasoline, as ozone rose whereas ultrafines fell while PM2.5 remained invariant.

Results

Ultrafines rose with shift to gasoline and fell upon return. Our two-step multivariate regression model considers price-induced shifts in consumer fuel shares in a first step, and the impact of these consumer choices, gasoline vs. ethanol, on ambient air in a second step[33, 40]. As the first step, we require a consumer demand model[30, 41] to predict day-to-day quantities from day-to-day prices because high-frequency fuel quantity data for the São Paulo metropolis are not available, only daily price data. In the second step, the econometric/statistical approach corrects for[37, 42, 43] potentially high variability in particle levels. Specifically, the analysis fixes or controls for potential factors of nanoparticle variation[8, 10], including the distance of measurement from roads, the time of day, the day of the week, seasonality, longer term trends such as growth and compositional changes in the vehicle fleet, key meteorological variables, traffic congestion, and the combustion of fuels other than gasoline and ethanol, which are our object of interest (Table 1). The econometric approach requires that the analyst give careful consideration to whether remaining, unobservable determinants of nanoparticles might co-vary with the gasoline-ethanol mix, and the evidence suggests not (Methods).

Figure 1 and Table 2 summarize our main results. We both plot and in the table's first row report the estimated changes in ultrafine (7–100-nm diameter), PM100-800 nm, BC, PM2.5, and ozone concentrations scaled for a 50-percentage point shift in the gasoline share in the flex fleet, from 30 to 80%. Induced by the most marked episode of fluctuation in ethanol prices in the past decade, shifts in gasoline use of this magnitude—a rise followed by a fall—were observed from mid-summer to mid-fall of 2011 (Fig. 2a). This was quite a seasonally homogeneous five-month period, for example, with temperatures trending downward only slightly and during which there were no school breaks, noting that large seasonal influences on ambient particles might otherwise be hard to control (correct) for.

Both Fig. 1 and Table 2 report 95% confidence intervals (CI), i.e., with about two standard errors on either side of a point estimate (point estimate $\pm 1.96 \times$ standard error; see Table 2 notes). Estimated effects from raising the gasoline share on BC mass concentration (reported for 08:00), PM2.5 mass concentration (24-h) and PM100-800 nm number concentration (08:00) are statistically insignificant from zero (Supplementary Notes 1, 2

Table 1 Description of the different data sets that the present study combines including summary statistics

Variable and unit of measurement (and method, if relevant)	Data Source	Full sample period[a]	Sampling sites	Data frequency	No. of observations	Mean	Std. Dev.	Min.	Max.
Particle pollution variable									
PM2.5 mass concentration, 24-h filter ($\mu g\,m^{-3}$)	CETESB	11/2008–5/2013	Three[b]	24-h	727	16.39	9.91	1.00	68.00
PM2.5 mass concentration, beta continuous ($\mu g\,m^{-3}$)	CETESB	1/2011–5/2013	Three[c]	1-h	43,571	20.44	14.94	0.00	160.00
Black carbon (BC) mass concentration, MAAP ($\mu g\,m^{-3}$)	Own	10/2010–4/2011[d]	One (USP)	1-h	6,152	3.23	2.69	0.06	15.67
Ultrafine particle number concentration (UFP) 7–100 nm, DMPS (cm^{-3})	Own	10/2010–9/2011	One (USP)[e]	1-h	6,454	14,561	6,384	1,339	56,019
PM 100–800 nm number concentration, DMPS (cm^{-3})	Own	10/2010–9/2011	One (USP)[e]	1-h	6,454	3,161	2,900	86	22,291
Fuel mix variables (light vehicles and motorcycles)									
Ratio of ethanol-to-gasoline regular-grade prices per litre (%)	ANP (at the pump)	11/2008–5/2013	Median SPMA[f]	Daily	1,673	0.64	0.07	0.49	0.85
Gasoline share in the flex-fuel light-vehicle fleet (%)	Salvo-Huse (2013)	11/2008–5/2013	Estimated[g]	Daily	1,673	0.35	0.14	0.11	0.76
Ethanol share in the flex-fuel light-vehicle fleet (%)	Salvo-Huse (2013)	11/2008–5/2013	Estimated[g]	Daily	1,673	0.65	0.14	0.89	0.24
Gasoline share among all gasoline and ethanol consumers (%)	ANP (wholesalers)	11/2008–5/2013	SP state[h]	Monthly	55	0.63	0.09	0.51	0.82
Ethanol share among all gasoline and ethanol consumers (%)	ANP (wholesalers)	11/2008–5/2013	SP state[h]	Monthly	55	0.37	0.09	0.49	0.18
Control variables									
Solar radiation ($W\,m^{-2}$)	CETESB	11/2008–5/2013	Mean SPMA[f]	1-h	40,112	175.73	257.95	0.00	1280.40
Ground temperature (°C)	CETESB	11/2008–5/2013	Mean SPMA[f]	1-h	40,144	20.77	4.84	5.53	38.40
Relative humidity (%)	CETESB	11/2008–5/2013	Mean SPMA[f]	1-h	40,013	77.28	17.73	12.30	98.90
Wind speed ($m\,s^{-1}$)	CETESB	11/2008–5/2013	Mean SPMA[f]	1-h	40,145	1.37	0.76	0.00	4.36
Wind blows from North-East (yes = 1)	CETESB	11/2008–5/2013	SPMA[f,i]	1-h	155,308	0.15	0.35	0.00	1.00
Wind blows from South-East (yes = 1)	CETESB	11/2008–5/2013	SPMA[f,i]	1-h	155,308	0.41	0.49	0.00	1.00
Wind blows from South-West (yes = 1)	CETESB	11/2008–5/2013	SPMA[f,i]	1-h	155,308	0.10	0.30	0.00	1.00
Wind blows from North-West (yes = 1)	CETESB	11/2008–5/2013	SPMA[f,i]	1-h	155,308	0.17	0.38	0.00	1.00
Precipitation ($mm\,h^{-1}$)	INMET	11/2008–5/2013	SPMA[f]	1-h	40,085	0.21	1.57	0.00	58.40
Thermal inversion at 09:00 with base of layer 0–199 m (yes = 1)	FAB	11/2008–5/2013	SPMA[f]	Daily	1,671	0.08	0.27	0.00	1.00
Thermal inversion at 09:00 with base of layer 200–499 m (yes = 1)	FAB	11/2008–5/2013	SPMA[f]	Daily	1,671	0.26	0.44	0.00	1.00
Road congestion at the citywide level (km)	CET	11/2008–5/2013	SP city[h]	1-h	40,152	24.65	36.57	0.00	294.66
Road congestion in the North region of SP city (km)	CET	11/2008–5/2013	SP city[h]	1-h	40,152	0.65	1.56	0.00	21.59
Road congestion in the East region of SP city (km)	CET	11/2008–5/2013	SP city[h]	1-h	40,152	6.23	10.03	0.00	99.51
Road congestion in the South region of SP city (km)	CET	11/2008–5/2013	SP city[h]	1-h	40,152	5.15	8.44	0.00	77.55
Road congestion in the West region of SP city (km)	CET	11/2008–5/2013	SP city[h]	1-h	40,152	5.50	9.19	0.00	89.76
Road congestion in the Center region of SP city (km)	CET	11/2008–5/2013	SP city[h]	1-h	40,152	7.11	11.03	0.00	81.35
Number of aircraft departing from Congonhas airport (h^{-1})	ANAC	11/2008–5/2013	CGN airport[j]	1-h	40,140	9.03	6.43	0.00	32.00
Number of aircraft landing at Congonhas airport (h^{-1})	ANAC	11/2008–5/2013	CGN airport[j]	1-h	40,140	9.01	6.51	0.00	29.00
Diesel prices and usage (heavy vehicles)									
Diesel real price index (October 2008 = 100, IPCA)	IBGE	11/2008–5/2013	SPMA[f]	Monthly	55	86.06	6.36	78.25	100.85
Ridership on diesel buses in the public transport system ($\times 10^6\,day^{-1}$)	SPTrans	11/2008–5/2013	SPMA[f]	Monthly	55	7.96	0.44	6.78	8.65

[a]Samples described here include the colder months of June to September and all days of the week
[b]Cerqueira César, Ibirapuera and Pinheiros air monitoring sites
[c]Congonhas, Pinheiros and University of São Paulo/IPEN air monitoring sites
[d]Sampling additionally occurred during 8–11/2012
[e]DMPS data validated against an independent CPC operated concurrently
[f]SPMA denotes São Paulo Metropolitan Area (São Paulo metropolis)
[g]Estimated using actual consumer choices at varying prices
[h]SP denotes São Paulo
[i]Wind monitors at Ibirapuera, Osasco, Pinheiros and Santana stations
[j]CGN denotes Congonhas. See Methods for the data sources beyond the acronyms provided here

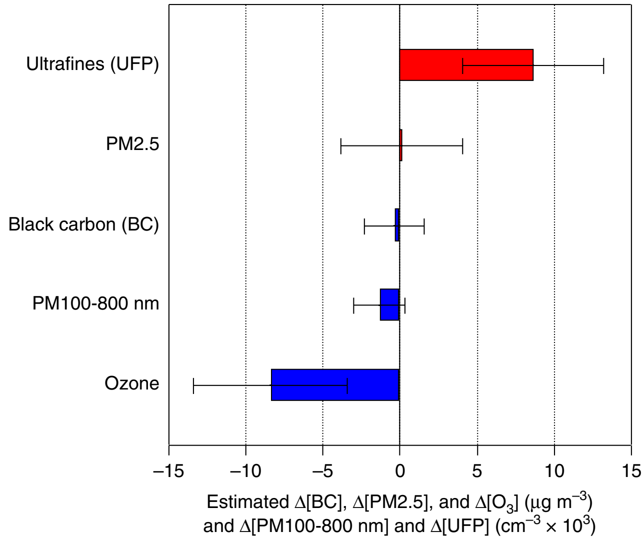

Fig. 1 Estimated changes in pollutant concentrations. For varying composition, size range, and time-of-day window, in the São Paulo metropolitan area as the gasoline share in the flex-fuel fleet rises from 30 to 80 percentage points. Submicron particles and BC correspond to readings at 08:00, PM2.5 are 24-h means, and ozone are afternoon means between 12:00 and 16:00. Sample periods are January to May 2011 for submicron particles, October 2010 to April 2011 and October to November 2012 for BC, and November 2008 to May 2013 for PM2.5 and ozone. 95% Confidence Intervals (CI) are shown. Source: Specifications reported in Table 2

and 4). Previous research identifies diesel use in heavy vehicles as the main source of BC in the metropolis,[34, 44, 45] and diesel combustion did not fluctuate in tandem with the gasoline-ethanol mix (Supplementary Figs. 5–8). This provides an explanation for the insignificant impact on BC (CI $-0.3 \pm 1.9\,\mu g\,m^{-3}$) from raising the proportion of the flex fleet burning gasoline rather than ethanol. Figure 3 shows that all estimated gasoline vs. ethanol effects reported in Fig. 1 and Table 2 remain unchanged when we include monthly ridership in diesel buses in the metropolis as an additional control in our regression models (Supplementary Fig. 6).

In contrast to the large size ranges, concentrations of ultrafines during the morning commute show a clear 30% increase with higher gasoline penetration. Taking the largest estimated change over the day, at 08:00, a 30–80% increase in gasoline penetration (equivalent to a 70–20% decrease in ethanol penetration) is associated with a $8,713 \pm 4,559\,cm^{-3}$ increase in ambient number concentrations of <100 nm diameter nanoparticles, i.e., a CI between +4,154 and +13,272 cm^{-3}. The fact that the experimental lever, the share of gasoline, was pulled in both directions—up then down—coinciding with movement in ultrafine levels—up then down—strengthens our result. In particular, the co-variation that we uncover is not estimated off a trend, which our regression models correct for (Table 2), and as such is unlikely to suffer from omitted variable bias.

Also reassuring is the estimated association between meteorology and pollutant concentrations reported in Table 2, such as the negative and statistically significant effect of wind speed on all measured parameters[46]. To illustrate the method, the last column of Table 2 reveals the reduction in afternoon ozone levels

Table 2 Changes to particle and ozone concentrations associated with variation in the gasoline-ethanol fuel mix

Column number:	(1)	(2)	(3)	(4)	(5)
Dependent variable:	BC	PM2.5	PM 100–800 nm	UFP 7–100 nm	Ozone
Unit:	$\mu g\,m^{-3}$	$\mu g\,m^{-3}$	cm^{-3}	cm^{-3}	$\mu g\,m^{-3}$
Mean over hour window:	08:00	24-h	08:00	08:00	12:00–16:00
Sample period:	Oct/2010 to Apr/2011 & Oct to Nov/2012	Nov/2008 to May/2013	Jan/2011 to May/2011	Jan/2011 to May/2011	Nov/2008 to May/2013
Number of sampling sites:	1	3	1	1	12
Source:	Own	CETESB	Own	Own	CETESB
Share of Gasoline E20/E25 in the flex fleet rises from 30 to 80% Equivalently, share of Ethanol E100 in the flex fleet falls from 70 to 20%	−0.3 ± 1.9	0.2 ± 3.9	−1,249 ± 1,669	8,713 ± 4,559	−8.3 ± 5.0
Control variables (to correct for the influence of other determinants of particles)					
Site-specific linear trend	Yes	Yes	Yes	Yes	Yes
Week-of-year fixed effects	No	Yes	No	No	Yes
Day-of-week fixed effects	Yes	Yes	Yes	Yes	Yes
Radiation (+100 $W\,m^{-2}$)	0.5 ± 0.7	−0.4 ± 2.2	4 ± 825	235 ± 1,798	4.2 ± 0.7
Temperature (+1 °C)	0.0 ± 0.2	1.2 ± 0.5	236 ± 235	−847 ± 836	3.1 ± 0.4
Humidity (+10%)	0.1 ± 0.7	−1.0 ± 1.6	349 ± 721	−1,020 ± 1,712	−4.9 ± 1.3
Wind speed (+1 $m\,s^{-1}$)	−3.2 ± 1.2	−6.5 ± 2.8	−2,102 ± 1,410	−4,217 ± 3,489	−13.2 ± 2.1
Other meteorological and road traffic conditions (see notes)	Yes	Yes	Yes	Yes	Yes
R^2	62.0%	73.4%	76.0%	69.8%	70.7%
Number of observations	129	511	80	80	13,203
Number of regressors	18	74	19	19	96
Mean value of dependent variable	6.0	13.8	3,577	18,659	72.2

Coefficients and 95% confidence intervals, i.e., point estimate ± 2 standard errors. An observation is a date (columns 1, 3, 4) or a date-site pair (columns 2, 5). Samples exclude the colder months of June to September, and include all days of the week (columns 2, 5) or non-holiday weekdays only (columns 1, 3, 4). Radiation, temperature, humidity, and wind speed in the recorded unit. All columns additionally include several precipitation, thermal inversion and road traffic congestion indicators. Columns 1 to 4 further control for wind direction and column 5 follows Supplementary Table 4. Since the longer samples encompass 2010, columns 2, 5 include site-specific intercepts indicating the opening of the Greater São Paulo beltway's southern section on March 31, 2010. The effect of raising the gasoline share in the flex fleet is scaled for in-sample variation from 30 to 80%. The corresponding variation in the ethanol share is one minus variation in the gasoline share. Ordinary Least Squares (OLS) estimates, with standard errors calculated by bootstrapping (200 samples each): (i) the consumer-level fuel choice data, to account for sampling variation in the predicted gasoline share in a first-step consumer demand model, and (ii) the pollutant-meterology-traffic data in the second-step particle regression, clustering by date

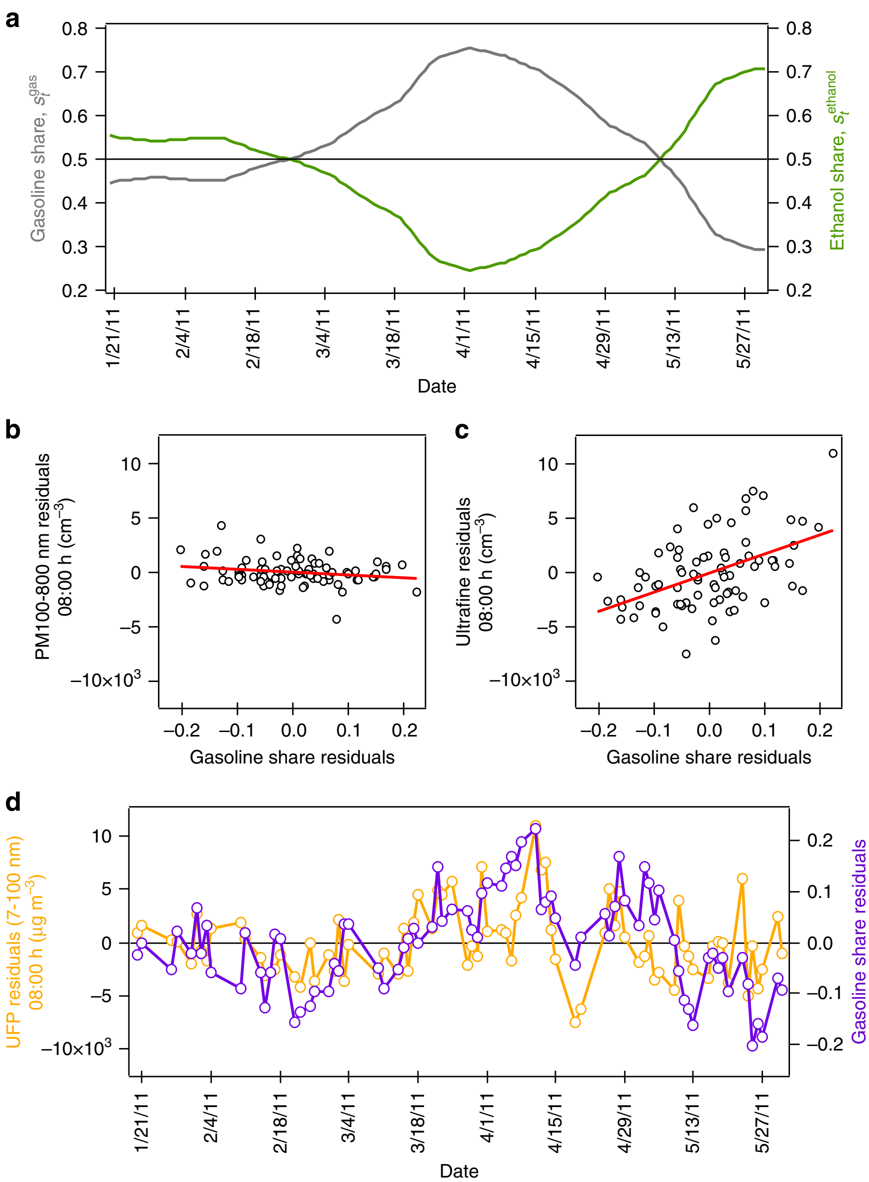

Fig. 2 Submicron particles and the gasoline share. **a** Fuel share variation among flex-fuel vehicles from January to May 2011. **b** Co-variation of PM 100–800 nm and **c** ultrafine number concentration residuals with gasoline share residuals for the weekday morning hour of 08:00 in the same period. The *red line* marks the best linear predictor. **d** Morning-hour variation of ultrafine number concentration and gasoline share residuals over the period. Source: Specifications reported in Table 2

previously reported for shifting ethanol to gasoline use[33], consistent with a hydrocarbon-limited regime[37], but estimated here from a longer sample than previously, namely 2008 to 2013, rather than to 2011 (Supplementary Note 3).

Tight co-variation during morning rush hour. Figure 2b and c provide a graphical representation of these submicron results. We separately plot residual concentrations at 08:00 for PM100-800 nm and for ultrafines, obtained after filtering out all co-variation with control variables, against the residual gasoline share, obtained in the same way. For clarity, from each raw data series—the 7–100 nm values at 08:00, the 100–800 nm values at 08:00, and the gasoline share—we "partial out" (correct for) any co-variation with observed meteorological and road traffic conditions, as well as systematic day-of-the-week (e.g., Monday vs. Friday) and trending variation (Supplementary Note 6). The illustration considers the two-step model specification reported in Table 2, columns (3) and (4), for a sample restricted to non-holiday weekdays between January 20 and May 31, 2011, and wind direction and a linear trend added to the vector of controls. We choose this as our preferred specification with a view to limiting unobserved determinants of the particle size distribution, which might bias our estimates of the effect of the fuel mix or make them less precise (Supplementary Note 5 reports robustness to these choices and Methods provides an overview of all estimated regression specifications).

Indeed, the panels show the strong positive association with gasoline for 7–100 nm (Fig. 2c), but not for 100–800 nm (Fig. 2b), at 08:00. We repeat the exercise for 7–100 nm and 100–800 nm measurements in the evening, at 18:00 (Supplementary Fig. 17f,g), and there is no clear relationship.

Figure 2d plots the strikingly tight and statistically significant day-to-day correlation at 08:00: the ultrafine particle levels we uncover, after correcting for the influence of other observed factors, move in lockstep with the gasoline share. In the context of a regression equation, both the outcome variable, ultrafines, and

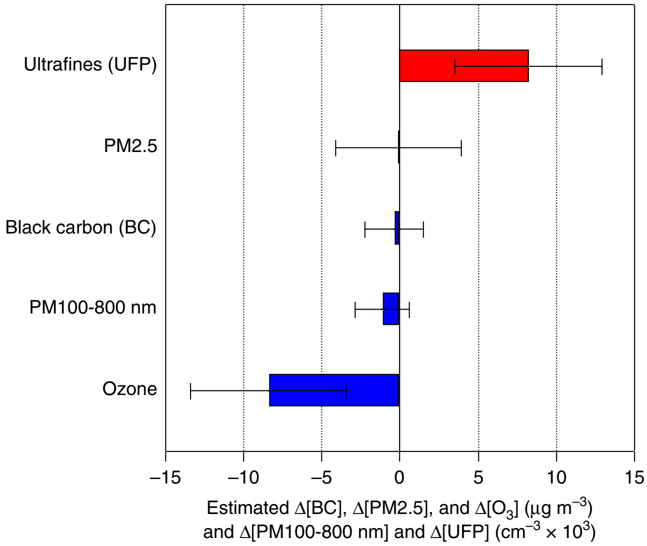

Fig. 3 Sensitivity to diesel control for changes in pollutant concentrations. For varying composition, size range, and time-of-day window, in the São Paulo metropolitan area as the gasoline share in the flex-fuel fleet rises from 30 to 80 percentage points. Submicron particles and BC correspond to readings at 08:00, PM2.5 are 24-h means, and ozone are afternoon means between 12:00 and 16:00. Sample periods are January to May 2011 for submicron particles, October 2010 to April 2011 and October to November 2012 for BC, and November 2008 to May 2013 for PM2.5 and ozone. 95% CI are shown. Source: Specifications reported in Table 2 additionally controlling for monthly diesel bus ridership in the metropolis' public transportation system (Supplementary Fig. 6)

the key regressor of interest, the gasoline share (which is assumed orthogonal to any remaining unobserved determinants of ultrafines) together move up until the beginning of April, and down thereafter. To emphasize, the result not only accounts for changes in observable meteorological parameters—for example, average daily minimum temperatures in this sample varied from 21 °C in January to 15 °C by May—but also for an unobservable seasonal trend (which should be mild in this sample).

The increase in ultrafine particle concentrations due to increased gasoline penetration manifests itself most clearly in the early morning commute. Figure 4a shows that once corrected for other factors, the positive association between the remaining (residual) concentration in ultrafines and gasoline use is most significant during the morning rush hour. This relationship is not significant during the evening rush hour (though, given a CI of −3,956 to +5,858 cm^{-3} at 18:00, a positive effect cannot be statistically rejected either). Figure 4b shows that changes in PM100-800 nm concentrations with the gasoline share remain indistinguishable from zero during the course of the day.

Sub-50 nm ultrafines vary most. To further zoom into which sizes in the ultrafine mode contribute the most to the increased PM concentrations, we integrated the aerosol number concentrations over size bins having increasing width, starting at 7 nm and going up to 800 nm. Figure 4c shows that the most important contributor to the increased (resp., decreased) particle concentration in the ultrafine mode that coincides with the observed increase (resp., decrease) in the gasoline share is the bin of particles having diameters up to 50 nm. No detectable change occurs in the particle concentration beyond that diameter, even all the way up to 800 nm. For comparison, Fig. 4c also shows the 100–800 nm mode, whose number concentration change with fuel mix variation is again indistinguishable from zero. In sum, changes in PM concentrations that coincide with consumers transitioning from ethanol into gasoline and back to ethanol are not driven by the accumulation mode but instead by the nucleation mode, specifically nanoparticles having diameters <50 nm.

Variation in 24-h means. Table 3 reports on regressions that examine variation in 24-h means for: the contribution of nucleation (10–50 nm), Aitken (30–120 nm) and accumulation (70–280 nm) modes to the aerosol particle size distribution[47]; BC mass concentrations; and PM2.5 mass concentrations. We provide two-step model estimates in the odd-numbered columns and, for sensitivity analysis in the even-number columns, estimates from an alternative model based on two-stage least squares (2SLS), with the ethanol-to-gasoline price ratio serving as an "instrumental variable (IV)" for the predicted gasoline share (Methods). Moreover, compared to Table 2, the submicron particle regressions that we report on in Table 3 use samples that are longer, starting October 2010 rather than January 2011, and contain all days of the week, including weekends and holidays. To control for the additional seasonal and weekly variability, we include quarter-of-year and additional day-of-week fixed effects (these allow fitted particle levels to vary systematically by quarter, on public holidays, on Saturdays, etc). PM2.5 levels, routinely monitored by the environmental authority[48] rather than our field campaign, are over multiple years, so we can add more granular week-of-year fixed effects, as these do not subsume the temporal source of fuel mix variation that is our main variable of interest. Two-step model estimates for PM2.5 in column (9) are as in Table 2, column (2).

Across the two model variants (two-step or 2SLS), we obtain a statistically significant and positive association between the gasoline share and the 24-h average contribution of nucleation mode particles, i.e., a $2{,}794 \pm 1{,}456$ cm^{-3} increase, or a 95% CI, between +1,338 and +4,250 cm^{-3} as gasoline usage in the flex fleet rises from 30 to 80% (Table 3, column (1)). This association is consistent with the results over the day and across the size range presented earlier in Fig. 4. Also consistent with the preceding analysis, we do not detect significant associations between gasoline and particle number in the Aitken and accumulation modes (columns (3) to (6)). Consistent with Table 2, the gasoline share is not significantly associated with 24-h BC concentrations in the all-day sample used in Table 3 (columns (7) and (8)). Two-step model estimates are very similar to 2SLS estimates; for example, compare 24-h PM2.5 concentrations in columns (9) and (10). In sum, the findings presented in Table 3 are consistent with those in Table 2.

Discussion

The empirical pattern that emerges is characterized by a positive and significant association between the gasoline share and 7–100 nm particle levels in the peak hours of morning travel, and the absence of a statistically significant relationship outside this size range and time window. We repeat the several aspects that give us confidence that our findings are not mere statistical artifacts. First, we infer "differences in differences": differential results for different particle size ranges, namely the nucleation vs. the Aitken and accumulation modes, and the 7–100 nm vs. 100–800 nm size ranges particularly during the morning commute (the first difference is the co-variation with the gasoline share—up and down in tandem over time). Second, in the shorter sample—a period in which meteorology varies mildly and "monotonically" as mid-summer conditions evolve into those that characterize mid-fall—ultrafine particle levels after correcting for confounders move in lockstep with the gasoline share: nanoparticles and gasoline jointly rise until the start of April, then jointly fall through the

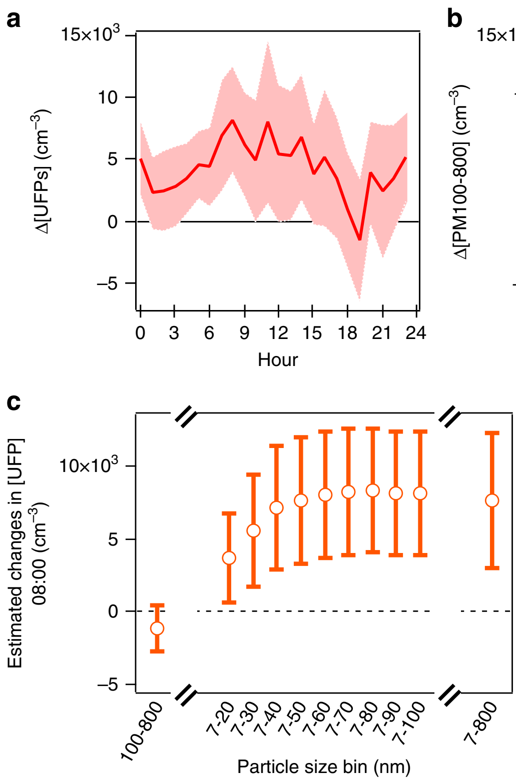

Fig. 4 Estimated changes over weekday diurnal cycle. **a** 7–100 nm and **b** 100–800 nm particle concentration levels, over the weekday diurnal cycle, associated with a 50-percentage-point rise in gasoline use in the flex-fuel fleet, from 30 to 80%. For clarity, for every hour of the day we plot the 95% CI for the gasoline share's association with the 7–100 nm size range **a**, and the 95% CI for the gasoline share's association with the 100–800 nm size range **b**. **c** Opening the 7–20 nm size bin towards 800 nm, and comparison to the 100–800 nm bin, for the weekday morning hour of 08:00. For clarity, for 08:00 we plot the CI for the gasoline share's association with every size bin. Source: Specifications reported in Supplementary Table 8 **B**, **D**, with sample period restricted to the summer/fall months of January to May 2011 and trend included as seasonality control (same specifications as Table 2 for 7–20 nm and 100–800 nm at 08:00)

end of May. The potential confounding factors that we control for include a trend and meteorological and road traffic conditions recorded concurrent to the day and hour. A third factor that strengthens our findings is that they are consistent with controlled emissions studies and laboratory experiments[13–16, 18]. Fourth, our approach indicates an insignificant association between the light-vehicle gasoline-ethanol mix and BC levels, which are influenced mainly by diesel combustion in heavy vehicles[39, 43, 44]. Fifth, controlling for monthly ridership of diesel buses in the metropolis does not change our estimates, due to bus ridership not varying over the sample period.

We provide the following possible rationalization of the associations identified here. Changes in the <50 nm diameter nanoparticle concentrations in ambient air are consistent with flame combustion experiments, which show emissions of nucleation mode particles decrease with increasing ethanol fraction in gasoline blends from E0, E20, and E50 to E85[13]. Insofar as these laboratory studies are applicable to São Paulo's urban air chemistry, it may be plausible to attribute the reported fluctuations in <50 nm diameter particles during a seasonally similar period to differences in the composition of direct emissions that occurred in tandem. Replacing gasoline-rich fuel blends with ones rich in ethanol may then result in significant reductions in ultrafine—specifically <50 nm diameter nanoparticle—levels, as we indeed estimated from the field-derived size distribution measurements. The chemical analysis of the nanoparticles, which did not occur during the period of fuel switching we studied, would be an important next step towards understanding how gasoline-ethanol mixes impact particle pollution in urban air.

In conclusion, we have combined aerosol, meteorological, traffic, and consumer behavior data in an econometric approach that identifies a statistically significant inverse association between ethanol content in gasoline and ambient <50 nm diameter nanoparticle concentrations. Specifically, we find decreases of up to 25–30% during morning rush hours associated with an in-sample 20 to 70% increase in ethanol penetration (equivalently, 80 to 30% decrease in gasoline use) in the São Paulo flex-fuel fleet. Whether subsequent atmospheric processing and/or secondary material formation are materially influenced by shifts in the fuel mix, and were not captured by our empirical model, is unknown and motivates further studies. As with any empirical observational study, confidence in its findings can only grow as new samples, in space and time, become available, supported by the results from different approaches and analysis techniques. Nevertheless, our result that, after correcting for other influences on particles, higher-followed-by-lower gasoline vs. ethanol use in São Paulo coincided with higher-followed-by-lower <50 nm diameter nanoparticle levels points towards the possibility that the use of ethanol-rich gasoline blends as a transportation fuel may decrease the atmospheric burden of health-relevant ultrafine particles, specifically those that can reach deep into the pulmonary system. This novel result, obtained in the field, is particularly timely as several countries now consider implementing their intended nationally determined contributions to reduce fossil fuel emissions, as agreed at the recent COP-21 in Paris, by increasing biofuel use. Yet, we caution that this environmentally desirable outcome is countered by the increases in local ozone concentrations reported on earlier[33, 49].

Table 3 Changes to 24-h mean particle concentrations associated with variation in the gasoline-ethanol fuel mix

Column number:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variable:	Nucleation		Aitken		Accumulation		BC		PM2.5	
Unit:	dN/dlogDp, cm^{-3}		dN/dlogDp, cm^{-3}		dN/dlogDp, cm^{-3}		$\mu g\ m^{-3}$		$\mu g\ m^{-3}$	
Mean over hour window:	24-h		24-h		24-h		24-h		24-h	
Sample period:	Oct/2010 to May/2011		Oct/2010 to May/2011		Oct/2010 to May/2011		Oct/2010 to Apr/2011 and Oct to Nov/2012		Nov/2008 to May/2013	
Number of sampling sites:	1		1		1		1		3	
Source:	Own		Own		Own		Own		CETESB	
Estimation:	2-step model	2SLS model	2-step model	2SLS model	2-step model	2SLS model	2-step model	2SLS model	2-step model	2SLS model
Flex fuel share of Gasoline E20/E25 rises from 30 to 80% Equivalently, share of Ethanol E100 falls from 70 to 20%	2,794 ± 1,456	2,783 ± 1,433	332 ± 818	361 ± 818	565 ± 785	553 ± 806	1.1 ± 1.3	1.0 ± 1.2	0.2 ± 3.9	−0.2 ± 2.9
Control variables (to correct for the influence of other determinants of particles)										
Site-specific linear trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-of-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	–	–
Week-of-year fixed effects	–	–	–	–	–	–	–	–	Yes	Yes
Day-of-week fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Radiation (+100 $W\ m^{-2}$)	−234 ± 664	−235 ± 607	110 ± 386	111 ± 361	108 ± 259	108 ± 226	0.0 ± 0.3	0.0 ± 0.2	−0.4 ± 2.2	−0.3 ± 1.3
Temperature (+1 °C)	−499 ± 234	−498 ± 211	−61 ± 119	−63 ± 105	32 ± 100	32 ± 91	0.1 ± 0.1	0.1 ± 0.1	1.2 ± 0.5	1.2 ± 0.4
Humidity (+10%)	−1,454 ± 699	−1,453 ± 543	−715 ± 384	−718 ± 322	−97 ± 265	−96 ± 243	−0.4 ± 0.2	−0.4 ± 0.2	−1.0 ± 1.6	−1.0 ± 1.2
Wind speed (+1 $m\ s^{-1}$)	−569 ± 1,144	−567 ± 1,046	−1,910 ± 686	−1,913 ± 593	−485 ± 449	−484 ± 389	−1.6 ± 0.6	−1.6 ± 0.5	−6.5 ± 2.8	−6.5 ± 2
Other meteorolog. and road traffic conditions (see notes)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	57.3%	57.3%	51.5%	51.5%	54.5%	54.5%	74.1%	74.1%	73.4%	73.4%
Number of observations	198	198	198	198	198	198	228	228	511	511
Number of regressors	30	30	30	30	30	30	29	29	74	74
Mean value of dependent variable	8,755	8,755	3,320	3,320	1,494	1,494	3.3	3.3	13.8	13.8

Coefficients and 95% confidence intervals, i.e., point estimate ± 2 standard errors. An observation is a date (columns 1–8) or a date-site pair (columns 9–10). Samples exclude the colder months of June to September and include all days of the week. Radiation, temperature, humidity, and wind speed in the recorded unit. All columns additionally include several wind direction, precipitation, thermal inversion and road traffic congestion indicators. Since the longer sample encompasses 2010, columns 9–10 include site-specific intercepts indicating the opening of the Greater São Paulo beltway's southern section on March 31, 2010. The effect of raising the gasoline share in the flex fleet is scaled for in-sample variation from 30 to 80%. The corresponding variation in the ethanol share is one minus variation in the gasoline share. Ordinary Least Squares estimates in the odd-numbered columns, with standard errors calculated by bootstrapping (200 samples each): (i) the consumer-level fuel choice data, to account for sampling variation in the predicted gasoline share in a first-step consumer demand model, and (ii) the pollutant-meterology-traffic data in the second-step particle regression, clustering by date. Two-Stage Least Squares estimates in the even-numbered columns, with the median ethanol-to-gasoline price ratio across pumping stations instrumenting for the predicted gasoline share in the particle regression equation

Methods

Particle sampling methods and coverage. We combine data from different sources. Among the particle pollution outcomes that we analyze, our most established data set—in terms of both method and temporal coverage—consists of 24-h filter measurements of PM2.5 mass concentration maintained by the environmental authority of the state of São Paulo (CETESB)[48]. Three stationary sites, at varying distance from roads, were sampled with a dichotomous sampler every six days in the city of São Paulo (Supplementary Fig. 1 showing Cerqueira César, Ibirapuera and Pinheiros sites). The sample period we study is November 1, 2008 to May 31, 2013.

This sample period includes two episodes of large variation in ethanol prices and subdued movement in gasoline prices, over the spring to fall 2009–2010 and again over the spring to fall 2010–2011. These large fluctuations in the price of ethanol relative to gasoline, and the induced shift in consumer choice at the pump between ethanol and gasoline, were driven by supply-side shocks, such as a poor sugarcane harvest in India in late 2009. In particular, the pronounced variation in relative ethanol prices was unrelated to the strength of consumer demand for driving or commuting in the São Paulo metropolis, which might otherwise confound our inference of the effect of the fuel mix on air quality. Shifting between gasoline and ethanol, consumers were merely responding to—not causing—the relative price movement at the pump. We return to these consumer shifts below.

A second sample on particles that we examine, also provided by the environmental authority[48], consists of hourly measurements of PM2.5 mass concentration (beta continuous analyzer, model 5014i, Thermo Scientific, Franklin, MA, USA). This higher-frequency (hourly) PM2.5 sampling started in January 2011 at the Congonhas site and continued through the end of our sample period in May 2013. This sample period includes the second and more pronounced of the two episodes of large variation in ethanol prices observed across the metropolis between 2008 and 2013. The Congonhas site lies near an inner city airport, Congonhas airport, and a busy multilane road. Subsequent to fall 2011, the environmental authority began collecting hourly measurements of PM2.5 mass concentration at the IPEN-USP site, starting in August 2011, and at the Pinheiros site, starting in January 2012 (Supplementary Fig. 1). The IPEN-USP site lies inside the Armando Salles de Oliveira campus of the University of São Paulo (USP), in very close proximity to the sampling site for our third data set, described next.

A third data set consists of aerosol particle size distributions in the 7–800 nm range using a Differential mobility particle sizer (DMPS)[40, 41], and BC mass concentrations measured using a Multi angle absorption photometer (MAAP, model 5012, Thermo Scientific, Franklin, MA, USA). This third sample is not routinely available from an official authority but was collected as part of a field campaign. The campaign lasted from October 2010 to September 2011 (DMPS), and October 2010 to April 2011 followed by August 2012 to November 2012 (MAAP). Importantly, sampling included a seasonally similar period of 4.5 months—from January 20 to May 31, 2011—of marked increase followed by decrease in ethanol prices. This subsample gives us heightened confidence in our submicron particle results.

We validated the DMPS measurements against an independently operated condensation particle counter (CPC, model 3022, TSI Inc., St. Paul, MN, USA), operated concurrently to the DMPS and at a similar lower size cut. As a result of the data validation, less than 2% of the original DMPS data were removed due to a deviation of the integrated aerosol number concentration 50% or higher than the aerosol number concentration measured independently by the CPC. A linear fit between the DMPS integrated concentration and the CPC concentration yields an R^2 of 0.99, with a slope of 1.18 (Supplementary Fig. 2a). The diurnal variation (median) and variance (interquartile range) of both measurements show very tight correlation, without differential trends throughout the day (Supplementary Fig. 2b).

Aerosol and sheath flow for the DMPS, CPC setup against an electrometer, compensation for system diffusion losses, and all other calibrations, adjustments and maintenance procedures follow previously published work[50] exactly, and can be found there. All aerosol size distribution measurements were performed with the DMPS with a high time resolution of 10 min for a full measurement cycle. DMPS aerosol particle size distributions were fitted for three lognormal modes[47], allowing the contribution of nucleation (10–50 nm), Aitken (30–120 nm) and accumulation (70–280 nm) modes to be analyzed separately (Supplementary Table 5). Measured parameters were averaged into 1-h data[50].

The DMPS, CPC and MAAP instrumentation was deployed at the roof of a four-storey building located inside the USP Armando Salles de Oliveira campus, about 10 km from the city center in a highly populated area (Supplementary Fig. 1)[50]. This site lies in relative proximity—on the opposite side of the Pinheiros river—to the Pinheiros site, where the environmental authority collected the 24-h PM2.5 samples over a common period. Below we examine the association between BC and PM2.5 mass concentrations measured separately on the same dates in the nearby sites.

The USP campus location for the DMPS/CPC instrumentation very likely provides a lower ultrafine particle number concentration when compared to a

Table 4 Overview of the estimated regression model specifications

Estimates reported in	Dependent variable(s) (and data source)	Sample description[a]	Time aggregation	Fuel mix variable	Estimation procedure (s)	Other sensitivity analysis provided
Supplementary Table 1	PM2.5 mass concentration, 24-h filter (CETESB)	11/2008–5/2013, 3 sites every 6 days	24-h mean	Gasoline share in the flex fleet	OLS + bootstrap	Across the columns, more and alternative controls are introduced, e.g., trend and meteorology
Supplementary Table 2 (column 1 in Supplementary Fig. 10)	PM2.5 mass concentration, 24-h filter (CETESB)	11/2008–5/2013, 3 sites every 6 days	24-h mean	Gasoline share in the flex fleet, or aggregate fleet	OLS + bootstrap; 2SLS; OLS	Across the columns, the gasoline share and the estimation procedure are varied. Models include controls
→Tables 2 and 3 and Fig. 1 report the effect of raising the gasoline share on 24-h PM2.5 levels (model with wind direction controls). Figure 3 reports robustness to diesel control						
Supplementary Table 3 (column 2 in Supplementary Fig. 10)	PM2.5 mass concentration, beta continuous (CETESB)	1/2011–5/2013, 3 sites by 2012	5-h mean, 07:00 to 11:00	Gasoline share in the flex fleet, or aggregate fleet	OLS + bootstrap; 2SLS; OLS	Across the columns, the gasoline share and the estimation procedure are varied. Models include controls
Supplementary Table 4 (column 3 in Supplementary Fig. 10)	Ozone mass concentration (CETESB)	11/2008–5/2013, 12 sites	5-h mean, 12:00 to 16:00	Gasoline share in the flex fleet, or aggregate fleet	OLS + bootstrap; 2SLS; OLS	Across the columns, the gasoline share and the estimation procedure are varied. Models include controls. Figure 3 reports robustness to diesel control
→Table 2 and Fig. 1 report the effect of raising the gasoline share on ozone levels in the early afternoon (reproduced in column 1 of Supplementary Table 4)						
Supplementary Table 5	Particle count, nucleation, Aitken, accumulation, BC mass concentration (Own)	10/2010–5/2011 for DMPS, 1 site (similar periods for other param.)	24-h mean	Gasoline share in the flex fleet	OLS + bootstrap; 2SLS	Across the columns, the dependent variable and the estimation procedure are varied. Models include controls
→Table 3 reports the effect of raising the gasoline share on 24-h nucleation, Aitken, accumulation, BC levels (model with wind direction controls)						
Supplementary Table 6 (Supplementary Fig. 13 shows panel D)	UFP 7-100 nm (Own)	10/2010–5/2011, i.e., full period of field campaign, 1 site	1-h mean[b]	Gasoline share in the flex fleet	OLS + bootstrap; 2SLS	The panels show variation in the sample (all days of the week vs. weekdays only), the estimation procedure, and the effect of wind direction controls
Supplementary Table 7 (Supplementary Fig. 13 shows panel D)	PM 100-800 nm (Own)	10/2010–5/2011, i.e., full period of field campaign, 1 site	1-h mean[b]	Gasoline share in the flex fleet	OLS + bootstrap; 2SLS	The panels show variation in the sample (all days of the week vs. weekdays only), the estimation procedure, and the effect of wind direction controls
Supplementary Table 8 (Supplementary Fig. 14 shows panels B,D)	UFP 7-100 nm and PM 100-800 nm (Own)	1/2011–5/2011, i.e., more seasonally homogeneous sample	1-h mean[b]	Gasoline share in the flex fleet	OLS + bootstrap	The panels show variation to including a linear trend vs. not allowing a trend (Specifications otherwise follow panel D, Supplementary Tables 6 & 7.[c])
→Table 2 and Figs. 1 & 2 report the effect of raising the gasoline share on UFP 7–100 nm and PM 100–800 nm levels at 08:00 (reproduced in panels B and D of Supplementary Table 8). →Figure 3 reports robustness to diesel control. Figure 4 shows effects over the day and across the size range using the specification in panels B and D of Supplementary Table 8.						
Supplementary Figs. 11 & 12	Particle count and BC mass concentration (Own)	1/2010–5/2011 for CPC, 1 site (similar period for BC)	1-h mean[b]	Gasoline share in the flex fleet	OLS + bootstrap	
→Table 2 and Fig. 1 report the effect of raising the gasoline share on BC levels at 08:00. Figure 3 reports robustness to diesel control.						
Supplementary Fig. 9	PM2.5 mass concentration, beta continuous (CETESB)	1/2011–5/2013, 3 sites by 2012	1-h mean[b]	Gasoline share in the flex fleet	OLS + bootstrap	

[a]All estimated samples exclude the colder months of June to September
[b]Hour-by-hour regressions
[c]Sample restricted to non-holiday weekdays, wind direction controlled for

roadside or on-road location, suggesting that the absolute changes in particle number concentrations that coincide with the fuel shifts may be different if they were to be measured near road traffic or at the vehicle exhaust[51, 52]. The site has been described as "ideal for tracking ambient aerosols" and "representative of the ambient pollution burden of the city," due to the well-mixed air masses arriving at the location and limited influence of local sources[50]. With 6 million passenger cars and 0.3 million heavy-duty vehicles circulating and emitting across the metropolis, it was critical to choose a site that is representative for the whole urban area. The site is not influenced by one passing accelerating smoky vehicle or idiosyncratic construction next door, nor is it a background site. Importantly, the site lies at a 1 km radius from a major road corridor (Marginal Pinheiros, running northwest to south, spanning over 200 degrees, and 20 express/local lanes in two directions) and is surrounded by busy roads (e.g., Corifeu de Azevedo Marques to the west–southwest). Non-anthropogenic influences, particularly in the ultrafine range, are limited. For example, vegetation on campus is limited compared to the dense vehicular traffic flows that surround it.

In sum, we have access to 24-h PM2.5 mass concentrations measured at three sites every six days between 2008 and 2013; 1-h PM2.5 mass concentrations measured continuously at (essentially) a fourth site between 2011 and 2013; and parameters in the submicron mode measured continuously at a fifth site for almost one year to September 2011.

Spatial and temporal variation in PM2.5 and BC levels. We compared PM2.5 mass concentrations measured on common dates across the different sampling locations and methods (Supplementary Fig. 3a–e). Measurements available at hourly frequency were aggregated into a 24-h mean within each date of measurement, from hour 0:00 to 23:00. Particle levels across sites and methods are highly correlated over time. Similarly, we compared BC to PM2.5 mass concentrations measured in nearby locations on common dates (Supplementary Fig. 3f,g).

There is large variation in particle concentrations between dates—due, for example, to time-varying meteorological conditions, which affect all sites in the same direction—and less variation across site locations. For example, low wind speeds and the occurrence of thermal inversions in the metropolis' atmosphere drive up particle levels measured at all sites. This suggests that if the heavy PM2.5 is well mixed in the atmosphere, then this may be the case for the much lighter ultrafines, and the chosen monitoring site is indeed likely representative of a much wider area. Moreover, if large fluctuations in ultrafine particle levels were observed at the site for idiosyncratic and unobservable reasons, other than due to determinants such as meteorology and seasonality that we explicitly account for, this would be reflected in large confidence intervals on our estimated effects, which would prevent us from making statistical inference.

In panel a, 24-h filter measurements at both Ibirapuera and Cerqueira César vary widely over time between 1 and 65 $\mu g\, m^{-3}$, approximately, but the two time series are highly correlated, with PM2.5 at Cerqueira César, a roadside site, exceeding that at Ibirapuera, a park site (though in a central area), by on average 4 $\mu g\, m^{-3}$. The US EPA 24-h PM2.5 standard of 35 $\mu g\, m^{-3}$ is exceeded on several occasions[53].

Panels b (filter measurements) and c (beta continuous) show PM2.5 mass concentrations in Ibirapuera, Pinheiros and the university campus again moving in step, driven by seasonal and meteorological shifts. Particle levels in Pinheiros, a roadside site, exceed those in Ibirapuera and the university campus. The IPEN-USP site on the university campus has little road traffic in its immediate vicinity.

Panel d compares beta-continuous PM2.5 measurements in Congonhas, a roadside site that is also near an inner city airport, against those in roadside Pinheiros. Judged by this beta-continuous fine-particle data, Pinheiros' air appears rather more polluted than that in Congonhas.

Panel e indicates that, at the same Pinheiros monitoring site and on the same dates, beta-continuous measurements of PM2.5 averaged over 24 h exceed 24-h filter measurements of the same particle range. This is consistent with the pattern in panel d suggesting that beta-continuous measures in Pinheiros appeared high relative to those in Congonhas. (We are not in a position to examine the reason for this divergence, but one possibility is calibration—the absorption coefficient—of the beta-instrument at the Pinheiros site, compared to the more reliable 24-h filter measurement.)

Finally, panels f and g show that BC mass concentrations measured during the field campaign at the university campus are highly correlated with PM2.5 mass concentrations measured by the environmental authority, both in the nearby IPEN-USP site in the same university campus (panel f), as well as in the nearby Pinheiros site across the Pinheiros river (panel g).

Such patterns reassure us as to the quality of the separate particle samples. Further description of the environmental authority's sampling sites, including aerial pictures, is available elsewhere[33, 48]. The submicron particle sampling site is located nearby to the environmental authority's IPEN-USP monitoring station.

Gasoline versus ethanol mix in the active flex-fuel fleet. Throughout the sample period, the composition of light-vehicle fuels that were ubiquitously dispensed across the metropolis' retailers, typically via a different nozzle at the same pump, were: ethanol E100, pure but hydrated, i.e., containing up to 4% of water; and gasoline E20 or E25, containing a 20 or 25% volumetric proportion of anhydrous ethanol. We refer throughout to E100 and E20/E25 by their consumer label, at retail, i.e., "ethanol" and "gasoline," respectively.

The gasoline blend, mandated nationwide by the federal government, was slightly modified on four occasions during our sample period. The blend shifted from E25 to E20 for purchases by retailers beginning February 1, 2010; from E20 back to E25 beginning May 1, 2010; again from E25 to E20 beginning October 1, 2011; and again from E20 back to E25 beginning May 1, 2013. The gasoline blend was consistently E20 during the DMPS sampling campaign that ran from October 2010 to September 2011, while it varied slightly during the PM2.5 sample period between November 2008 and May 2013. There were no other reported changes to the composition and quality of gasoline and ethanol fuels used by light-duty vehicles and motorcycles.

The vehicle fleet that was actively circulating in São Paulo city in July 2011 has been estimated at 5.9 million light vehicles (passenger vehicles including sport utility vehicles, minivans and light pickup trucks), 0.9 million motorcycles and 0.3 million heavy vehicles (trucks and buses)[33]. Whereas older light vehicles, sold prior to 2005, were predominantly equipped with single-fuel gasoline engines, the overwhelming majority of light vehicles sold after 2005 were "flex-fuel" gasoline–ethanol vehicles, transitioning between gasoline and ethanol combustion, according to consumer preferences, as relative fuel prices varied. Flex-fuel vehicles accounted for a likely but unknown share of total light-vehicle distance traveled within the São Paulo metropolitan area of "over (if not well over) 50% by 2011"[33]. Completing the fuel mix, motorcycles and heavy-duty vehicles were powered predominantly by gasoline and diesel, respectively, during the sample period. Variation in diesel prices and combustion over the sample period is discussed separately below.

Our empirical method is not based on trends in fuel consumption or trends in site-specific particle levels. We control for such potentially confounding trends in our regression models. The predominant combustion of gasoline among single-fuel light vehicles, and of diesel among heavy vehicles, are then interpreted as background levels of emissions that were unlikely to vary with the ethanol price fluctuations that occurred over the space of months.

We follow an earlier study[33] and, as the first step in a two-step model, construct the second step's main explanatory variable of interest, the gasoline share in the flex-fuel light-vehicle fleet from a consumer demand model, namely a multinomial probit choice model[30, 33]. We predict this time-varying market share of flex-fuel vehicles fueled with gasoline over ethanol based on gasoline and ethanol prices observed at the pump in São Paulo city during the sample period. To this end, we obtained a large weekly panel of fuel prices, detailed by fuel pumping station and day the pumping station was surveyed, from the National Agency for Oil, Biofuels and Natural Gas (ANP; http://www.anp.gov.br/wwwanp/). This first-step demand model is estimated using actual consumer choices as a function of observed fuel prices and consumer demographics[30]. It is important to realize that the reason why we need a demand model to predict day-to-day fuel quantities from day-to-day fuel prices is that high-frequency fuel quantity or usage data for the metropolitan area of São Paulo are not available, only price data. Otherwise, we would skip the first-step model and use the fuel quantity data directly.

To account for fuel stored in vehicles' tanks, following consumer purchase but prior to combustion, we use four-day lagged prices at the pump. Previous research documents that the median consumer purchases fuel once a week[30]. Thus, the gasoline share of combustion on day t is predicted from fuel prices at the pump $7/2 \approx 4$ days earlier. In a robustness test, we increase consumer stocks to 7 days.

The predicted gasoline share in the flex-fuel vehicle fleet, denoted by $\hat{s}_t^{\text{gas}}$, ranges from a sample minimum of 0.14 in spring 2009, and similarly in spring 2010, to a sample maximum of 0.76 in late summer/early fall 2011 (Supplementary Fig. 4a). The hat in $\hat{s}_t^{\text{gas}}$ indicates that the gasoline share is estimated from the first-step model. Correspondingly, the ethanol share (one minus the gasoline share) among flex-fuel vehicles fluctuated between 0.86 and 0.24 at these points in time.

Denoting the retail prices of 1 litre of ethanol and one litre of gasoline by p_e and p_g, respectively, the evolution of the price ratio p_e/p_g mirrors that of the predicted gasoline share, $\hat{s}_t^{\text{gas}}$, over the 2008 to 2013 sample period (Supplementary Fig. 4b). The fact that the fuel mix $\hat{s}_t^{\text{gas}}$ and the relative price p_e/p_g move together reflects the previous finding that the relationship between the gasoline (or ethanol) choice probability and the ethanol-to-gasoline price ratio is quite linear over a wide range of price variation[30]. In particular, consumer preferences and behavior are such that flex-fuel vehicle drivers, who are overwhelmingly household consumers, do *not* as a whole transition abruptly between gasoline and ethanol at the relative price point at which the effective prices of ethanol and gasoline, in \$/km of distance traveled, are equalized.

Instead, consumer switching is significantly more gradual—or demand is less elastic—around this parity price ratio or threshold, that lies just under 0.70 for most vehicle models. To further describe consumer substitution patterns, as the price of ethanol rises slightly from a very competitive level (e.g., $p_e/p_g = 0.58$, or 0.70/1.2), some flex-fuel vehicle consumers already transition out of ethanol into gasoline, despite ethanol still remaining very competitively priced. As the price of ethanol rises further and further, reaching a very uncompetitive level relative to gasoline (e.g., $p_e/p_g = 0.84$, or 0.70×1.2), some flex-fuel vehicle consumers still stay with ethanol at the pump.

The variation in the consumer price of ethanol relative to gasoline was observed throughout São Paulo. The resulting variation in the fuel mix that our work takes advantage of, with drivers induced to switch to gasoline and back to ethanol, was not isolated to specific neighborhoods. Any changes to particle emissions and secondary particle formation[54] that were a result of transitions between gasoline and ethanol combustion were happening at the citywide level (more precisely, at the state level), including the air surrounding each of the particle sampling sites. Moreover, ethanol price movements were the result of developments in world food and energy markets, rather than concerns over air pollution in São Paulo, which would otherwise make the main regressor of interest, the gasoline-ethanol mix, an endogenous variable (i.e., responding to the system we model, rather than exogenous to it).

Also following earlier work[33], our regression analysis drops the colder months of June to September. Seasonal variation in pollution tends to be pronounced[56, 57] and, importantly, the two episodes of marked ethanol price variation occurred outside these months (Supplementary Fig. 4b). Intuitively, we wish to keep the "high ethanol price, high gasoline share" days as otherwise comparable as possible to the "low ethanol price, low gasoline share" days. Including the colder months of June to September might introduce unobserved heterogeneity to this comparison.

As an alternative to the predicted gasoline share of consumer purchases at the pump, which is a series that varies daily based on daily prices for the city of São Paulo, we also compute a lower-frequency, more-regional gasoline share from aggregate quantity data, available from ANP (Supplementary Fig. 4c). Denote this gasoline share by $s_t^{\text{gas,aggr}}$, where the absence of a hat indicates that the share is calculated, not predicted, from data. This alternative measure of the fuel mix is computed from monthly, and possibly incomplete, fuel shipments reported by wholesalers for the state (not city) of São Paulo. Wholesale quantities of blended gasoline (E20/E25) and hydrated ethanol (E100) are reported separately, in cubic meters/month. Prior to computing aggregate shares, we adjust for differences in energy content by converting the separate fuel quantities in cubic meters to light-vehicle distance traveled, given assumptions on the fleet's fuel economy.

The alternative aggregate wholesaler gasoline share, $s_t^{\text{gas,aggr}}$, varies less than the baseline gasoline share, $\hat{s}_t^{\text{gas}}$, since the latter relates to choices in the subpopulation of flex-fuel vehicles whereas the former includes gasoline and, to a lesser extent, ethanol consumption by single-fuel light vehicles and motorcycles. Importantly, $s_t^{\text{gas,aggr}}$ moves in step with $\hat{s}_t^{\text{gas}}$. For example, $s_t^{\text{gas,aggr}}$ also reaches a sample minimum in spring 2009 and a sample maximum in late summer/early fall 2011. That $\hat{s}_t^{\text{gas}}$ (a high-frequency series predicted from high-frequency price data) and $s_t^{\text{gas,aggr}}$ (a low-frequency series based on data for the state)—move in tandem heightens our confidence in using the high-frequency $\hat{s}_t^{\text{gas}}$ as the preferred specification for our main explanatory variable of interest.

Earlier work[33] described the "large-scale switching out of ethanol and into gasoline as ethanol prices soared, and back to ethanol when prices dropped," as indicated by the ANP reports between 2009 and 2011: "wholesaler reports suggest that the unblended (pure) gasoline component shifted between 42 and 68% of total gasoline-plus-ethanol light-vehicle distance travelled". This represented a 60% increase in the pure gasoline share (68/42-1), equivalent to a 45% reduction in the pure ethanol share (1–32/58). The additional evidence agrees that the change in the fuel mix was massive. To summarize, the alternative measure $s_t^{\mathrm{gas,aggr}}$, based on aggregate monthly wholesale reported quantities for the entire state's fleet, serves as a robustness check on the gasoline share in the flex-fuel vehicle fleet $\hat{s}_t^{\mathrm{gas}}$ that is predicted from the high-frequency price series.

Diesel combustion in the heavy vehicle fleet. We argue that diesel combustion in heavy vehicles, while an important contributor to particle emissions and secondary particle formation, is unlikely to confound our inference of the effect on particles of gasoline vs. ethanol use in light vehicles during the periods we examine. We begin by considering variation in the retail price of diesel oil in the São Paulo metropolitan area between November 2008 and May 2013, available from the Brazilian Institute for Geography and Statistics (IBGE, Supplementary Fig. 5).

After a downward 5% price adjustment in mid 2009, diesel prices stayed constant in nominal (inflation-unadjusted) terms, and gradually declined in real (inflation-adjusted) terms, until mid 2012, when the federal government began to partially adjust diesel prices for cumulative inflation observed in the preceding years. In real terms, diesel prices in May 2013 were still below their October 2008 level, as was the case for gasoline prices. In particular, diesel prices hardly changed in nominal terms (and hardly changed beyond a gradual downward trend in real terms) during the DMPS sampling campaign that ran from October 2010 to September 2011.

In contrast to pronounced fluctuations in the price of ethanol, the subdued variation in the price of diesel—including the absence of fluctuations—suggests that diesel use is unlikely to be a confounder in our regression analysis. If anything, diesel prices in real terms followed a gradual downward trend over several years, and our particle regression models include a time trend, which absorbs the effect of any omitted determinant of particle concentrations that exhibits a trend. Controlling for diesel prices in the particle regression, as we do in robustness tests, indeed does not change our results.

We provide three additional pieces of evidence to underscore the point that omitted variable bias due to variation in diesel combustion is unlikely to be present. First, buses in the public transport system are a key source of diesel emissions in the São Paulo metropolitan area. From São Paulo's public transportation authorities (SPTrans), we obtained monthly ridership on buses in the public transport system across the metropolis from November 2008 to May 2013 (Supplementary Fig. 6). Ridership was quite stable over the period, tending to fall in the month of January due to the yearend school vacation period, and similarly in the winter month of July in which schools also break (these days are either controlled for using separate type-of-day fixed effects, or excluded from our regression samples). There is no indication that commuting on (use of) diesel buses responded to the gradual decline in real diesel prices (Supplementary Fig. 5), consistent with the provision of public transport being insensitive to diesel prices (which hardly varied in the first place). Moreover, there is no indication that flex-fuel vehicle motorists might have taken to public transport as ethanol prices rose, which could otherwise confound our inference. Controlling for diesel bus ridership in the particle regression, as we do in robustness tests, does not change our results (Fig. 3 compared to Fig. 1).

Second, from SPTrans we further obtained the actual frequency of public transit diesel buses passing through the university campus where the submicron particle sampling site was located, during the sample period between October 2010 and May 2011 that we use to estimate our submicron particle regression models. The data come from billing records and are for realized trips in both directions. The number of diesel buses passing within a horizontal distance of 400 m from the site on a weekday morning (09:00 to 09:59) was stable at about 25 h^{-1} from October 2010 to March 2011 (Supplementary Fig. 7). This is about one diesel bus every 2 min, underscoring the limited influence of local sources on the fourth-storey site. Moreover, bus line 8012–10 was added on March 29, 2011, increasing the number of diesel buses in April and May 2011. Our finding that ultrafine particle levels fell during these months of expanded bus service on campus further underscores the limited influence of local sources on the submicron particle site (and both series are uncorrelated during most of the sample period).

Indeed, in sensitivity analysis we include the (always low) observed diesel bus frequencies on campus as an additional control and show that the estimated effect of gasoline penetration on ultrafine particle levels is robust, and even strengthened (Supplementary Figs. 15 and 16). The intuition is that, contrary to diesel bus frequency, gasoline use varies along with ultrafine particle levels. Beyond the October 2010–May 2011 diesel bus frequencies observed from SPTrans, we obtained student enrollment at the USP Armando Salles de Oliveira campus between 2009 and 2013. This should inform on any variation in the demand for diesel bus services on the university campus. Enrollment over 2009–2013 has been very stable, for example, undergraduate enrollment varied by no more than 50 students around a mean enrollment of 7,451 students. Regular circulation of campus buses, or diesel vehicles anywhere, contribute to background levels of emissions that were unlikely to vary with the ethanol price fluctuations.

Third, we obtained monthly diesel fuel shipments reported by wholesalers for the state of São Paulo—the same ANP data source as the wholesale gasoline and ethanol fuel shipments described above[58]. Unfortunately, these diesel shipments include the large and seasonal statewide highway market; diesel volumes specific to the São Paulo metropolitan market are not publicly available. State-level diesel shipments over the course of the first semester of 2011 broadly followed their typical upward seasonal trend (Supplementary Fig. 8). Importantly, there is no evidence of confounding correlation with the pronounced fluctuation in the price of ethanol relative to gasoline and in the gasoline share—namely up until the beginning of April 2011, and down thereafter—that we exploit in our empirical analysis (noting, again, that our regression models control for trends).

In view of a recent literature that studies the effect on particle emissions of introducing biodiesel as a substitute for diesel[59–62], we note for completeness that the biodiesel fraction is low and changed only slightly in July 2009, from 3 to 4%, and in January 2010, from 4 to 5%. In particular, the diesel-biodiesel mix did not change during the submicron particle sampling period and is unlikely to confound our estimates. Moreover, the slight changes in diesel composition that happened earlier were mandated nationwide by the federal government, and were not policy responses to fluctuations in particle pollution in São Paulo.

In sum, the evidence indicates that potentially confounding effects on the particle size distribution from variation in heavy vehicle traffic around the time of each ethanol price hike are unlikely.

Meteorological and atmospheric conditions. Beyond the gasoline-ethanol fuel mix that is our focus, meteorology, including the occurrence of thermal inversions, is a key determinant of particle pollution. To control for possible confounders and increase estimation precision, we obtained hourly meteorological data recorded at weather stations run by the environmental authority (CETESB)[48] and by the Institute for Meteorology (INMET; http://www.inmet.gov.br), located in different parts of the metropolis. This follows earlier work on gaseous pollutants,[33] which describes the hourly meteorological data, provides an overview of meteorology in São Paulo including spatial correlation across the metropolis, and examines how meteorology is strongly associated with O_3, NO, CO, and PM10 concentrations. In addition to the weather controls used in earlier work, we control for the occurrence and height of thermal inversions in the lower atmosphere. These are recorded every 12 h, at 09:00 and 21:00 local time, by the Brazilian Air Force (FAB)[48].

Local vehicle traffic conditions. To control for vehicle traffic in the area surrounding a particle sampling site as well as across the city's road grid, we use hourly traffic congestion records from the city's traffic authority (CET; http://cetsp1.cetsp.com.br/monitransmapa/agora/). These are available at the road segment level (approximate length 100 m) for an 840-km grid of monitored roads and corridors across São Paulo city. As previous work points out, "(a) concern that might arise in a real-world—as opposed to lab or synthetic—setting such as ours is the possibility that consumers may have cut back on vehicle usage when faced with rising ethanol prices"[33]. Previous research finds that vehicle usage, as measured by road traffic congestion and speeds, did not fluctuate with the ethanol-to-gasoline price ratio that drives the fuel mix. Nevertheless, all the particle regression models we estimate control for possibly confounding variation in road congestion.

Specifically, the evidence suggests that commuters did not change their travel behavior as ethanol prices rose, such as drive less or switch from light vehicles to public transport. A previous study concluded that "(r)ising ethanol prices, beginning in mid 2009 and again in mid 2010, did not ease traffic congestion, raise traffic speeds, or increase ridership in the public transportation system. Similarly, when ethanol prices began falling in March 2010 and again in April 2011, motorists did not take to their vehicles more often"[33]. One can interpret this empirical finding on the basis of the poor availability of short-run substitutes to a commuter's adopted mode and distance of travel, the relatively stable price of gasoline fuel (a substitute for most consumers of ethanol fuel), and the state of "repressed demand" for road space in the face of widespread gridlock across the São Paulo metropolis.

This earlier study also described patterns in the road traffic data, including the daily and weekly commuting cycles, the annual calendar of public holidays, and the yearend school vacation fortnight that typically starts on December 24 and during which traffic might flow a bit more freely. To illustrate, aggregated across a citywide 840-km grid of monitored roads and corridors, records show that the total extent of congested road segments peaks at 09:00 during the workday morning commute (at 82 km of traffic extension), and again at 19:00 during the workday evening commute (121 km). Beyond workdays, congestion is relatively high (though at lower levels) at 14:00 on a non-holiday Saturday (16 km), at 19:00 on a public holiday (14 km) and at 20:00 on a non-holiday Sunday (4 km). These statistics are means across dates in the sample period 2008 to 2013.

We can also use the detailed traffic congestion data to rank the particle sampling sites in terms of their proximity to vehicular traffic. Averaged across all non-holiday weekdays in the 2008 to 2013 sample, road traffic congestion recorded at 09:00 within a 2 km radius of each site is, in increasing order: USP (0.5 km of traffic extension); Cerqueira César (1.8 km); Pinheiros (4.4 km); Ibirapuera (6.6 km); Congonhas (7.6 km). We note that while the Ibirapuera site is located in a park, busy (traffic-monitored) roads surround the park itself.

In addition to road traffic, we obtained the number of aircraft take-offs and landings hour by hour at Congonhas airport, obtained from the National Agency for

Civil Aviation (ANAC). In principle, controlling for such variation may be most relevant to explaining particle levels in the neighboring Congonhas air monitoring site.

First-step inference in a two-step regression model. We examine particle measurements through the lens of our two-step multivariate regression model[33]. In a first step, the gasoline share—the proportion of flex-fuel vehicles fueled with gasoline E20/E25 rather than ethanol E100—is constructed using daily gasoline and ethanol prices and a demand model that was estimated using actual consumer choices[30]. Intuitively, we used observational data on how consumers actually substituted gasoline for ethanol and back when prices fluctuated in 2010, to predict how they substituted gasoline for ethanol and back when prices fluctuated during the submicron particle sampling period in 2011 (Supplementary Fig. 4). Since the gasoline share is a prediction from this first-step model, the confidence intervals in our second-step particle regression estimates need to account for this sampling variation[40]: widening the confidence intervals on the estimated effects of shifting the gasoline vs. ethanol mix on ambient particle levels is in effect what the bootstrap procedure[63] described below achieves. As stated, the reason we need a demand model to predict day-to-day fuel quantities from day-to-day fuel prices is that the former are not available for the São Paulo metropolis; otherwise, we would use the fuel quantity data directly in the second step and skip the first-step model.

Second-step particle regression model specifications. In a second step, we investigate how mass concentrations of PM2.5 and of BC as well as PM number concentrations in the 7–800 nm size range change as the proportion of gasoline in the fuel mix varies, holding other factors constant. We fit empirical models of the form (Table 4):

$$\text{particles}_{lt} = \text{fuel\_mix}_t'\lambda + W_{lt}{}'\Delta^W + A_{lt}{}'\Delta^A + T_{lt}{}'\Delta^T + \upsilon_t + \mu_l + \varepsilon_{lt} \quad (1)$$

An observation is a measurement location l by time period t pair, or simply a time period t for regressions estimated for a single location. The dependent variable particles is the field measurement—namely particle mass concentration or particle count according to our different data sets—that we seek to explain on the basis of temporal variation in the gasoline-ethanol fuel mix, fuel_mix, and other temporal and spatial determinants of particle pollution, namely meteorological, atmospheric, and road traffic conditions, respectively denoted by vectors W, A and T. Intuitively, we seek to uncover the co-variation between (say) ultrafine particle levels in ambient air and the gasoline share, after correcting for differences in other determinants of particle levels, such as meteorological, atmospheric, and road traffic conditions, and fixing season, day of the week and time of the day. In addition to road traffic, we include controls for aircraft traffic in T when examining PM2.5 measured near Congonhas airport (Supplementary Table 3).

Fixed effects μ_l and variables υ_t, respectively, capture omitted location-varying and time-varying drivers of particles. These include indicator variables to account for cyclical effects at the annual level (seasonality, by week or quarter of year) and weekly level (within-week commuting and trade patterns, by type of day), as well as site-specific time trends or year fixed effects, to account for secular changes in economic activity or in road and fleet composition. For example, specifying a separate binary variable (intercept) for each day of the week, included in vector υ_t, allows mean particle levels at a given time on Sundays, as explained by the model, to differ from mean particle levels on Mondays.

Of potential relevance to some locations and the longer samples, we include site-specific binary variables to indicate dates after the opening of the southern section of the Greater São Paulo beltway, on March 31, 2010. The beltway inauguration may have shifted the composition of road users, with less diesel-burning heavy vehicles circulating in the inner city after March 2010, as they could now use the beltway. Estimates for PM2.5 and ozone since 2008 in Tables 2 and 3 correct for this potential omitted variable. In sensitivity analysis, to vector T we add diesel bus ridership or the real price of diesel in the São Paulo metropolis, or public transit bus frequency on the USP campus, and show that our estimates hardly change (Supplementary Figs. 8, 15 and 16). In effect, these proxies for diesel combustion did not vary around a trend or in step with the gasoline-ethanol mix.

Regression model (1) is estimated by ordinary least squares (OLS). λ, Δ^W, Δ^A and Δ^T are coefficients to be estimated, and ε_{lt} is an econometric residual. The identifying assumption is that, conditional on controls $X_{lt} := (W_{lt}, A_{lt}, T_{lt}, \upsilon_t, \mu_l)$, the residual is uncorrelated with the fuel mix, in particular:

$$E[\text{fuel\_mix}_t \varepsilon_{lt}|X_{lt}] = 0, \text{ where } X_{lt} := (W_{lt}, A_{lt}, T_{lt}, \upsilon_t, \mu_l) \quad (2)$$

For our main variable of interest, fuel_mix, we consider the gasoline share $\hat{s}_t^{\text{gas}}$ predicted by a consumer demand model (Supplementary Fig. 4a)[30]. To account for sampling variation in generating a prediction for s_t^{gas}—an estimated rather than observed variable—we bootstrap the original sample of consumers observed making choices at the pump[30, 33]. For every one of 200 bootstrap samples of consumers, $b = 1,\ldots,200$, we obtain a different gasoline choice probability $s_t^{\text{gas},b}$, for each different combination of ethanol and gasoline prices (i.e., a different day) in the particle sample. We then use these 200 first-step bootstrap consumer samples to make inference from our second-step particle regressions. What this means in practice is that we obtain a slightly different set of estimated coefficients $(\hat{\lambda}^b, \widehat{\Delta}^{W,b}, \widehat{\Delta}^{A,b}, \widehat{\Delta}^{T,b})$ for each bootstrap sample b (the hat denotes an estimated, rather than known, parameter); the bootstrap standard error is then the standard deviation of the coefficients estimated over the 200 bootstrap samples. It is because we estimate rather than observe this measure of the fuel mix that we need to correct for sampling error in $\hat{s}_t^{\text{gas}}$ when reporting standard errors on the estimated coefficients of model (1)[40].

To illustrate how identification of the causal effect of the fuel mix (gasoline share) on particle pollution works, via condition (2), we describe a hypothetical example where it would fail. Consider the January to May 2011 submicron particle size distribution sample (Fig. 2). We find that ultrafine particle levels and the gasoline share rose in tandem from January 20 to late March, and similarly the two variables jointly declined over April and May. This is seen once we correct for other potential influences on ultrafine particles such as random variation in wind speed (Fig. 2d). Now suppose that, hypothetically, ultrafine particle levels are unrelated to the gasoline share and, instead, there exists a time-varying driver of ultrafine particle levels that the researcher is unaware of, which similarly moves in one direction from January to March (say up), and then moves in the opposite direction from April to May (say down). In this case, the researcher would mistakenly interpret the tight co-movement between the gasoline share and ultrafine particles as a causal relationship, whereas all that is being estimated is a correlation between the unknown time-varying omitted variable (the true driver in the hypothetical example), the gasoline share (the interpreted driver in the hypothetical example), and ultrafine particle levels. Formally, the confounding omitted variable in the example, whose influence is not corrected for, would remain in the econometric residual, ε_{lt}. Since this omitted variable, even after conditioning on controls, is (positively) correlated with the gasoline share, which is included as a regressor in the estimating equation, the identifying assumption would fail: in this hypothetical example, $E[\text{fuel\_mix}_t \varepsilon_{lt}|X_{lt}] > 0$.

As a first alternative to correcting for standard errors on estimates of particle regression model (1) by way of a bootstrap procedure, we can estimate the model by 2SLS. Taking advantage of the finding that over the relevant range fuel shares are highly correlated (and approximately linear in) the ethanol-to-gasoline price ratio (Supplementary Fig. 4b)[30], we use this price ratio as an IV for the estimated regressor $\hat{s}_t^{\text{gas}}$. The identifying assumption for this variant is then:

$$E\left[(p_e/p_g)_t \varepsilon_{lt}|X_{lt}\right] = 0, \text{ where } p_e/p_g \text{ is the ethanol} - \text{to} - \text{gasoline price ratio} \quad (3)$$

Importantly, ethanol prices were responding to developments in the world sugar market; in particular, price shocks can credibly be taken as exogenous to air pollution in the São Paulo metropolis—thus $(p_e/p_g)_t$ is likely to be uncorrelated with unobserved determinants of particle levels ε_{lt}, and is a valid instrument for the imputed (estimated) gasoline share regressor $\hat{s}_t^{\text{gas}}$. This specification (robustness) test based on an IV estimator may alleviate any concern with regard to the possible presence of measurement error in the gasoline share, or potential confounding from unobserved determinants of particle pollution, captured in the residual, that may correlate with the gasoline share but not with its instrument (the observed price ratio).

As a second alternative to using the gasoline share imputed for the São Paulo metropolis from an estimated consumer demand model, we use the gasoline share calculated from available aggregate monthly fuel quantity data reported by wholesalers for the entire state's fleet, $s_t^{\text{gas,aggr}}$ (Supplementary Fig. 4c). We estimate particle regression model (1) by OLS, with the identifying assumption:

$$E\left[s_t^{\text{gas,aggr}} \varepsilon_{lt}|X_{lt}\right] = 0 \quad (4)$$

Again, alternative measure $s_t^{\text{gas,aggr}}$ serves as a robustness check on the flex-fleet gasoline share $\hat{s}_t^{\text{gas}}$ that is predicted from the high-frequency price series, and both variables move in step.

Table 1 summarizes the alternative outcome variables, particles, that we examine, and the key regressor of interest $\hat{s}_t^{\text{gas}}$ (the second row in the section labeled "Fuel mix variables"), along with the alternative share $s_t^{\text{gas,aggr}}$ (two rows below). The table also describes the different control variables—determinants of particles levels other than the gasoline–ethanol fuel mix—that the multivariate regression corrects for. Table 4 provides an overview of all the estimated regression model specifications, reported both in the main text and in the Supplementary Information. We list: the dependent variable of the regression equation (e.g., UFP 7–100 nm); the sample period and temporal aggregation of the data as employed in the regression (e.g., 1-h or 24-h mean); the main regressor of interest (e.g., $\hat{s}_t^{\text{gas}}$ or $s_t^{\text{gas,aggr}}$); the estimation procedure (e.g., OLS + bootstrap or 2SLS) and other sensitivity analysis provided.

Data availability. The data archive can be accessed at https://goo.gl/9tNzvj.

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Author contributions

All authors analyzed the data and wrote the paper.

Additional information

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Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 8

2010-01-2129

Ethanol Blend Effects On Direct Injection Spark-Ignition Gasoline Vehicle Particulate Matter Emissions

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ABSTRACT

Direct injection spark-ignition (DISI) gasoline engines can offer better fuel economy and higher performance over their port fuel-injected counterparts, and are now appearing increasingly in more U.S. vehicles. Small displacement, turbocharged DISI engines are likely to be used in lieu of large displacement engines, particularly in light-duty trucks and sport utility vehicles, to meet fuel economy standards for 2016. In addition to changes in gasoline engine technology, fuel composition may increase in ethanol content beyond the 10% allowed by current law due to the Renewable Fuels Standard passed as part of the 2007 Energy Independence and Security Act (EISA). In this study, we present the results of an emissions analysis of a U.S.-legal stoichiometric, turbocharged DISI vehicle, operating on ethanol blends, with an emphasis on detailed particulate matter (PM) characterization.

Gaseous species, particle mass, and particle number concentration emissions were measured for the Federal Test Procedure urban driving cycle (FTP 75) and the more aggressive US06 cycle. Particle number-size distributions and organic to elemental carbon ratios (OC/EC) were measured for 30 MPH and 80 MPH steady-state operation. In addition, particle number concentration was measured during wide open throttle accelerations (WOTs) and gradual accelerations representative of the FTP 75. For the gaseous species and particle mass measurements, dilution was carried out using a full flow constant volume sampling system (CVS). For the particle number concentration and size distribution measurements, a micro-tunnel dilution system was employed. The vehicles were fueled by a standard test gasoline and 10% (E10) and 20% (E20) ethanol blends from the same supplier.

The particle mass emissions were approximately 3 and 7 mg/mile for the FTP75 and US06, respectively, with lower emissions for the ethanol blends. During steady-state operation, the geometric mean diameter of the particle-number size distribution remained approximately the same (50 nm) but the particle number concentration decreased with increasing ethanol content in the fuel. In addition, increasing ethanol content significantly reduced the number concentration of 50 and 100 nm particles during gradual and WOT accelerations.

INTRODUCTION

Direct injection spark-ignition (DISI) gasoline engines have been in commercial production since the late 1990's [1, 2] but have only become common in the U.S. light-duty fleet in the past five years. Several passenger car and light-duty truck/SUV models for almost every manufacturer have DISI engines, and it is widely known that smaller displacement, turbocharged DISI engines may likely supplant larger displacement engines as one means for manufacturers to meet the 2016 light-duty vehicle fuel economy regulations. DISI engines can be more fuel efficient, in particular under fuel lean operating conditions, and also offer a performance benefit due to the higher volumetric efficiency at high load. [3] . However, DISI engines tend to make more PM than their port-injected counterparts, with PM mass levels exceeding those of diesels equipped with diesel particulate filters [4].

In 2007, the U.S. Congress passed the Energy Independence and Security Act (EISA 2007) which contained specific goals for the use of renewable fuels (36 billion gallons by 2022). The majority of this goal is expected to be met with ethanol from both corn and "advanced biofuel" sources like cellulosic feedstocks. The mandated volume of ethanol is likely to be utilized as E85 and potentially as a blending component of gasoline higher than the current 10% level. Thus, there was interest in seeing the effects of the convergence of the two advanced technologies, DISI and ethanol blends, on emission levels. Others have investigated ethanol blend effects on in-use gasoline vehicles and PM emissions [5,6] and 10% ethanol blends with DISI engines [7].

EXPERIMENTAL

A 2007 Pontiac Solstice equipped with a 2.0 L, turbocharged, direct injection engine was operated over several transient and steady state cycles on the 48" roll chassis dynamometer at Oak Ridge National Laboratory's Fuels, Engines, and Emissions Research Center (FEERC). Federal Certification Gasoline (E0), a 10% ethanol blend (E10), and a 20% ethanol blend (E20) were all blended by the fuel supplier (Gage Products) with the same base gasoline. The fuel properties are given in Table 1, and further information for the same fuel type can be found in a report for a large DOE project on intermediate ethanol blends [6,8]. Test cycles included the Federal Test Procedure 75 (FTP), the US06, the aggressive driving portion of the supplemental FTP, and gradual and wide-open throttle (WOT) accelerations. At least three replicates of each test with each fuel were performed, and criteria emissions, fuel economy, and aldehydes and ketones were measured. In addition, steady state cycles at 30 MPH and 80 MPH were done for particle size distribution measurements.

Table 1. Fuel Properties[6, 8]

Fuel Property	ASTM Method:	E0	E10	E20
EtOH (vol-%)	D5599	0	9.1	19.8
DVPE (kPa)	D5191	57.9	65.4	63.6
LHV (MJ/kg)	D240	43.11	41.51	39.64
SG (kg/l)	D4052	0.746	0.75	0.755
C (wt-%)	D5291	86.83	82.56	79.66

H (wt-%)	D5291	12.97	12.62	12.84
O (wt-%)	D5599	0	3.36	7.23
T10 (°C)	D86*	51	49	51
T50 (°C)	D86*	104	92	73
T90 (°C)	D86*	159	156	151
Total Aromatics (wt-%)	D5580	45.0	39.9	37.3
Sulfur (ppm)	D5453	29.3	27.7	25.4
Research Octane (RON)	D2699	97.1	100.0	101.2
Motor Octane (MON)	D2700	88.3	89.7	90.2

* These methods were performed on the NREL fuel used in the study as reported in [6,8]. The NREL fuelwas obtained from the same supplier using the same feedstocks as this study, but the E10 and E20 content were slightly different, 9.9% and 18.6% respectively.

ALDEHYDE SAMPLING AND ANALYSIS

Gaseous aldehydes and ketones were collected following CVS dilution of the exhaust for each phase of the FTP using dinitrophenylhydrazine (DNPH)-coated solid phase extraction cartridges (Waters Corp.). The sample flow rate was 0.8 l/min. The DNPH derivatives were solvent extracted with acetonitrile and subsequently analyzed by a Hewlett-Packard 1100 high performance liquid chromatograph (HPLC) using a Restek Allure C18 column with ultraviolet absorption detection for the determination of aldehyde and ketone concentrations. The eluent of the HPLC unit was transferred directly to a Bruker Daltonics® Esquire mass spectrometer where the hydrazone derivatives were positively identified using electrospray with negative ionization mass spectrometry (ESI-MS).

PM SAMPLING AND ANALYSIS

PM Mass

Filter samples were collected on 70mm Teflon™-coated glass fiber filters (Pallflex TX-40, Pall Corp.) following full-flow dilution by the CVS. The temperature of the dilute exhaust was maintained below 50 °C throughout the test. Filters were conditioned and weighed in a temperature and humidity controlled chamber and a balance with 0.1 µg sensitivity was used (Model UMX-2, Mettler-Toledo, Inc.) Two PM mass filters were collected for the FTP cycle: the first filter over the cycle corresponding to Bags 1 and 2, also known as the cold LA4; and the second filter over the cycle corresponding to FTP Bags 3 and 4, also known as the hot LA4 cycle. This approach allowed greater PM mass to be collected without affecting the weighted calculation of cycle emissions. A single filter was collected for the US06 cycle.

PM Size and Number Concentration

A micro-tunnel dilution system was used to dilute exhaust for particle number concentration and number-size distribution measurements. The system is based on an ejector pump dilution design by Abdul-Khalek et al. [9]. In the ejector pump, HEPA-filtered compressed air passes through a venturi nozzle and expands. The expansion of the air creates negative pressure and draws raw exhaust into the pump. One micro-tunnel diluter was placed after the turbocharger (pre-catalyst position) and another after the under floor catalytic converter (post-catalyst position). Short lengths of heated stainless tubing were used between the exhaust port and the ejector pump to avoid storage and release of material in the sampling line as described by Maricq et al.[10].

Number-size distributions of 5 to 160 nm particles were measured during 30 MPH and 80 MPH runs by a scanning mobility particle sizer (SMPS, Model 3936, TSI Inc.) equipped with the differential mobility analyzer (DMA, Model 3085, TSI, Inc.) The dilution ratio for the exhaust samples was 21. The number of particles < 15 nm was relatively low, indicating that the chosen dilution ratio was most likely high enough to avoid nucleation of semi-volatile components inside the micro-tunnel.

For particle number concentration measurements, an additional micro-tunnel was added to increase the dilution ratio to approximately 1000:1. Even at this very high dilution, the detection limit of condensation particle counter (CPC, Model 3025, TSI, Inc.) was exceeded during some of the transients. Thus, for subsequent runs, the DMA was used at a fixed particle diameter, 50 nm, the peak of the steady-state size distributions, to enable counting of the particles. The dilution ratio was maintained at 1000 for all of the transient experiments. All particle number concentrations presented here are corrected for dilution to the raw exhaust value.

OC and EC sampling

For the analysis of the organic and elemental carbon content of the particles, raw exhaust was sampled through a 47mm heated quartz filter (QAOT2500-UP, Pall Corp.) that had been pre-fired in a muffle furnace. The sampling apparatus was a modified version of the sampling apparatuses used for collecting PM from point sources [11]. The heated, stainless steel lines were kept at 190 °C and the filter oven was kept at 125 °C to avoid water condensation. Flow measurements were made with a dry gas meter (DTM-200, American Meter Corp.). The raw exhaust was sampled rather than the dilute exhaust to avoid OC artifacts on the quartz media due to the release of volatile organic compounds which may be adsorbed in the dilution tunnel. Samples were collected pre-catalyst and post catalyst to examine the nature of the engine out PM. Both the 30 MPH and 80 MPH steady-state conditions were used. The filters were analyzed by Sunset Laboratory (Tigard, OR) using the thermo-optical transmission method [12]. Blank values were less than 1% of the sample values.

RESULTS

At least three repetitions of each measurement of the effects of E0, E10, and E20 were carried out. Sufficient PM was collected for accurate mass measurement over the cold and hot FTP and US06 cycles. The vehicle's performance and fuel economy matched expectations for all three fuels; Table 2 shows the expected decline in fuel economy due to the lower energy density of the ethanol blends. NOx emissions were low and showed a downward trend with ethanol blend, while HC emissions increased with the E20 due to higher values in Bag 1, the cold start portion.

Table 2. Fuel Economy and criteria pollutant emissions for the e-blends

	E0	E10	E20
FTP FE (MPG)	25.1	24.1	23.9
US06 FE (MPG)	26.6	25.4	24.9
NMHC (g/mile)	0.055	0.044	0.091
NOx (g/mile)	0.031	0.018	0.009
CO (g/mile)	0.35	0.36	0.30

ALDEHYDE EMISSIONS

Carbonyl emissions were collected using DNPH cartridges over Bags 1, 2, and 3 of the FTP. Bags 2 and 3 consistently had < 5% of the carbonyl mass of Bag 1, so only Bag 1 emissions are reported here in Figure 1. The levels are very low, even when limited to the cold start phase. Acrolein and some other aldehydes were detected in some samples, but at much lower levels than formaldehyde, acetaldehyde and benzaldehyde given in Figure 1. There is a significant change upward in acetaldehyde with increasing ethanol content, as would be expected from previous studies with ethanol blends [6, 13]. Formaldehyde was observed to increase slightly (10%) with E10, but no further for higher blends in a previous study of modern in-use vehicles [6]. Although there was a significant increase in formaldehyde, the study had several individual vehicles with no change or a decrease in formaldehyde emissions.

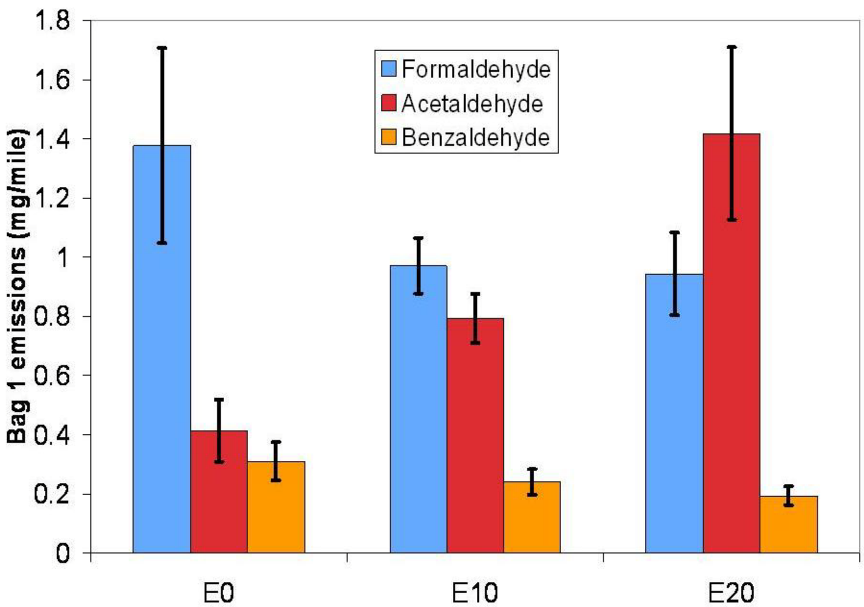

Figure 1. Aldehydes show trends consistent with ethanol blends. Error bars are one standard deviation.

PM MASS EMISSIONS

The cycle-based PM mass emissions are shown in Figure 2 with error bars representing maximum and minimum values. There is a 30% decrease in the average PM emissions for E20 relative to E0; and the E10 emissions are slightly lower as well. The more aggressive US06 cycle not only had much higher PM emissions for all three fuels, but also a bigger decline in emissions with E20. The E20 results showed a 42% decrease relative to the E0 average. Overall, the cycle-based PM mass emissions are similar to pre-2002, in-use, port fuel injection low-emission vehicles (LEVs) for which an average of 4 mg/mile PM levels was observed [14]. However, a more recent study of port fuel-injection, ultra-low emission vehicles (ULEVs) of model year 2005 and newer showed PM mass emission rates of < 1 mg/mile over the FTP [15]. This study used PM filter collection and conditioning methods consistent with the new Part 1065 regulations for heavy-duty diesel engines [16] which specify higher dilution sampling temperatures and filter media less prone to HC adsorption artifact than the TX-40 filters, likely resulting in less mass collection. Furthermore, contrary to our results, another group observed an increase in PM mass emissions from an automotive DISI engine equipped with a three-way catalyst operating on E10 [7], so platform to platform variation may occur and further research may be important if the blending level of ethanol increases in the U.S.

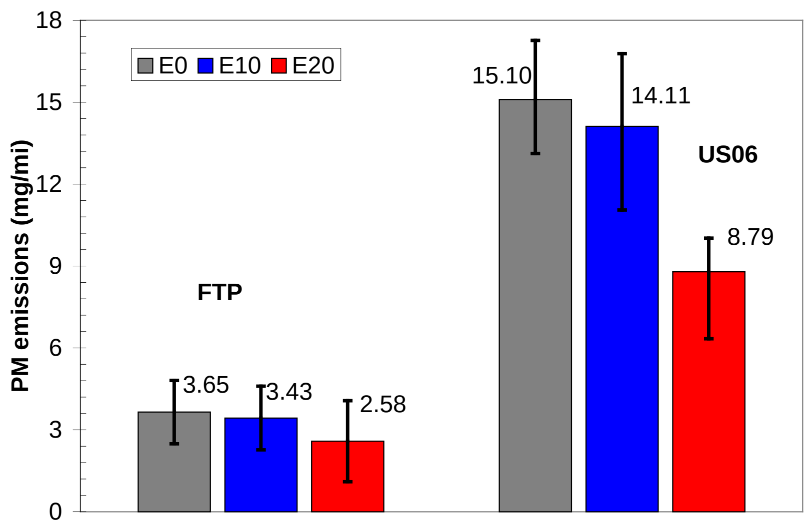

Figure 2. PM mass emissions decrease 30-40% with E20

OC AND EC EMISSIONS

The exhaust concentrations of EC are given in Figure 3 for 30 MPH and 80 MPH steady-state operation. As shown in Figure 3, the EC concentration is significantly reduced with increasing ethanol content in the fuel. EC can be considered as an approximate measure of soot-like carbon, and it has been shown in flame studies that oxygenates like ethanol interfere with soot formation by limiting aromatic precursors[17]. Others have shown that the carbon originating from ethanol is not present in the PM emissions of a diesel engine burning ethanol-diesel blends [18]. To further describe the data presented in Figure 3, the pre-catalyst and post-catalyst concentrations of EC are very similar, indicating that there is little particle loss in the catalyst. The EC is not expected to be affected by the catalyst because the short residence time in the catalytic converter doesn't allow for significant oxidation to take place.

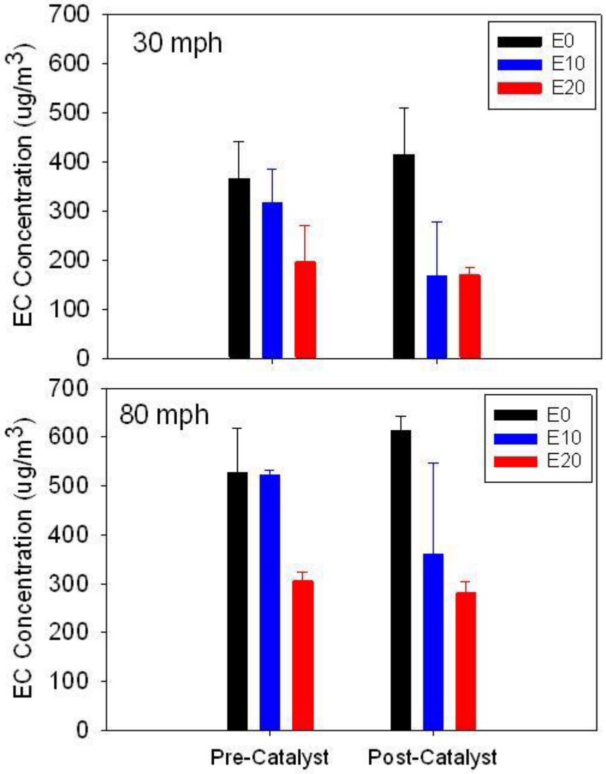

Figure 3. Elemental carbon decreases with increasing ethanol content

OC/EC ratio is a measure of the proportion of adsorbed semivolatile organics in the particulate matter, although a fraction of the semivolatile organics may be adsorbed to the quartz fiber filter medium. Our samples for the OC/EC measurement were collected at 125 °C, so more than 80% of the fuel-fraction hydrocarbons would tend to remain in the gas phase and not influence the results. The organic fraction likely represents heavy fuel ends, lube-type HCs and or highly-oxygenated HCs originating from the ethanol in the fuel. In Figure 4, the OC/EC ratio is plotted pre- and post-catalyst for the 30 and 80 MPH cases. The pre-catalyst OC/EC ratio is very high and increases with increasing ethanol content. There is little previously published data for pre-catalyst OC/EC values for gasoline engines, particularly DISI engines. One recent study [7] on DISI with E0 and E10 blends has thermogravimetric analysis (TGA) results for a single cylinder engine running on a reference fuel of 65:35 iso-octane:toluene (E0) and an E10 blend of this fuel. While the TGA method is not the same as the OC/EC reference method, the E0 fuel produced a ratio of volatile organic to elemental carbon of 6:1 for injection timing of 35° bTDC and 7.5:1 for an ignition timing of 15° bTDC. These values are similar to our OC/EC values for E0. Unlike our study, they did not find an increase in OC/EC ratio with increasing ethanol fuel content. There are many differences between the experimental conditions of the two studies, but both studies point out a rich area of research on the topic of fuel oxygenates and PM formation in DISI engines. For a qualitative comparison of the pre- and post-catalyst HC emissions, exhaust condensate was collected downstream of the OC/EC quartz fiber filters by cooling and impinging the exhaust gases on glass beads. The pre-catalyst condensate was brown-yellow in color and the post-catalyst condensate was clear. As shown in Figure 4, the catalyst was able to remove the vast majority of the OC fraction. At 80 MPH, the higher EC concentration leads to lower OC/EC ratios than 30 MPH. At 80 MPH, higher combustion temperatures may have led to greater EC formation than at the lower speed condition.

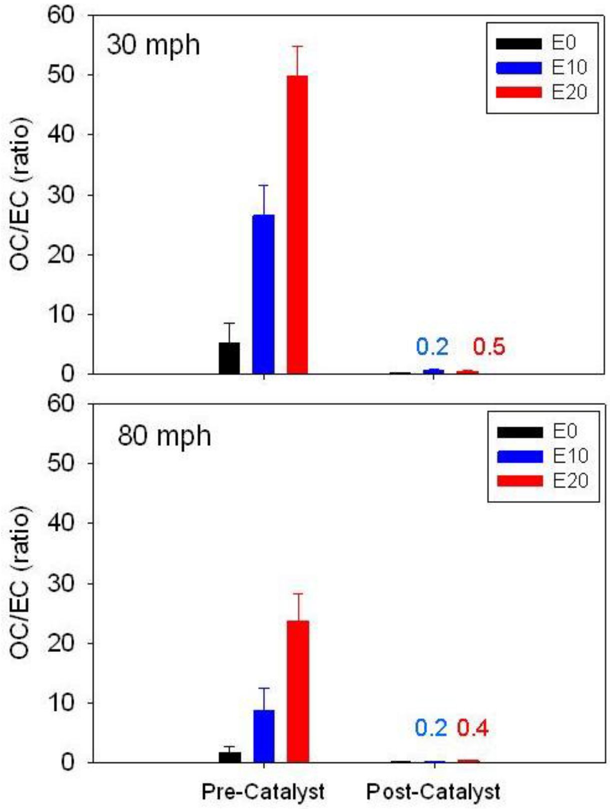

Figure 4. Pre-catalyst OC/EC increases 10-fold with increasing ethanol; the catalyst effectively removes OC for each E-blend.

PM SIZE AND NUMBER CONCENTRATION RESULTS

Particle number-size distributions were obtained with the SMPS at 30 MPH and 80 MPH for the three fuels and the results shown in Figure 5. The distributions for the three fuels are very similar with a geometric mean diameter of 50 nm. Also note the broad range of sizes; from earlier unpublished work in our laboratory with PFI vehicles, we had expected much sharper size distributions with few particles above 50 nm. The size distributions are similar to what has been observed with a 2.0 L turbocharged light-duty diesel engine operating at a speed and load similar to the load required by the vehicle to maintain 30 MPH [19].The 80 MPH condition shows approximately 3 times the number concentration of particles as the 30 MPH condition, but shape of the size distributions are very similar. The higher concentrations particles for 80 MPH are consistent with the much higher mass observed for the US06 cycle which has a high speed cruise section. The higher ethanol content decreases the number concentration of particles in the region near the peak of the distribution for both speed conditions, which is consistent with the decrease in PM mass emissions.

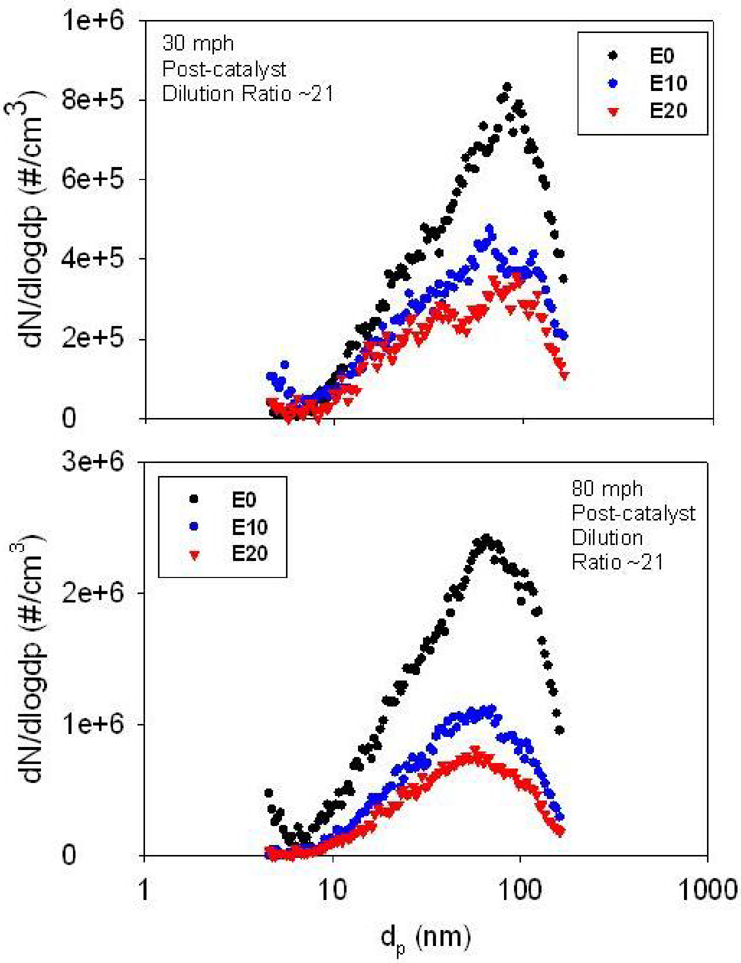

Figure 5. Size distributions of post-catalyst exhaust for 30 MPH and 80 MPH; dN/dlogDp values are corrected to raw exhaust concentrations.

Although the peak number concentrations given in Figure 5 were not very high, the broad distribution implies that there were a large number of particles. When we attempted to measure total particle number concentration during the transient cycles, the concentration overwhelmed the particle counter, despite a very high dilution ratio of about 1000:1. The high particle number concentration is consistent with observations for European DISI vehicles [4]. Because the 50 nm geometric mean diameter of the distributions was consistent between fuels and speeds, this size was selected for measurements during transient cycles. Figure 6 shows the post-catalyst number concentration of 50 nm particles for the cold start phase (Bags 1 and 2) and the hot start phase (Bags 3 and 4) of the FTP cycle. The ethanol blends have little effect on particle number concentration over the cold start phase, but the hot start phase shows lower number concentrations for E10 and E20, with close to a factor of 10 decrease for E20.

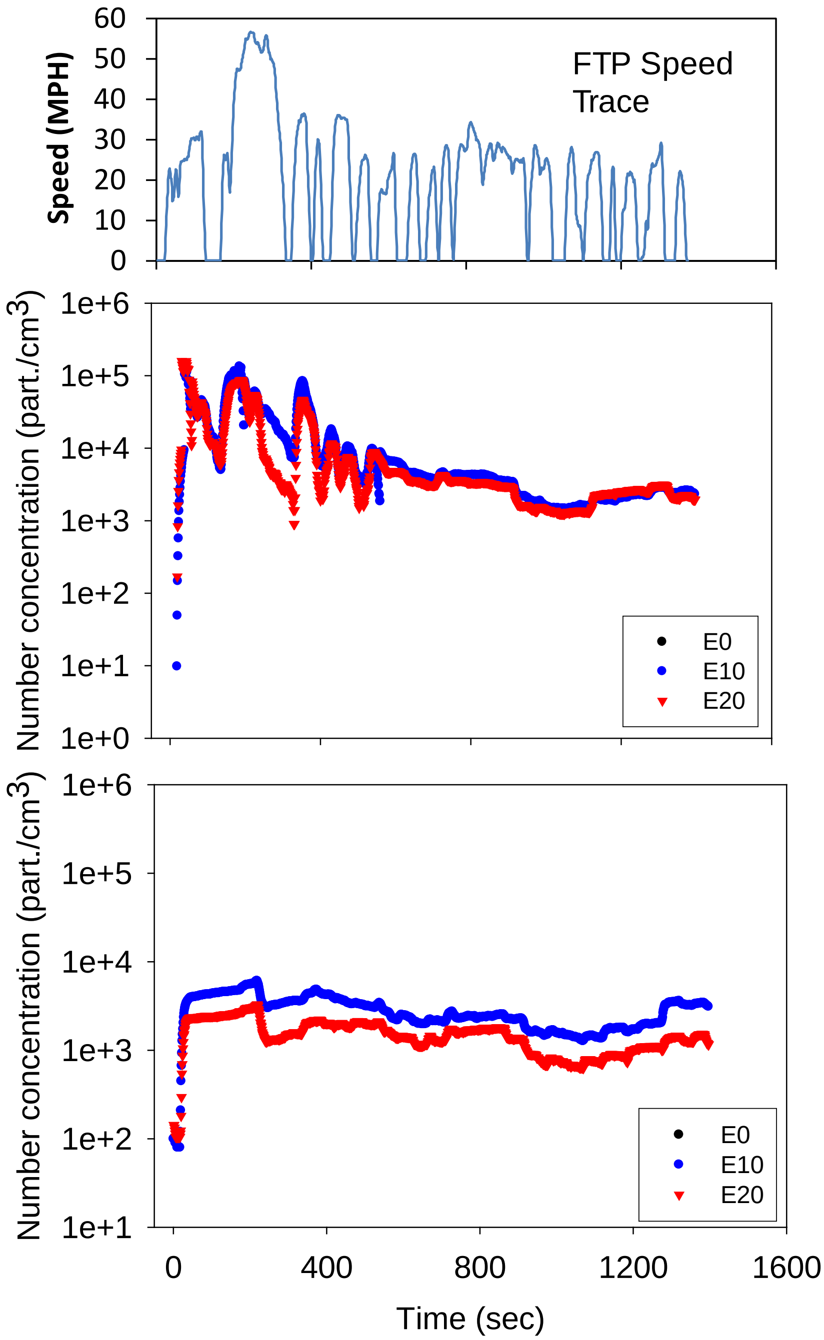

Figure 6. A comparison of the 50 nm PM number concentrations for the cold and hot transient cycles with E0, E10, and E20. The speed trace for the FTP is shown at the top. Number concentrations are corrected for dilution to raw exhaust

In order to resolve additional transient effects on PM number concentration, a series of simple accelerations and decelerations were performed with each fuel, and the number concentration monitored at three different sizes selected by the differential mobility analyzer (DMA); 10, 50, and 100 nm. Wide open throttle (WOT) accelerations from 0-80 MPH were performed and compared in Figure 7 for the E0 and E20 fuels. The speed trace is shown at the top of Figure 7. As shown in Figure 7, E20 dramatically reduces the peak number concentrations of the 50 and 100 nm particles during acceleration. Because the y-axis scales in Figure 7 are identical, the E20 results look as if the CPC was saturated, but close inspection of the raw data revealed that the counts were well within the specifications of the instrument. The lack of larger particles is consistent with the 40% drop in PM mass observed for E20 during the aggressive US06 cycle (Figure 2). The PM reduction observed during a WOT is also consistent with the fuel ethanol interfering in some manner with soot particle formation because WOT operation will likely result in fuel enrichment locally in-cylinder and thus a tendency to form more PM.

The speed trace shows that after each WOT, the speed rapidly decreases to 30 MPH and is held for several seconds. This procedure was done to allow the catalyst to cool with some exhaust flow. The particle generation, however, appears to cease even before the deceleration, and the concentrations were low during the 30 MPH portion. This result is consistent with local and temporal enrichment during the acceleration being responsible for PM formation.

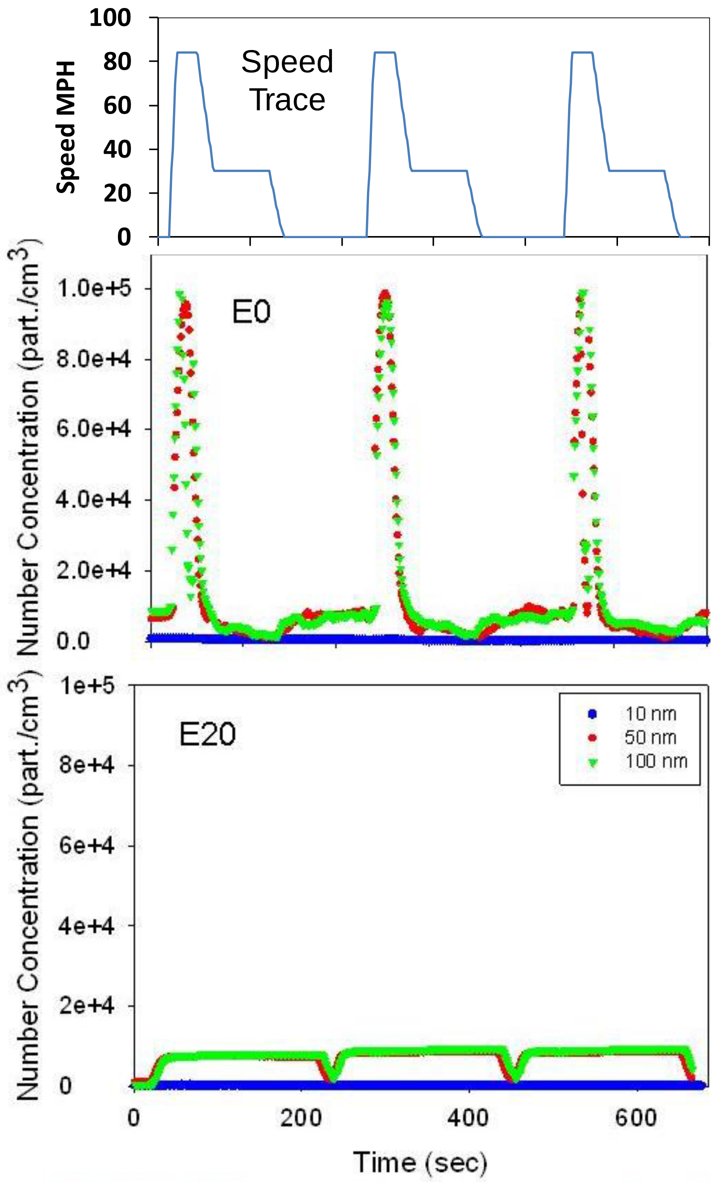

Figure 7. Raw exhaust PM number concentrations during WOTs for E0 and E20.

An insignificant amount of 10 nm particles were found in the post-catalyst exhaust for the WOT accelerations (Figure 7) since these particles were effectively removed by the catalyst as shown by comparison with pre-catalyst concentrations (Figure 8). This result provides evidence that the 10 nm particles originated from low-volatile hydrocarbons that are susceptible to catalytic oxidation. Because our ejector diluter was positioned close to the source, nanoparticle formation by storage and release of material in the sampling line [10] was prevented and thus, made possible the absence transfer line artifacts in the 10 nm post-catalyst results.

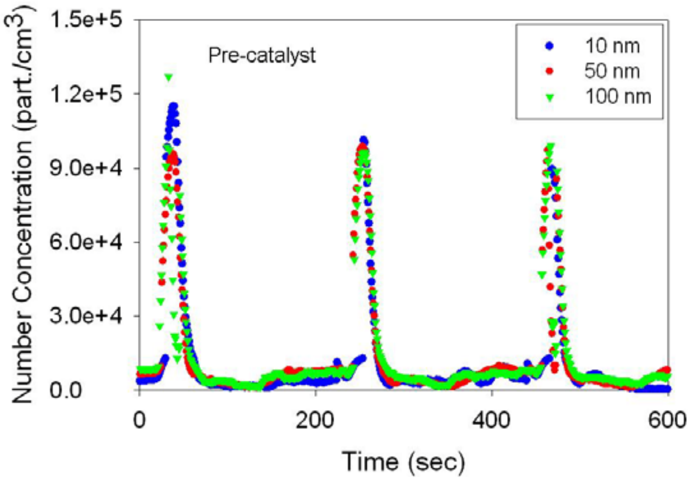

Figure 8. Pre-catalyst raw exhaust particle number concentrations during WOT accelerations for E0

The difference between particle generation for the WOT acceleration vs. the FTP-like acceleration, Figure 7 vs. Figure 9, is about a factor of 5 which is consistent with the five-fold mass increase observed during the US06 over the FTP. The reduction in 50 and 100 nm particles by E20 and the removal of 10 nm particles by the catalyst also resulted from these more gradual accelerations. The drop in PM mass with E20 observed for the cycle-averaged mass emissions, as shown in Figure 2, is also consistent with the lower numbers of the 50 nm and 100 nm particles. Although there is a 30% drop in PM mass over the FTP for E0 vs. E20, as shown in Figure 2, there is an 80% -90% drop in number for E0 vs. E20 in Figure 9. One explanation may be that the FTP includes a cold start, and the majority of the FTP mass emissions for all fuels were found on the Bag 1 filter. For this particular vehicle then, operating on E20, the contribution to the FTP PM emissions from the acceleration portions may be very small.

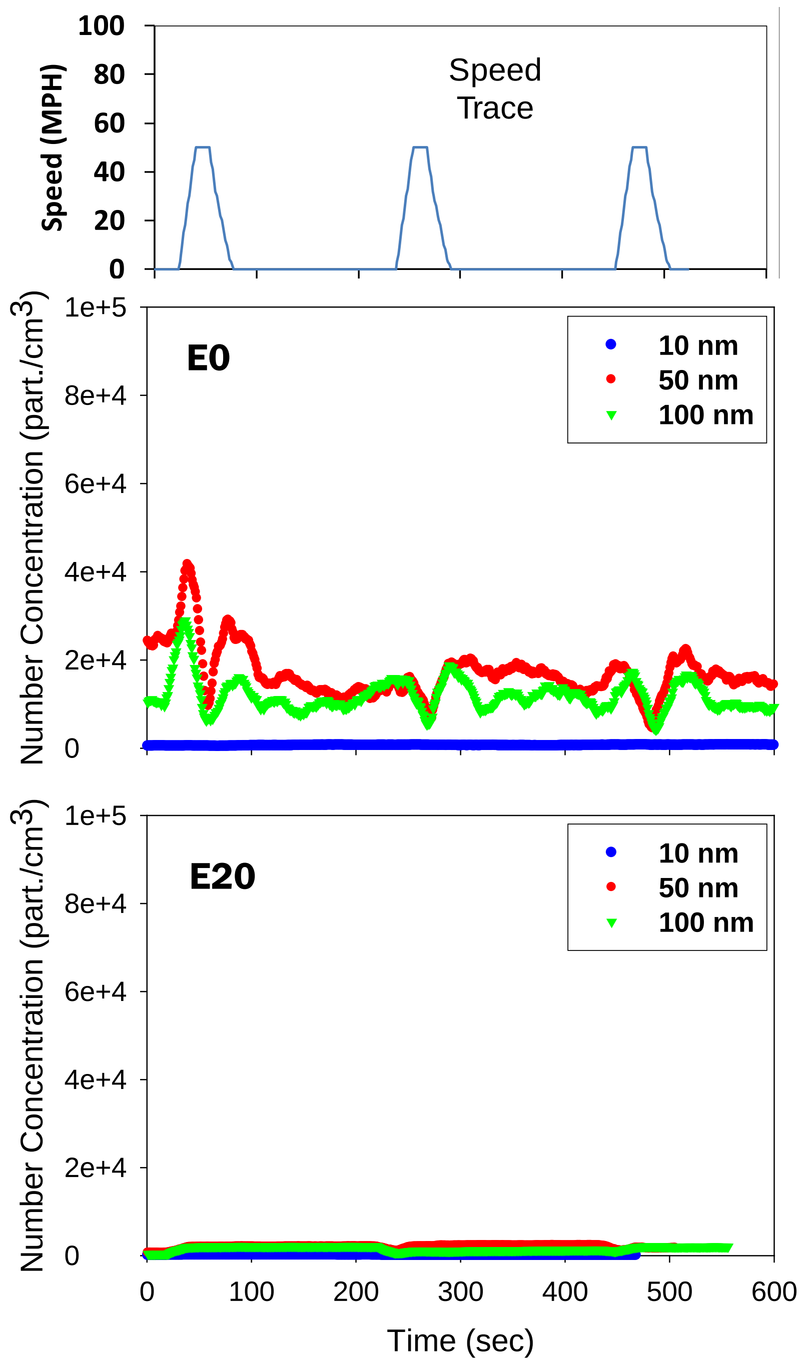

Figure 9. Post-catalyst exhaust particle number concentrations during three accelerations from 0-50 MPH for E0 and E20 fuels. The speed trace is shown above; accelerations were equivalent to the maximum FTP acceleration of 3.3 MPH/s/s.

SUMMARY/CONCLUSIONS

The emissions, including PM and aldehydes, from a U.S. legal stoichiometric DISI vehicle operating on E0, E10, and E20 were characterized. The PM emissions were characterized for mass, size, number concentration and OC-EC content. The DISI particle number-size distribution curves were similar in shape to light-duty diesel vehicles without DPFs, but had lower overall particle number and mass emissions. The aggressive US06 transient cycle had much higher PM mass emissions in comparison to the PM mass emission observed for the FTP. Ethanol blends reduced the PM mass and number concentration emissions for both transient and steady-state cycles. By increasing the ethanol blend level from E0 to E20, the average mass emissions declined 30% and 42% over the FTP and US06, respectively. Measurements during hot cycle transient operation demonstrated that E20 also lowered particle number concentrations. The adoption of small displacement, turbocharged DISI engines into the U.S. fleet is likely to continue in the future, and the results of this study suggest that increasing ethanol blend levels in gasoline will lower DISI PM emissions.

CONTACT INFORMATION

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DISCLAIMER

DEFINITIONS/ABBREVIATIONS

ASTM American Society for Testing and Materials

CO carbon monoxide

CPC Condensation particle counter

CVS Constant Volume Sampling

DISI direct injection spark-ignition

DOE U.S. Department of Energy

DNPH dinitrophenylhydrazine

DVPE dry vapor pressure equivalent

E0 100% gasoline

E10 10% ethanol in gasoline

E20 20% ethanol in gasoline

EISA Energy Independence and Security Act

EPA Environmental Protection Agency

EtOH ethanol

FE Fuel economy

FTP Federal Test Procedure

HPLC High performance liquid chromatography

LA4 505s + 872s portions of FTP

LHV lower heating value

MPH miles per hour

NMHC nonmethane hydrocarbons

NOx oxides of nitrogen

OC/EC organic carbon/elemental carbon ratio

OEM original equipment manufacturer

ORNL Oak Ridge National Laboratory

PFI port fuel injection

PM particulate matter

RFS Renewable Fuel Standard

SG specific gravity

SMPS scanning mobility particle sizer

THC total hydrocarbon

US06 aggressive driving cycle, part of the supplemental FTP

WOT wide-open throttle

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Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 9

Aerosol Science and Technology, 46:576–583, 2012

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The Impact of Ethanol Fuel Blends on PM Emissions from a Light-Duty GDI Vehicle

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This study explores the influence of ethanol on particulate matter (PM) emissions from gasoline direct injection (GDI) vehicles, a technology introduced to improve fuel economy and lower CO_2 emissions, but facing challenges to meet next-generation emissions standards. Because PM formation in GDI engines is sensitive to a number of operating parameters, two engine calibrations are examined to gauge the robustness of the results. As the ethanol level in gasoline increases from 0% to 20%, there is possibly a small (<20%) benefit in PM mass and particle number emissions, but this is within test variability. When the ethanol content increases to >30%, there is a statistically significant 30%–45% reduction in PM mass and number emissions observed for both engine calibrations. Particle size is unaffected by ethanol level. PM composition is primarily elemental carbon; the organic fraction increases from ∼5% for E0 to 15% for E45 fuel. Engine-out hydrocarbon and NO_x emissions exhibit 10–20% decreases, consistent with oxygenated fuel additives. These results are discussed in the context of the changing commercial fuel and engine technology landscapes.

[Supplementary materials are available for this article. Go to the publisher's online edition of *Aerosol Science and Technology* to view the free supplementary files.]

INTRODUCTION

Three areas related to motor vehicles and air quality are experiencing major changes. The first is fuel composition. Recent energy policy decisions, such as the 2007 Energy Independence and Security Act, mandate increased reliance on renewable fuels, directives to enhance national security and ameliorate climate change impacts (U.S. Environmental Protection Agency 2007). This implies increased blending of ethanol into conventional gasoline fuel. Roughly 90% of gasoline sold in the United States currently contains nearly 10% ethanol (E10) (U. S. Energy Information Administration 2011). This will increase following the United States Environmental Protection Agency (EPA) partial waiver to allow E15 fuel use in 2007+ model year vehicles (U. S. Environmental Protection Agency 2010).

The second is the growth of gasoline direct injection (GDI) engine technology, aimed to offer fuel economy and CO_2 emissions benefits (Fraser et al. 2009; Yi et al. 2009). Direct injection of gasoline into the cylinder allows better combustion control, for example, multiple fuel injections and charge-air cooling. But it risks incomplete fuel volatilization and impingement onto piston and cylinder surfaces, exacerbating particulate matter (PM) emissions. The third is regulatory; California Air Resources Board (ARB) and EPA are both contemplating next-generation emissions standards which would lower tailpipe PM emissions from 10 mg/mi to 6 mg/mi, and then 3 mg/mi, over the next decade (California Air Resources Board 2010).

Consequently, it is important to examine the interplay and potential synergies between fuel composition and engine technology in efforts to reduce emissions. There are ongoing investigations of ethanol's effects on fuel systems, evaporative emissions, and gaseous emissions (Durbin et al. 2007; Kar and Cheng 2009; Knoll et al. 2009; Coordinating Research Council 2011), but few gasoline engine studies have examined its impact on PM emissions. The paucity of data is presumably because stoichiometric combustion in spark ignition engines naturally produces very low PM emissions, a few milligrams per mile (Maricq et al. 1999), and because GDI is a new technology. One exception is the effort by Aikawa et al. (2010) to create a PM index based on fuel properties, which is of interest for GDI because of the potential to help model air fuel mixing and sooting propensity.

Ethanol effects on GDI particulate emissions have been reported by Storey et al. (2010) and He et al. (2010), who observed reductions of about 30% for E20 fuel over the Federal Test Procedure (FTP) drive cycle. However, the detailed characterizations, such as particle number, size, and composition, were undertaken at steady-state engine operation, whereas cold and hot starts and transients are typically of more interest for gasoline engines. Work by Chen et al. (2010) showed that PM

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emissions can either increase or decrease with ethanol content depending on fuel injection timing. Such results point out a difficulty in investigating potential fuel benefits, namely that these might be masked by adjustments in engine calibration when the fuel is changed. Other properties of fuel besides ethanol content can also impact PM emissions; thus, Khalek et al. (2010) noted higher PM levels from a GDI vehicle operated on a commercial E10 fuel relative to two E0 fuels, but attributed this to a higher volatility in the base gasoline.

The goal of this paper is to examine how ethanol–gasoline blends impact PM emissions from GDI vehicles. Six fuels are examined, ranging from E0 (base gasoline) to E45 (45% ethanol). The study utilizes the FTP drive cycle to include the important effects of cold start and transient operation. It addresses measurement variability both by repeat tests and the use of three metrics of PM emissions: mass, number, and elemental/organic carbon composition. The issue of sensitivity to engine parameters is handled in two ways: First, we conduct testing at two different engine calibrations to assess the consistency of ethanol's impact on emissions. Second, we compare the vehicle exhaust results to observations from a study of ethanol–gasoline blend diffusion flames (Maricq 2011).

TABLE 1
Fuel properties

Characteristic	E0	E10 cert	E10 pump	E100
Ethanol (%vol)	0	10.1	9.0	97.3
10% recovery dist. T (°C)	56.7	54.8	48.5	
50% recovery dist. T (°C)	105.6	98.4	69.8	
90% recovery dist. T (°C)	155.8	158.8	165.5	
Density (g/mL)	0.744	0.754	0.734	0.795
Vapor pres. ASTM (kPa)	55.2	54.5	70.6	21.0
Net heating value (MJ/kg)	43.34	41.5		26.73
Research octane	97.3	94.4	91.8	
Carbon weight%	86.41	82.90		52.16
Hydrogen weight%	13.59	13.41		13.08
Oxygen weight%	<0.05	3.69		34.76
Sulfur (ppm)	19	5	58.8	3
Aromatics (%vol)	28.5	24.1	16.9	

EXPERIMENTAL METHODS

Test Vehicle and Fuels

The test vehicle is a light-duty truck equipped with a 3.5-L V6 gasoline turbocharged direct injection engine. It is representative of current GDI products, but contains prototype elements, such as the engine calibrations tested here. It has a compression ratio of 9.8:1 and independent variable cam timing. The fuel injectors are side-mounted and deliver single-fuel pulses, except for split injection (two pulses) during crank and early cold start operation. Exhaust aftertreatment consists of a three-way catalyst to control hydrocarbon (HC) and NO_x emissions.

The study uses four fuels: certification test gasoline (E0), a commercial E10 fuel similar to that expected for future certification, a commercial pump grade E10, and a commercial E100 fuel used for blending. Their properties are listed in Table 1. E100 and E0 were splash-blended to produce the E17, E32, and E45 fuels. All fuels were analyzed by gas chromatography to verify ethanol content. Fuel changes were done by draining the tank, filling with new fuel, and running the vehicle through the FTP drive cycle prior to testing. Emissions were measured over the FTP cycle, consisting of three phases: (1) cold start, (2) urban, and (3) hot start. E0 tests were conducted first and last to confirm that no changes in vehicle emissions performance occurred.

PM Sampling and Measurement

The vehicle was tested on a 48-inch single roll, AC electric, chassis dynamometer. The experimental setup is illustrated in Figure 1. Vehicle exhaust was sampled in two ways: (1) directly from the tailpipe and (2) through a full-flow constant volume sampling (CVS) dilution tunnel, as per the regulatory method (except to substitute quartz filter EC/OC analysis for Teflo filter gravimetric PM mass). In our CVS system, exhaust is diluted with a "remote mix T" connected to the tailpipe via a short (~1 m) extension. The dilution air is filtered, temperature- and humidity-controlled (38°C and −9°C dew point), and actively regulated to maintain a constant total flow of exhaust plus dilution air. This was set to 9.34 m^3/min for E0, E10, and E17 fuels, but raised to 19.8 m^3/min for E32 and E45 because of increased exhaust humidity. The diluted exhaust travels via a ~7-m, 25.4-cm-diameter, conductive coated Teflon tube to a 30.4-cm-diameter stainless steel tunnel.

Direct tailpipe sampling employs a Dekati Fine Particle Sampler (FPS) originally developed to provide standardized dilution conditions for studying nucleation mode formation (Ntziachristos and Samaras 2010). It uses a coaxial perforated tube diluter that allows room temperature dilution, but avoids thermophoretic deposition of PM from hot exhaust. This approach contrasts with the European Union solid particle counting method, which is designed to remove nucleation mode particles by hot dilution and evaporation (Giechaskiel et al. 2008). Instead, the FPS samples both semivolatile and solid particles. It was used at a dilution factor of 25–30. A Dekati ejector pump provides 8.5 times secondary dilution for particle number counting. Room temperature nitrogen from liquid boil-off supplies the diluent for both the FPS and the ejector pumps.

Three PM emissions metrics are examined: (1) mass, (2) elemental/organic carbon (EC/OC), and (3) total particle

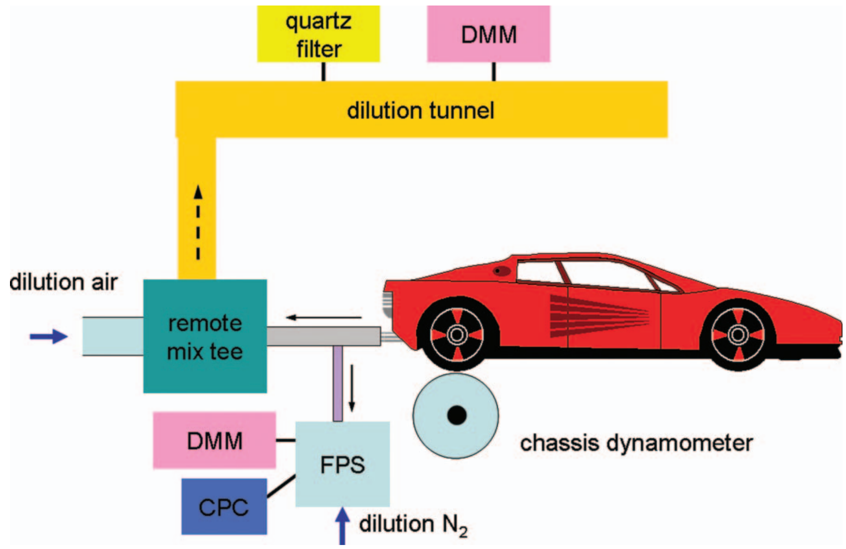

FIG. 1. Schematic diagram of the experimental setup. Solid arrows show exhaust and diluent flows. Dashed arrow indicates diluted exhaust flow. (Color figure available online).

number. Engine-out HC and NO_x emissions are also reported. They are measured using Horiba analyzers based on flame ionization detection (FID) and chemiluminescence detection, respectively.

PM mass is determined by Dekati Mass Monitor (DMM) using a combination of electrical mobility and aerodynamic particle size measurements (Mamakos et al. 2006). Particles are charged in a corona discharge, segregated by mobility (D_{50} = 50 nm), and those penetrating the mobility classifier enter a cascade impactor. The resulting electrical currents and aerodynamic and mobility size information yield estimates for the quantity, volume, and effective density of particles, which are combined to calculate second-by-second PM mass concentration. Two DMMs were used, one at the tailpipe and the second at the CVS tunnel.

EC/OC particulate mass is determined by sampling diluted exhaust through prebaked 47-mm-diameter quartz filters, followed by thermal analysis with a Horiba MEXA 1370PM (Akard et al. 2004). The filters are heated to 980°C, first under nitrogen and then with oxygen present. CO_2 from the oxidation of material evolved under nitrogen is equated with organic carbon, whereas that produced with oxygen is attributed to elemental carbon. The OC mass includes a correction for hydrogen content assuming an H/C ratio of 1.85. A correction is also made for gas phase adsorption, which amounts to about 0.5 mg/mi (Maricq et al. 2011). Unlike the IMPROVE and NIOSH methods (Chow et al. 2001), there is no correction for pyrolysis, which impacts interpretation of EC/OC values. But the total PM mass compares well with gravimetric data (Akard et al. 2004).

Total particle number concentration is measured via TSI 3010 CPC (condensation particle counter). The lower size cutoff, 50% count efficiency, is 12 nm. This is nearly a factor of two smaller than the 23-nm cutpoint adopted by the EU for their solid particle method. The CPC counting efficiency at 70 and 100 nm was calibrated by electrometer to 100%.

Many of the E0 and E10 tests included tailpipe PM measurements by an electrical low-pressure impactor (ELPI) (Keskinen et al. 1992). This is a cascade impactor that measures second-by-second aerodynamic size distributions by first charging the particles in a corona discharge and then recording the electrical currents from the impactor stages. Previous work has shown that analysis of diesel particulate matter ELPI data using a fractal-like effective density results in PM mass and geometric mean mobility diameter estimates in good agreement with gravimetric and scanning mobility particle sizer data (Maricq et al. 2006).

RESULTS

Four engine calibrations (engine computer control of fuel pressure, fuel injection and spark timing, etc.) were initially examined with E0 fuel and found to have FTP cycle-weighted average PM emissions in the range of 3–7 mg/mi. Two of these near the proposed 3 mg/mi LEV III standard were selected for further study, labeled A and B. These differ in that calibration A produces lower cold start but higher urban and hot start PM relative to calibration B. Three to four repeat tests were performed with calibration A for each fuel; whereas, one to three were conducted with calibration B. The calibrations were not altered between fuels, except to adjust the amount of fuel needed to maintain a stoichiometric air/fuel ratio. The two calibrations show similar PM emissions trends with ethanol level; therefore, calibration A data are presented next, whereas those for calibration B are included in Supplementary Information.

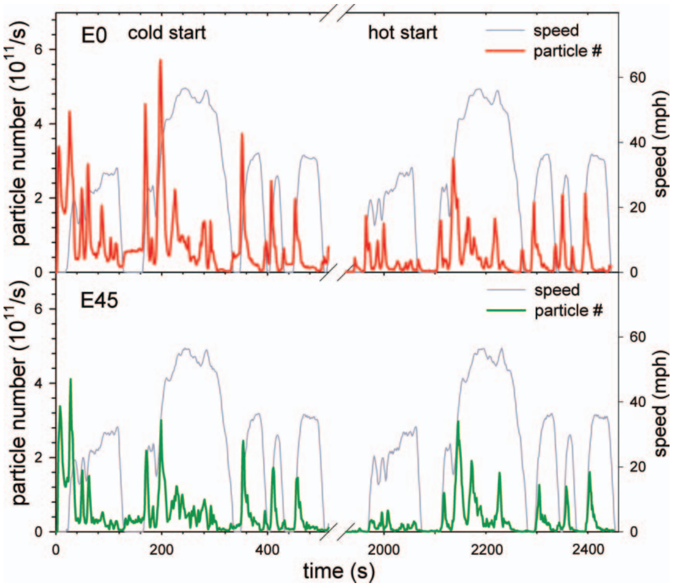

FIG. 2. Transient particle number emissions from the GDI test vehicle for the cold and hot start phases of the FTP drive cycle. Data are recorded by direct tailpipe sampling. Top panel: E0 fuel. Bottom panel: E45 fuel. (Color figure available online).

PM Mass and Number Emissions

Figure 2 illustrates tailpipe particle number emission rates over the cold and hot start FTP phases. Mass emissions (Figure S2 in Supplementary Information) exhibit a similar pattern.

When measured at the tailpipe, the particle concentrations recorded by DMM or CPC are multiplied by the time-aligned exhaust flow volume to derive emissions rates. Concentrations recorded via CVS sampling are simply scaled by the dilution tunnel flow. Not surprisingly, PM emissions correlate with vehicle acceleration owing to the increased fueling. But one also observes smaller emissions peaks during decelerations, likely a consequence of fuel shut-off. Emissions with E45 fuel are consistently below those for E0, but the decrease is not uniform, as seen from the accentuated reduction in particle emissions at the beginning of the hot start.

The effect of ethanol on PM emissions is summarized by Figures 3 and S3. These portray five parallel measurements: (1) mass from the tailpipe DMM, (2) mass from CVS tunnel DMM, (3) EC/OC mass from CVS, (4) particle count at tailpipe, and (5) ELPI PM mass for a subset of tests. The 1σ error bars represent test-to-test variability. Differences between the five methods reflect measurement uncertainty. This includes both systematic and random effects, but the data scatter points to random noise as the major contributor at these low emissions levels. The variability between the five PM methods is comparable to test-to-test variability in any given method. No statistically significant differences are observed between direct tailpipe and CVS sampling.

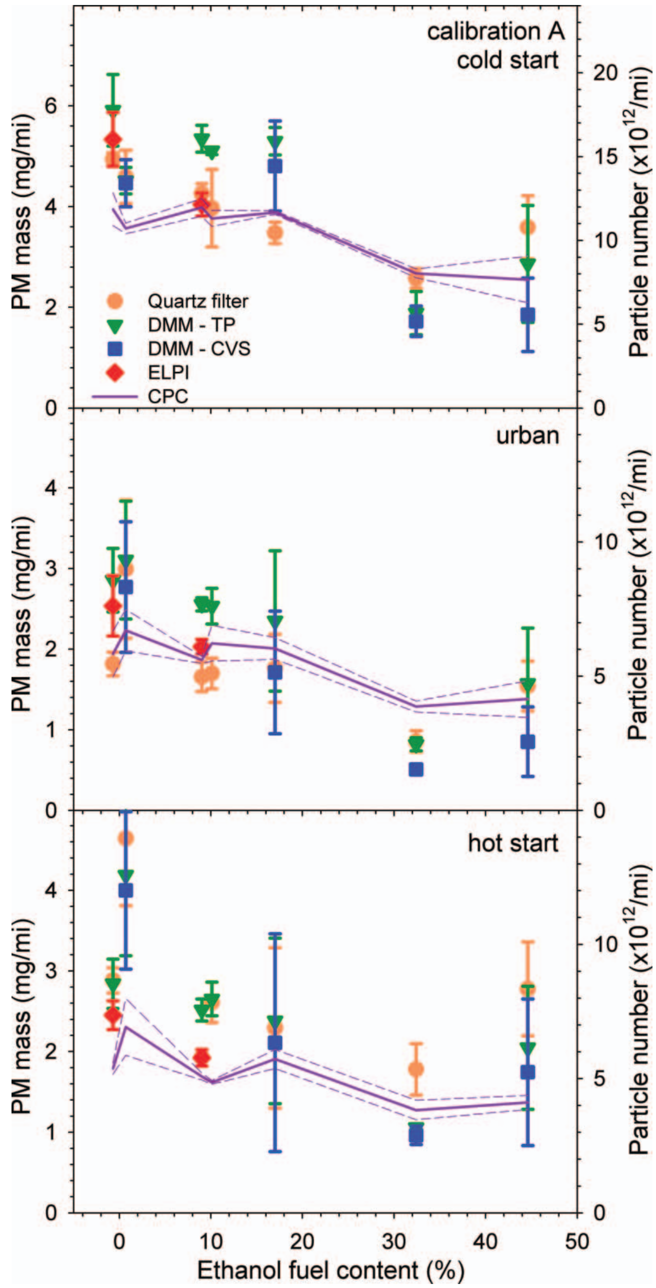

FIG. 3. GDI vehicle exhaust particle number and mass emissions versus ethanol content of fuel. Emissions are measured over the three-phase FTP drive cycle using calibration A. Symbols = mass. Lines = particle number. E0 data recorded at the beginning and end of the study are distinguished by plotting them slightly below and above 0% ethanol, respectively. Error bars are 1σ of the test repeatability. (Color figure available online).

All three metrics indicate a statistically significant reduction in particulate emissions with E32 and E45 fuels compared to base gasoline, relative to the average measurement uncertainty of approximately ± 0.7 mg/mi. The decrease from E0 to these fuels is on average ~30% by particle number and ~45% by mass. This distinction is likely within the uncertainty, but could also originate from differences in nuclei mode particle emissions. Since E85 fuel further reduces PM (not part of this study), the small increase from E32 to E45 is likely from vehicle variability.

Figures 3 and S3 suggest a small (∼20%) PM benefit for the lower ethanol blends relative to E0, but the data are mixed. Averaged over the parallel measurements, PM mass decreases 10–30% from E0 to E10 fuel using calibration A, but then remains constant from E10 to E17. For calibration B, there is a 10–20% PM increase from E0 to E10, but a ∼10% decrease from E0 to E17 fuel. However, the individual DMM and EC/OC data are not always consistent in their trends for the lower-ethanol blends, reflective of the difficulties in measuring PM at the ∼1 mg/mi level. Particle number measurements show a similar circa 20% improvement from E0 to E17 fuel. But even with somewhat lower variability than the PM mass data, this ∼20% falls within the overall measurement uncertainty.

Figure 4 shows that engine-out HC and NO_x emissions exhibit similar dependences on fuel ethanol content. The decreases are more modest, about 20%. For calibration A, they occur already for the E17 blend, but calibration B data in Figure S4 indicate the decreases to occur above E17. The HC decrease

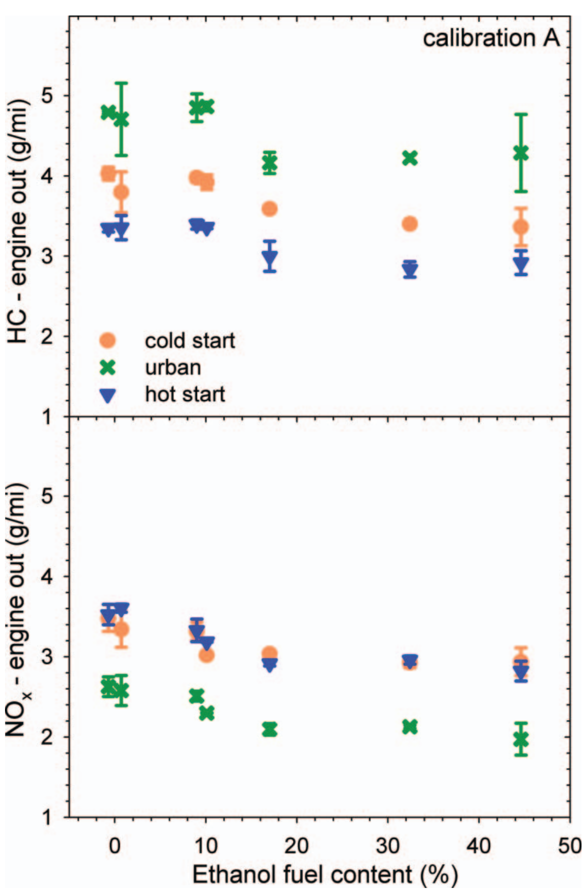

FIG. 4. FTP engine-out (feedgas) total hydrocarbon and NO_x emissions versus fuel ethanol content for calibration A. Initial and final E0 tests are distinguished as in Figure 3. (Color figure available online).

should be interpreted with caution. Adding ethanol to gasoline changes HC composition, increasing the proportion of alcohols and aldehydes. These compounds are less efficiently detected by FID, which by itself can lead to an apparent emissions reduction. Additional measurements to correct under-determination of these compounds were not conducted in this study.

PM Mode and Size

Engine exhaust particles have an agglomerate morphology; thus, their size is characterized by the notion of an equivalent diameter. The DMM employs a combination of mobility and aerodynamic analysis, but does not directly measure either equivalent diameter. Rather, we derive estimates of geometric mean mobility diameter by assuming a bimodal lognormal distribution of particle number concentration versus mobility diameter and fitting the DMM impactor and mobility currents to the calculated currents. This is similar to the procedure described previously for the ELPI (Maricq et al. 2006). The number of adjustable parameters is reduced to three by fixing the nucleation mode geometric mean diameter to 20 nm, its standard deviation to 1.3, and by assigning the universal value of 1.8 to the accumulation mode geometric standard deviation (Harris and Maricq 2001). Best fits of the DMM data and a typical OC density of 0.8 g/cm^3 yield nucleation mode masses increasing from 2% to 5% of the total PM as the ethanol content rises. Choosing a different nucleation mode diameter or standard deviation alters the calculated mass, but it remains a small fraction of the total PM mass.

The influence of ethanol level on accumulation mode diameter is illustrated in Figure 5. This shows three estimates of the geometric mean mobility diameter (μ_g): (1) ELPI, (2) fits of DMM currents, and (3) calculated from the PM mass and number measurements via:

$$M = N_0 \frac{\pi}{6} \rho_0 d_0^{(3-D_f)} \mu_g^{D_f} e^{(D_f \ln \sigma_g)^2/2}. \quad [1]$$

Equation (1) assumes a log-normal mobility distribution of N_0 particles with geometric mean μ_g and standard deviation σ_g, an aggregate morphology with mass-mobility exponent $D_f = 2.3$, a primary particle density of $\rho_0 = 2$ g/cm^3, and a primary particle diameter of $d_0 = 20$ nm typical of engine soot (Maricq et al. 2006). Fits of DMM data yield mean mobility diameters of ∼150 nm, roughly double the size normally expected for combustion engines. This discrepancy is systematic but independent of the agreement between DMM and filter-based PM mass values. Figures 3 and S3 show that PM mass measurements from the two DMMs, ELPI, and EC/OC agree within the test-to-test variability. The question of size is discussed further in the Supplementary Information. Here, scaling the DMM values by 0.5 provides a consistent estimate of mean mobility equivalent particle diameter. The results reveal that accumulation mode particle diameter is essentially independent of ethanol level. For the E0–E17 fuels, average size may decrease a bit (∼5 nm)

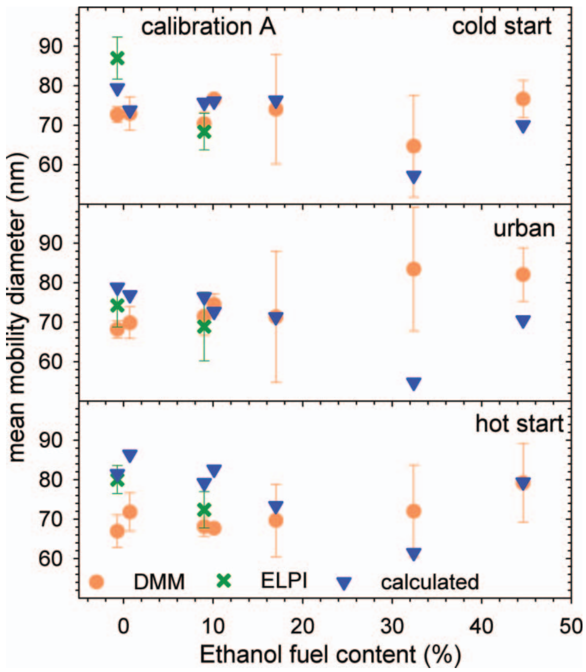

FIG. 5. Geometric mean mobility diameter of GDI particle emissions versus fuel ethanol. (Color figure available online).

from cold start to warmed-up operation and from calibration A to calibration B (Figure S5). For E32 and E45, such changes are within measurement uncertainty.

EC/OC Composition

Figures 6 and S6 plot the elemental and organic carbon fractions of the PM emissions versus ethanol blend. EC is clearly the predominant component and follows the same trend as total PM mass, namely it decreases slightly from 0% to 17% ethanol, but falls by ∼45% for E32 and E45. In contrast, the OC component increases from about 0.1 mg/mi to 0.4 mg/mi from E0 to E45.

The low OC fraction is consistent with the small (<5%) nucleation mode mass determined from DMM data. However, this result should not be interpreted too literally. First, pyrolysis during thermal evolution of the OC introduces a bias toward a higher EC/OC ratio. Second, the ∼0.5-mg/mi correction for gaseous HC adsorption by quartz filters is only approximate. Nevertheless, OC constitutes a small fraction of the GDI vehicle PM emissions.

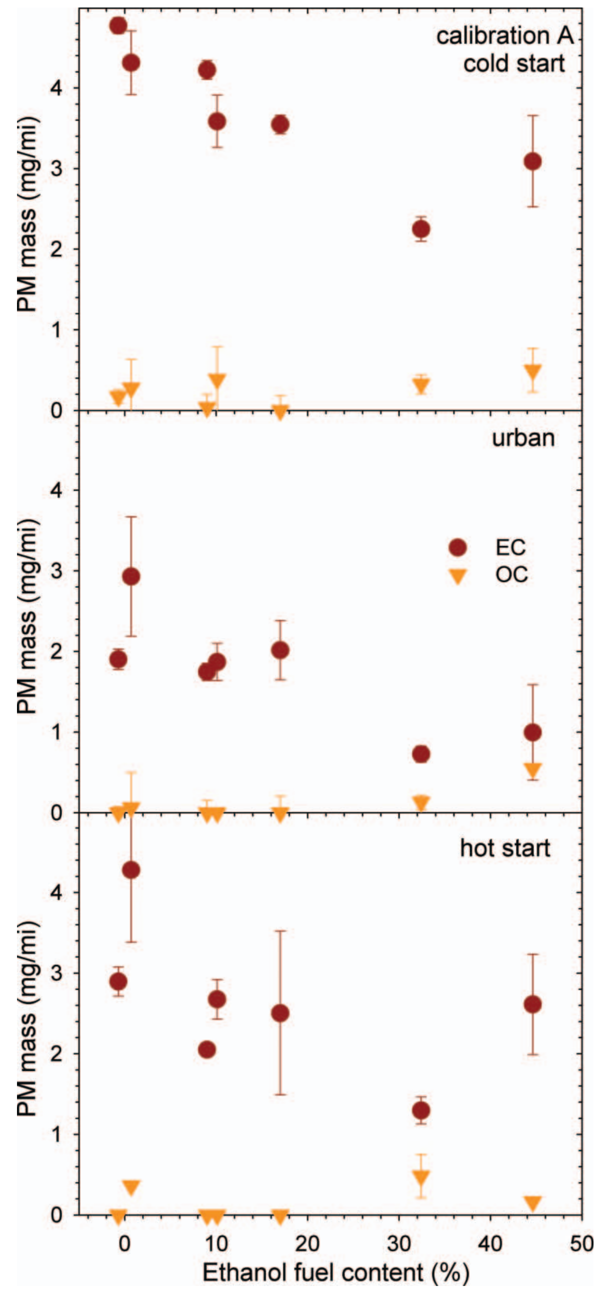

FIG. 6. Elemental carbon/organic carbon PM emissions versus fuel ethanol. (Color figure available online).

DISCUSSION

Overall, the effects of ethanol blends on GDI vehicle PM emissions described above agree with previous work. The data in Storey et al. (2010) show a 30% PM decrease for E20, but as for the present study, this decrease lies within measurement uncertainty. In He et al. (2010), there is likewise no clear distinction between E0 and E10, but they report a statistically significant 20% PM reduction for E20. Interestingly, He et al. (2010) observe bimodal size distributions in their fast mobility particle sizer data, with peaks at 10 nm and 70 nm. The latter value coincides with the ∼70-nm mean accumulation mode mobility diameter depicted in Figure 5. They further report that a three-way catalyst reduces nucleation mode emissions, consistent with the present DMM data, which indicate that this mode contributes little to the total PM mass from the three-way catalyst-equipped test vehicle.

The present study of GDI vehicle exhaust PM reveals interesting features not typically associated with gasoline vehicles:

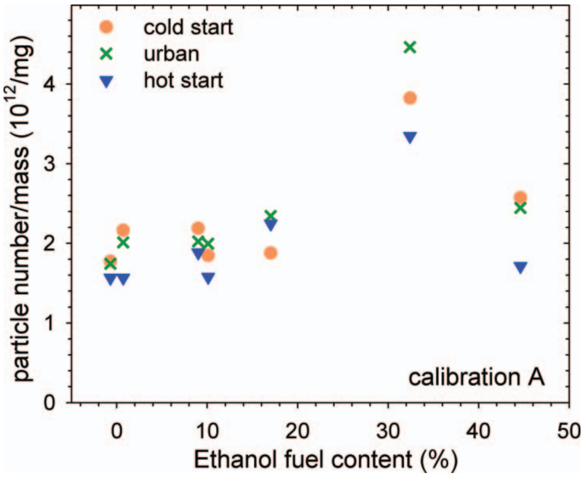

FIG. 7. Particle number to PM mass ratio versus fuel ethanol. (Color figure available online).

(1) a high fraction of elemental carbon and (2) a correlation between particle mass and number emissions. Normally, gasoline vehicle PM is considered primarily organic in nature; for example, EPA's Kansas City Study reports that OC accounts for about 80% of the particulate emissions (U.S. Environmental Protection Agency 2008). The explanation is that tight control of air/fuel stoichiometry allows little chance for sooting conditions to develop and, therefore, the observed PM largely derives from organic combustion byproducts and fugitive low-volatility fuel and lube components. But this reasoning applies to port fuel injection, where the fuel is vaporized at the intake port. Direct injection provides less opportunity for fuel vaporization and increases the likelihood of fuel impingement onto piston and cylinder surfaces, and the resulting combustion of liquid fuel produces soot. HC precursors to organic PM, though, are removed by the three-way catalyst, leaving the tailpipe PM with a high EC/OC content.

Figures 7 and 7S demonstrate the correlation between particle number and mass emissions. The ratio of $\sim 2 \times 10^{12}$ particles/mg for E0–E17 fuels is the same as found for solid particles emissions from both GDI and diesel vehicles (Kirchner et al. 2010; Maricq et al. 2011). Since in the present work, we did not purposefully remove liquid droplets, this similarity indicates that there is virtually no nucleation mode. Apparently, pool fires and liquid droplet combustion in GDI engines produce PM sufficiently similar to the 60- to 80-nm geometric mean mobility diameter soot in diesel exhaust to yield a comparable number to mass correlation (Harris and Maricq 2001). The increase of the ratio toward 4×10^{12} particles/mg in some tests, particularly E32, suggests the possibility of a small nucleation mode.

The high soot content and likely formation by liquid fuel combustion suggest that a comparison of GDI vehicle PM to soot in ethanol–gasoline diffusion flames may be interesting (Maricq 2011). These flames fall into two characteristic groups: (1) open flames, orange in color and emitting soot from their tips, and (2) closed flames, yellow in color with no smoke emitted from the tip. E0 and E20 flames belong to the first group. They exhibit little difference in how soot size and number density develop with height of the flame. E50 is similar, but shows signs of reduced soot formation. In contrast, the E85 flame falls into group 2. In effect, ethanol blend combustion fundamentally follows a similar trend as found in the GDI vehicle emissions, namely a minimal impact on soot up to about E20, but then, larger reductions for high-level blends.

The present study suggests that substantial PM emissions benefits are not expected for low-level ethanol blends; at least not more than the ~0.7-mg/mi measurement uncertainty. But, neither is there a PM disadvantage as the commercial light-duty fuel composition moves to E10, and possibly E20. The specific conclusions from this study might change as GDI engine designs evolve, but the reproducibility of the fuel effects at two different calibrations, plus the similar behavior in flames, suggests a measure of robustness to these conclusions.

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Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 10

Blending In

The Role of Renewable Fuel in Achieving Energy Policy Goals - 2018 Updated Edition

PREPARED FOR

growth energy
America's Ethanol Supporters

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August 17, 2018

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This report was prepared for Growth Energy. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group or its clients.

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Table of Contents

Preface to the 2018 Update

The authors originally produced a version of this report for Growth Energy to submit with the 2017 comments to EPA Docket EPA-HQ-OAR-2017-0091. The primary theme developed in the 2017 version was that the contribution of corn ethanol into the nation's energy supply was consistent with, and contributed to, the Trump Administration's objectives of "Energy Dominance" as primarily measured in terms of overall energy exports. In the course of updating the figures in the 2017 report we found that our findings had not changed; in fact, the additional data supported and confirmed our previous conclusions. As a result, we have issued this revised version that largely repeats the narrative of the original 2017 report, with updated figures and text reflecting the proposed 2019 standards for renewable fuels.

Executive Summary

On July 10, 2018 the U.S. Environmental Protection Agency (EPA) published in the Federal Register the 2019 proposed mandated volumes for all categories of renewable fuels, along with the 2020 biomass-based diesel volume requirements. While EPA did not propose to exercise general waiver authority to limit overall renewable fuel, EPA did solicit comment regarding circumstances that might warrant exercising such authority in the case of some advanced fuels, namely whether there is any evidence that current renewable fuel consumption levels lead to "severe economic harm" that would justify such a waiver (83 FR 32048).

EPA concedes that analyzing whether a severe economic harm would justify using waiver authority is "a difficult and complex issue and one of intense interest to stakeholders." Such an analysis would raise broad issues involving energy markets, along with outcomes related to energy policy, environmental policy, agriculture and trade. Ethanol has been a significant portion of U.S. vehicle fuel consumption for several years. The Energy Policy Act of 2005 established the Renewable Fuel Standard (RFS), which was then expanded by the Energy Independence and Security Act (EISA) of 2007, sometimes called RFS2. The objectives of the EISA are articulated in the preamble to the bill:

> To move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government…

The proposed 2019 standards roughly maintain the current contribution of renewable fuels in the nation's transportation fuel supply. Reviewing the current energy market conditions, as well as agricultural markets and trade aspects, we do not find any economic or policy basis for exercising the general waiver authority. In fact, we conclude that there are significant economic benefits and legitimate policy reasons for maintaining the contribution of ethanol in the U.S. motor vehicle fuel market. Finally, we believe that such a policy is entirely consistent with, and supportive of, the Trump Administration's stated energy policy.

Our primary conclusions are:

- The use of domestically produced ethanol in transportation fuel contributes to energy independence and security and is consistent with the new Administration's energy policy priorities.

- Domestic production of crude oil, petroleum products and renewable fuels has increased across the board over the past decade. The result has been a significant decrease in imports of crude oil while exports of petroleum products have increased.
- The gasoline displaced by ethanol in domestic fuel markets does not appear to reduce U.S. crude production or domestic refinery output. Instead, the surplus gasoline likely is absorbed by the export markets and improves the nation's market share in the world petroleum products market.
- Ethanol currently plays an important diversification and hedging function in motor fuel markets, continuing to moderate prices and helping to shield U.S. consumers from potential world oil price spikes.

- As a domestically produced energy, ethanol is an important source of income and economic development in rural communities in the U.S.

I. Introduction

Ethanol has been a significant portion of U.S. vehicle fuel consumption for several years. The Energy Policy Act of 2005 established the Renewable Fuel Standard (RFS), which was then expanded by the Energy Independence and Security Act (EISA) of 2007, sometimes called RFS2. The objectives of the EISA are articulated in the preamble to the bill:

> To move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government…[1]

On July 10, 2018 the U.S. Environmental Protection Agency (EPA) published in the Federal Register the proposed 2019 mandated volumes for all categories of renewable fuels, along with the proposed 2020 biodiesel requirements. EPA proposed to use the cellulosic waiver authority to reduce the statutory volume requirement for cellulosic-based fuel and to reduce the statutory volume requirements for advanced renewable fuels and total renewable fuel by the same amount. EPA did not propose to use the general waiver authority to further reduce the advanced or total volume requirements, but did ask for comments on the appropriateness of using general waiver authority and whether there was any evidence that current use of renewable fuels imposes "severe economic harm" on the U.S. economy.[2] Analysis of the appropriateness of exercising general waiver authority focuses primarily on domestic renewable fuel supply and economic (or environmental) impacts, which can also raise broad issues involving energy markets and outcomes related to energy policy, environmental policy, agriculture and trade.

This report examines recent trends and conditions in petroleum and renewable fuel markets, including international trade patterns, since the extension of the RFS in 2007. In addition, we comment on how ethanol use meets the objectives of EISA – greater energy independence and security – as well as the new Administration's aim of "American energy dominance." This

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1 Energy Independence and Security Act of 2007, 100th Congress of the United States of America, House Resolution 6 (approved December 19, 2007). Available at: https://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

2 See 83 FR 32,048.

objective was articulated by the President in his June 29, 2017 remarks at the U.S. Department of Energy (DOE):

> We are a top producer of petroleum and the number-one producer of natural gas. We have so much more than we ever thought possible. We are really in the driving seat. And you know what? We don't want to let other countries take away our sovereignty and tell us what to do and how to do it. That's not going to happen. With these incredible resources, my administration will seek not only American energy independence that we've been looking for so long, but American energy dominance.
>
> And we're going to be an exporter – exporter. We will be dominant. We will export American energy all over the world, all around the globe. These energy exports will create countless jobs for our people, and provide true energy security to our friends, partners, and allies all across the globe.
>
> But this full potential can only be realized when government promotes energy development….[3]

The Administration has prioritized the development of domestic energy resources to expand exports and create U.S. jobs under the concept of promoting U.S. "energy dominance." The promotion of ethanol fuel fits right into this paradigm because its use as a transportation fuel in the U.S. frees up domestically produced oil and petroleum products for expanding exports, and because ethanol production, like any domestic energy resource, creates jobs in the U.S.

II. The Effects of Increased Ethanol Production on U.S. Participation in Global Energy Markets

U.S. energy production has risen dramatically in recent years, particularly in the oil and natural gas sectors. The increase in crude oil production has led to reduced imports and expanded exports of both crude oil and refined products. Expanded domestic production contributes to enhanced energy independence and security as traditionally understood, and furthers the Administration's supply-focused and export-oriented energy policy of achieving dominance in global markets. Alongside this increase in domestic petroleum supply, ethanol volumes also increased

[3] The White House Office of the Press Secretary, Remarks by President Trump at the Unleashing American Energy Event, U.S. Department of Energy, Washington, D.C., June 29, 2017. Available at: https://www.whitehouse.gov/the-press-office/2017/06/29/remarks-president-trump-unleashing-american-energy-event

dramatically in the past decade. This naturally raises the question: did the expansion of ethanol contribute to increased energy independence and security, or did increased ethanol somehow offset these trends in the oil industry? To examine this, we look at the expansion of ethanol production under the RFS and the performance of the U.S. oil and petroleum product industry over the past decade.

In this report we examine volume quantities and trends in energy production, consumption and trends since the advent of the RFS, but recognize that many observed changes in volumes reflect complex underlying causes (such as regional supply/demand balances, prices and exogenous shocks) or intricate relationships among various markets. For example, we note that the poor corn harvest of 2012 reduced ethanol volumes (and increased the price); the recession of 2008 caused U.S. domestic gasoline and diesel demand (and refinery output) to fall; and the global crude oil price drop in 2014 caused U.S. crude production to fall temporarily and crude imports to increase slightly from 2014 through 2017. Thus, our conclusions are not the result of simulations or formal comparative analysis but rather they are the result of our observations and judgments regarding the primary drivers of energy product flows and their implications for U.S. energy security, independence, and dominance.

A. Domestic Ethanol Production Grew Significantly

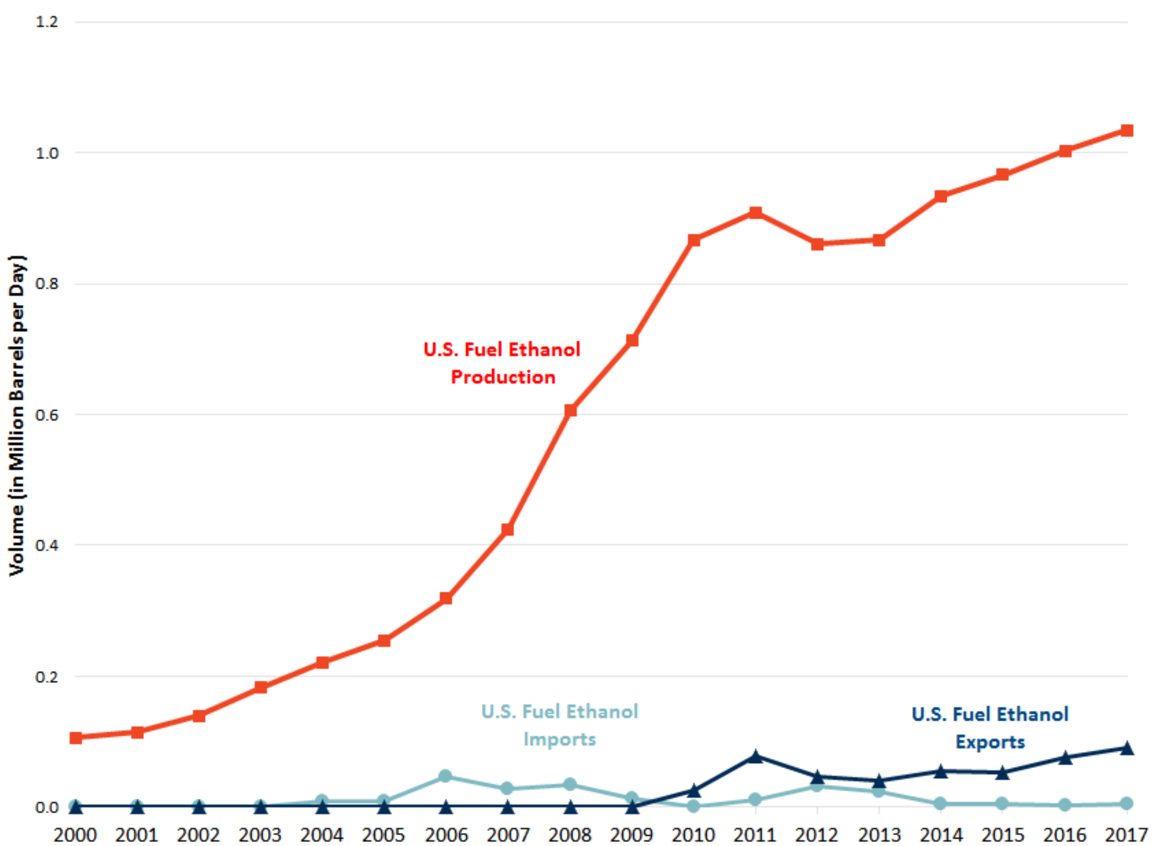
Ethanol production had been modestly expanding prior to the creation of the RFS in the Energy Policy Act of 2005 and the later expansion in the Energy Independence and Security Act (EISA) of 2007. Growth in fuel ethanol production during the early part of the 2000s was fueled by several factors, such as nascent alternative fuel programs, the ban on methyl tertiary butyl ether (MTBE) as an oxygenate, and advances in manufacturing plant technology.

The RFS program requires a certain percentage of renewable fuels to be incorporated into various categories of vehicle fuels sold, including gasoline and diesel. The total renewable volume obligation (RVO) currently implies the consumption of 15 billion gallons per year of non-advanced renewable fuel, most of which is domestically produced corn-based ethanol.[4] Figure 1 below shows the gains in ethanol production, along with imports and exports from 2000 through 2016. Ethanol production accelerated through 2011 and has since grown more steadily over the

4 The proposed volume requirements in 2019 for renewable fuel are 19.88 billion gallons and the advanced biofuel requirement is 4.88 billion gallons. 83 FR 32,025.

past six years. Between the enactment of EISA in 2007 and 2011, U.S. ethanol production more than doubled from about 420,000 barrels per day to about 900,000 barrels per day.[5] Ethanol production fell (and imports rose) due to a poor corn harvest in 2012, but growth resumed and by 2017 ethanol production was over 1 million barrels per day with about 90,000 barrels per day of exports and negligible imports.[6]

Figure 1: U.S. Annual Fuel Ethanol Production, Imports, and Exports, 2000 – 2017



Source: U.S. Energy Information Administration (EIA).

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5 U.S. Energy Information Administration (EIA), Fuel Ethanol Oxygenate Production, https://www.eia.gov/dnav/pet/pet_pnp_oxy_a_epooxe_yop_mbblpd_a.htm.

6 For exports, see: U.S. EIA, U.S. Exports of Crude Oil and Petroleum Products, https://www.eia.gov/dnav/pet/pet_move_exp_dc_NUS-Z00_mbbl_m.htm.
For imports, see: U.S. EIA, U.S. Imports of Crude Oil and Petroleum Products, https://www.eia.gov/dnav/pet/pet_move_imp_dc_NUS-Z00_mbblpd_a.htm.

This increase in ethanol production represents a major expansion of domestic transportation fuel supply assuming that the ethanol fuel in fact was incremental, *i.e.*, did not crowd out some other source of petroleum supply and therefore leave the U.S. energy balances unaffected. As we discuss below, this does not appear to be the case; the increase in U.S. ethanol production largely coincided with both lower imports and greater exports of gasoline and petroleum products as well as crude oil. Thus, ethanol use expanded the overall domestic supply of fuel and enhanced energy independence and security.

B. Domestic Oil Industry Expansion Coincided with Ethanol Growth

Next, we examine the coincident changes in petroleum markets segments, including imports and exports. The intent is to discern how increased volumes of ethanol consumed over the past decade may have affected the supply and disposition of petroleum products for which the ethanol substituted.

1. Refineries Expanded Capacity and Enhanced Utilization

We examine the output and utilization in the U.S. oil refining sector in order to observe any high-level impacts of increased ethanol use on its output or capacity utilization. Refinery utilization has generally trended upward during the period 2009 to 2017, by 2014 returning to pre-recession (2007) levels of approximately 90% and reaching 91% in 2017 as shown on Figure 2 below.[7] (For perspective, the highest level of U.S. refinery capacity utilization since 2000 was about 93% in 2004.) At the same time, refinery capacity increased by over 1.0 million barrels per day. Overall refinery processing production (as measured by volume of inputs, since changing product slates vary in volumetric terms) also rose during this time period, reaching a record level 16.9 million barrels per day in 2017, a particularly impressive performance given the Gulf Coast refinery shutdowns related to Hurricane Harvey. Refinery inputs continue to grow and reached an all-time high of 18.0 million barrels per day for the four-week period ending July 6, 2018.[8] Neither the rising use of ethanol over the past decade, nor other factors influencing domestic

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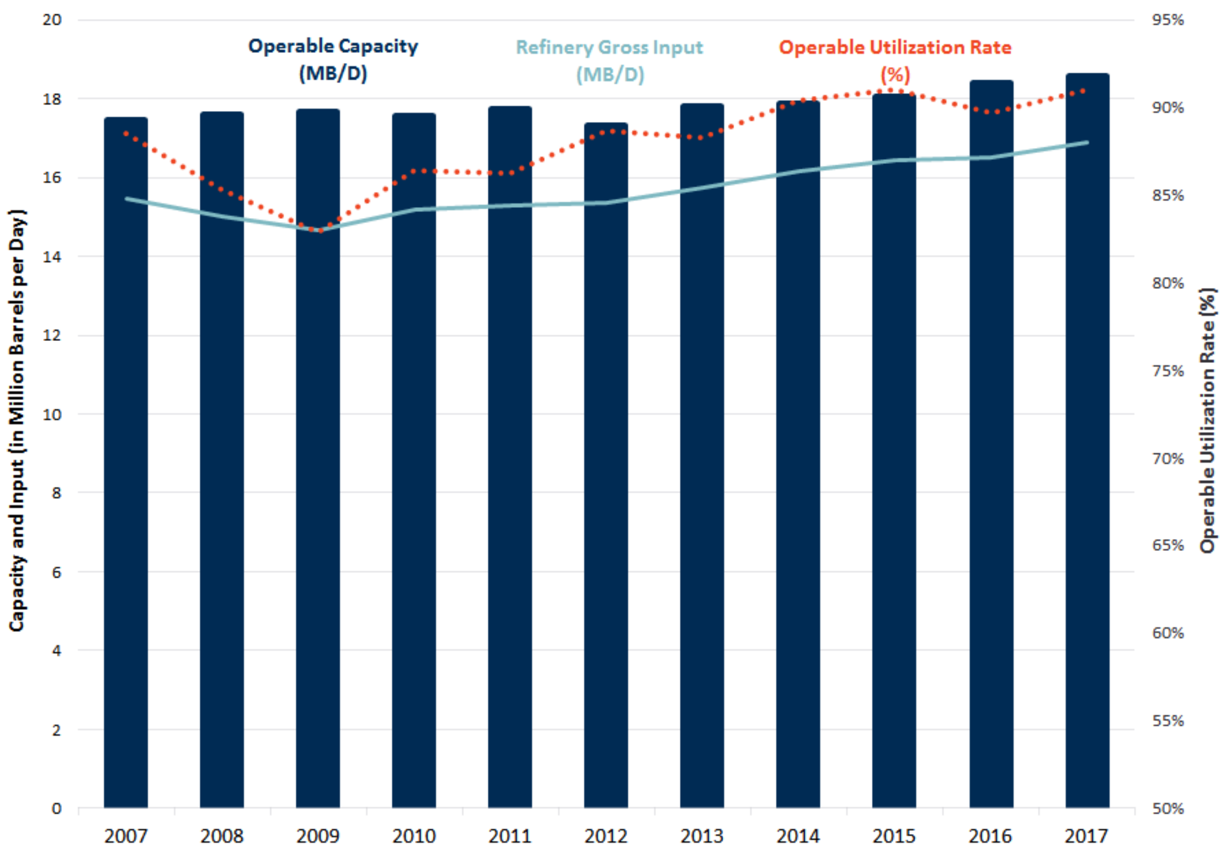
[7] U.S. EIA, U.S. Refinery Utilization and Capacity, https://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_nus_a.htm.

[8] See U.S. EIA, "U.S. refineries running at near-record highs" *Today in Energy, August 13, 2018* at: https://www.eia.gov/todayinenergy/detail.php?id=36872

gasoline demand such as slow economic growth and improved fuel economy, has reduced refining sector production or capacity utilization.

Figure 2: U.S. Crude Oil Refinery Capacity, Input and Utilization, 2007 – 2017



Sources and notes: U.S. EIA. Operable utilization rate is calculated by dividing annual refinery gross inputs by annual refinery operable capacity.

In short, refinery production does not exhibit any decline that might be associated with increased amounts of ethanol blended into gasoline sold in the U.S. Given that nationwide transportation fuel consumption has not increased commensurate with domestic production, the question arises: how is the market achieving equilibrium? Domestic gasoline production is only a small part of the overall petroleum market landscape. U.S. refiners participate in global petroleum products markets, including exporting gasoline, while the U.S. also imports gasoline and other products. The overall picture of U.S. petroleum product markets reflects a host of geographic, economic and technical factors that determine the level and patterns of production, consumption and trade. Product imports arise from the effects of pipeline constraints, cabotage laws (particularly the Jones Act) and locational advantages that create opportunities for refiners in other parts of the world to supply the U.S. For example, a large Canadian refinery in New

Brunswick is a key supplier to the U.S. East Coast, and European refiners also supply products to the U.S. East Coast. The U.S. West Coast is geographically separated from the rest of the country, which sometimes gives refiners in Asia opportunities to ship product to the U.S. West Coast. Meanwhile, refineries on the U.S. Gulf Coast have become large exporters of petroleum products, particularly diesel fuel to Europe, following the upgrade of U.S. Gulf Coast refineries to remove sulfur. And U.S. Gulf Coast refineries also export significant amounts of gasoline, primarily to Canada, Mexico, and South America.

2. Gasoline Exports Grew in Tandem with Increased Ethanol Use

The overall trend in gasoline trade volumes since 2007 is a pronounced reduction in imports and a significant increase in exports. In 2016 the U.S. became a net exporter of gasoline (for the first time since 1961) and net exports expanded further in 2017. This is shown in Figure 3.

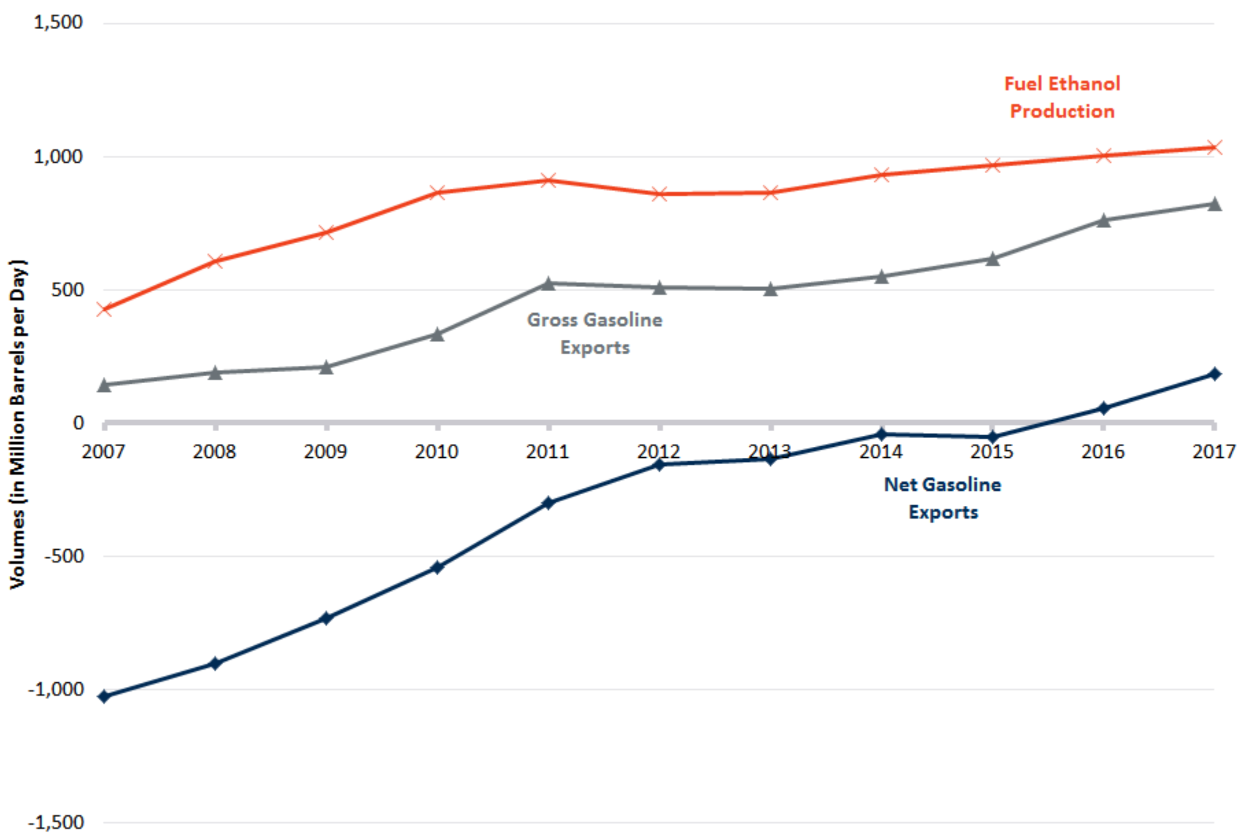
Figure 3: U.S. Imports and Exports of Gasoline, 2007 – 2017

Source and notes: U.S. EIA. Gasoline import and export volumes include volumes for both finished motor gasoline and motor gasoline blending components.

When compared with Figure 1, which showed the growth in U.S. ethanol production volumes, Figure 3 suggests that any gasoline displaced by ethanol use either helped reduce imports or was exported outside the U.S (or both). Between 2007 and 2011, ethanol production increased by about 500,000 barrels per day, while exports grew by about 300,000 barrels per day and imports fell by about 400,000 barrels per day. We believe that this comparison is consistent with the view that domestic ethanol production augmented total U.S. transportation fuel supply, and that the domestically produced gasoline that otherwise would have been sold to U.S. motorists instead was either sold abroad or reduced gasoline imports (or both).

Figure 4 summarizes the relationship between U.S. ethanol production and U.S. gross and net exports of gasoline. It suggests that the rise in U.S. gasoline exports is related to increased U.S. ethanol production. This is consistent with the observation that U.S. refinery capacity and output has increased even while domestic ethanol consumption rose and the percentage blended into the vehicle fuel market increased. Thus, the increased contribution of domestically produced ethanol to the retail gasoline supply has not reduced U.S. refinery output, but rather stimulated U.S. gasoline exports, consistent with the objectives of the energy dominance paradigm. In fact, Figure 4 implies that absent the contribution of domestically produced ethanol in the transportation fuel market, the U.S. would remain a net importer of gasoline.

Figure 4: U.S. Fuel Ethanol Production and Exports of Gasoline, 2007 – 2017

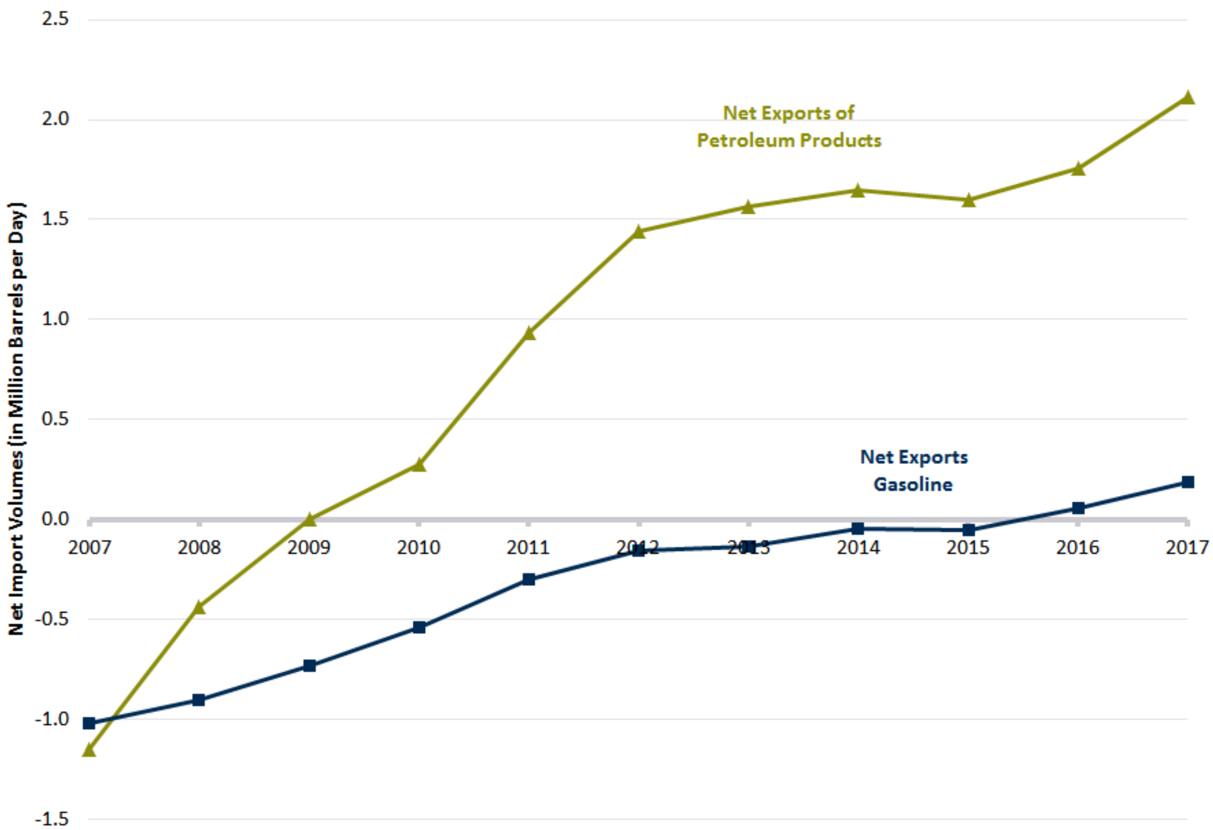


Sources and notes: U.S. EIA. Gasoline import and export volumes include volumes for both finished motor gasoline and motor gasoline blending components.

3. Exports of Petroleum Products Grew

The improved trade balance in energy was not confined to gasoline as the U.S. became a significant net exporter of petroleum products during this time. Figure 5 shows the net exports (exports minus imports) for gasoline and petroleum products between 2007 and 2017. This figure shows that net exports of gasoline rose by over one million barrels per day between 2007 and 2017, while net exports of petroleum products increased by over three million barrels per day during the same period. Again, increased ethanol production and consumption occurred during a significant expansion of U.S. gasoline and other petroleum product supplies.

Figure 5: U.S. Net Exports of Gasoline and Petroleum Products, 2007 – 2017

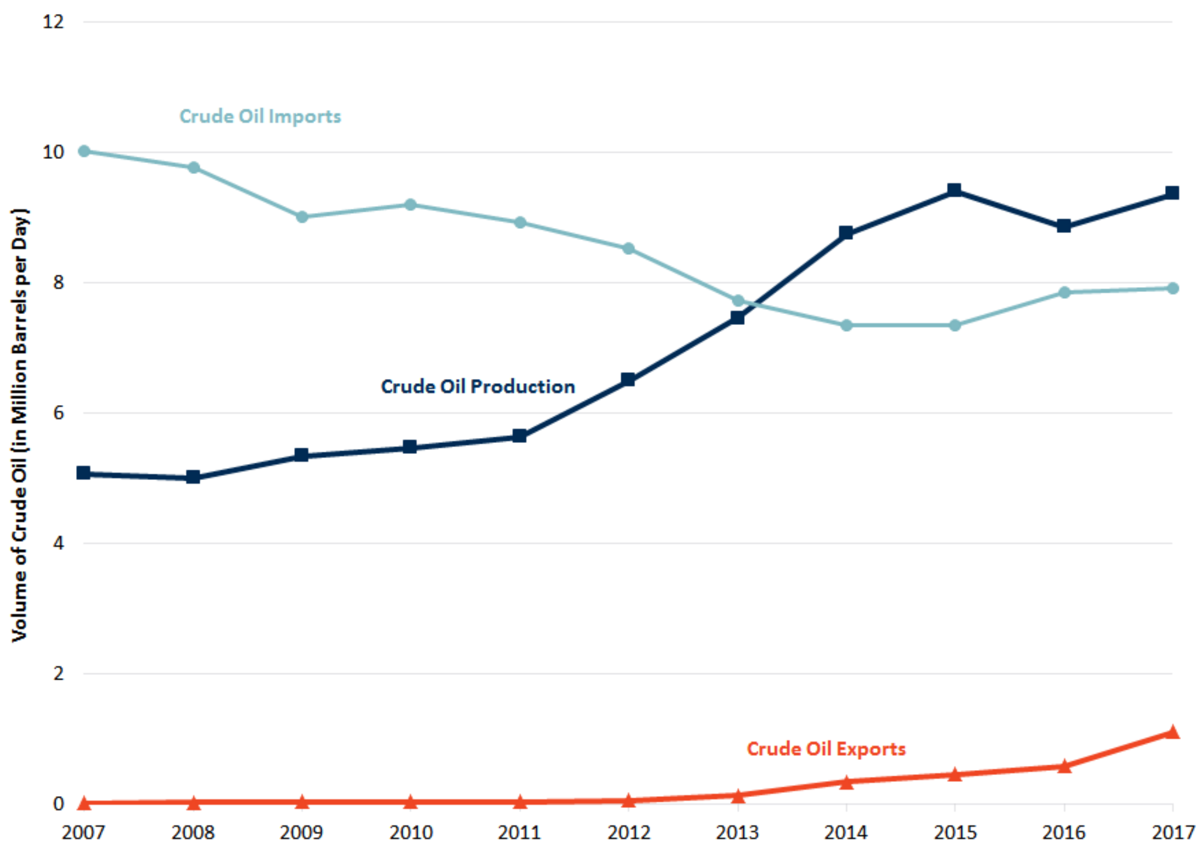


Sources and notes: U.S. EIA. Gasoline volumes include volumes for both finished motor gasoline and motor gasoline blending components. Petroleum product volumes include volumes for both finished petroleum products and motor gasoline blending components.

4. U.S. Crude Oil Production and Exports Expanded

Ethanol use increased even while U.S. refinery capacity and output rose, and net exports of gasoline and petroleum products increased. These favorable supply conditions also extended upstream into crude oil markets, where expanded ethanol use did not dampen the dramatic increase in domestic crude production. The past decade has seen the transformation of the U.S. natural gas and petroleum extraction industry, primarily due to advances in technology such as hydraulic fracturing ("fracking") and horizontal drilling. By 2014, domestic crude oil production exceeded crude oil imports on a sustained basis – a relationship that had not occurred since 1993 – and modest amounts of crude oil exports had begun to flow as well, as shown in Figure 6. The increased production of U.S. crude oil has also enhanced energy independence and security.

Figure 6: U.S. Crude Oil Production, Import, and Export Volumes, 2007 – 2017



Source: U.S. EIA.

The remarkable resurgence of U.S. crude oil production can be seen in the increase from roughly 5 million barrels per day in 2007 to about 9.4 million barrels per day in 2017, as shown on Figure 6 above.[9] The aggregate figures of production, imports and exports arise from the complex interplay of geography (affecting, *e.g.*, the types of oil produced and cost of available transport modes), regulatory constraints (*e.g.*, Jones Act), regional refinery configurations, and markets. Much of the increased production is light sweet crude from the Permian Basin the Bakken and Eagle Ford shale plays, which is not well suited to refineries in the Midwest or U.S. Gulf Coast because they have been configured to process heavier Canadian and Venezuelan crude. Thus, some of the increased production of light sweet crude oil from Texas and North Dakota travels to

[9] U.S. EIA, U.S. Field Production of Crude Oil, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpus1&f=a.

the U.S. Gulf Coast for export or is exported to Canada. The removal of the ban on exporting crude oil has led to an increase in exports, primarily to Asian and European buyers. Exports in 2017 nearly doubled from the 2016 level, reaching 1.12 one million barrels per day of crude oil. Despite the dramatic gains in production, the U.S. continues to import a significant but declining amount of crude oil. Crude imports fell from about 10 million barrels per day in 2007 to about 7.3 million barrels per day in 2014, then rising slowly and levelling off at slightly less than 8 million barrels per day in 2017.[10] The refining industry in the U.S. generally prefers to process heavy sour crude oil of the type produced in Canada, Venezuela, or Mexico. Thus, the continuing volume of imports reflects in part the demand for sour crude by U.S. Gulf Coast refiners and in part regulatory, logistic and geographical constraints which force West Coast refiners to source a significant portion of their crude supplies from foreign sources rather than the United States.

In summary, the resurgence of a dominant oil and petroleum product industry occurred during a period when ethanol use in transportation fuels increased. Rather than leading to a reduction in domestic refinery utilization, gasoline production or crude oil output, domestically produced ethanol instead augmented domestic energy supplies and thus enabled the expansion of energy exports.

III. The Effects of Increased Ethanol Production on U.S. Agriculture and Economic Development

The increased volumes of ethanol produced in the U.S. represent the development and maturation of an energy industry based on a domestically grown resource. This industry provides a significant and steady source of income and jobs to the middle portion of the country that is dependent on sometimes variable and uncertain farm income.

A. Effect of Ethanol Demand on Corn Production

The increased demand for corn-based ethanol has significantly increased production of grain corn and increased energy-related jobs in the U.S. Figure 7 below shows total U.S. corn grain

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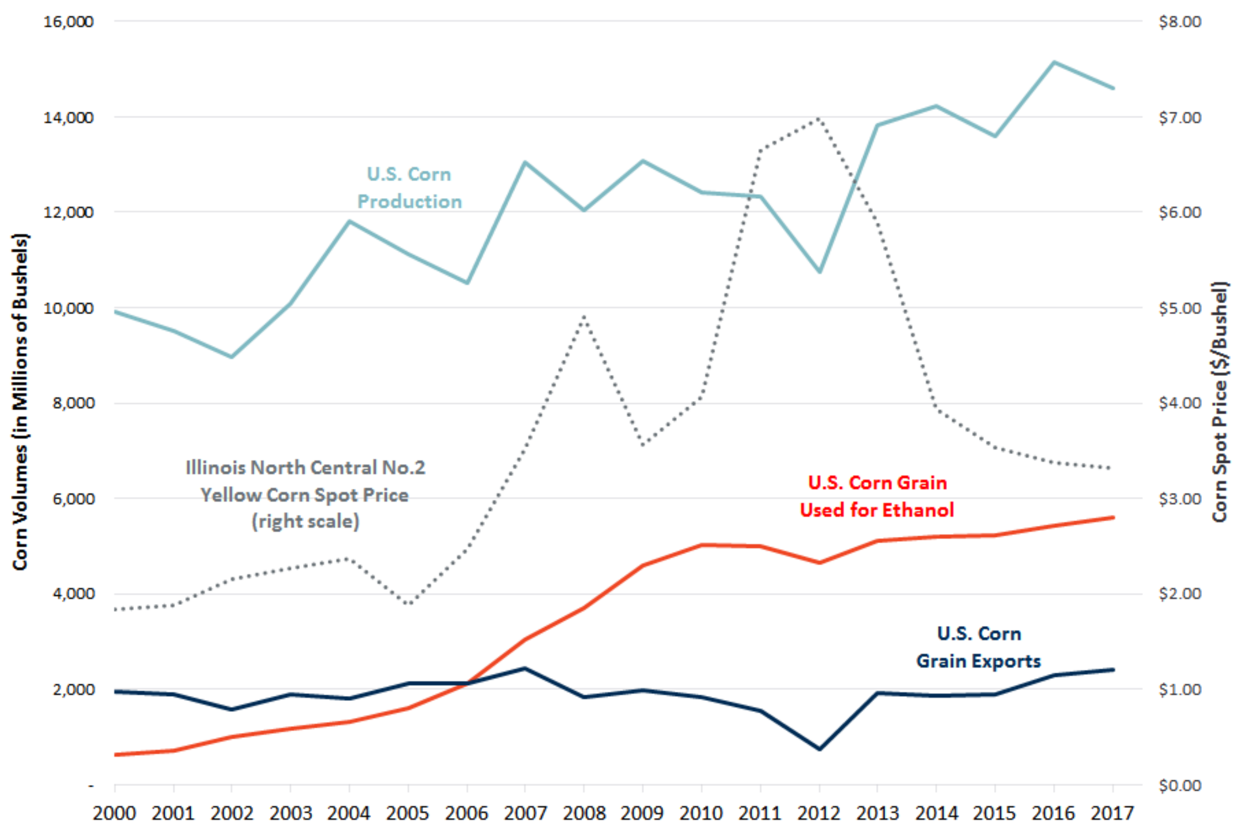
10 U.S. EIA, U.S. Imports of Crude Oil, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRIMUS2&f=A, July 31, 2017.

production and sources of demand since 2000.[11] This figure demonstrates several important points. First, between the early 2000s (2000 – 2002) and the three most recently reported years (2015 – 2017), the 3-year average annual U.S. annual corn grain production increased by nearly 5,000 million bushels, primarily due to increased ethanol-related demand. In fact, ethanol demand represented 93% of the increase in corn production during this period. Second, in 2017, ethanol production used about 38% of total U.S. corn production, which was about 46% of the domestic consumption of U.S. corn (production minus exports).

Figure 7: U.S. Corn Grain Production, Use, and Prices, 2000 – 2017



Sources: USDA Economic Research Service (ERS) and Bloomberg

Increased demand for corn production has not resulted in reduced corn exports. During the period in which corn production increased due to ethanol demand U.S. corn exports remained

11 U.S. DOE, U.S. Total Corn Production and Corn Used for Fuel Ethanol Production, Alternative Fuels Data Center, https://www.afdc.energy.gov/data/.

fairly steady around 2,000 million bushels per year (except for the poor harvest year of 2012), and have risen slightly in the past two years.[12] In other words, U.S. corn production has increased to meet rising U.S. corn demand from expanded ethanol production.

The figure above also highlights the importance of increased corn production to sustaining farm incomes and employment during a period of reduced corn prices. Corn prices rose from about $2/bushel in 2005 and reached $7/bushel as a result of the poor harvest of 2012, but have since reverted to $3.32/bushel in 2017.[13] While the recently lower corn prices have raised concerns for corn producers, a recent article from the Iowa State University Center for Agricultural and Rural Development (CARD) notes that the income accumulation by corn producers since the late 2000s fueled by the expanding renewable fuel market "puts agricultural producers and businesses [in] a much better condition now to weather storms."[14] Corn used for ethanol production in 2017 accounted for about $18.6 billion in income for corn growers.[15]

B. Effect of Ethanol Production on Rural Economies

Producing ethanol fuel from corn provides additional employment and income benefits to corn-producing regions in the U.S. Figure 8 below shows that over 90 percent of ethanol production occurs in the Midwest and is distributed throughout the U.S. but primarily to satisfy demand along the coasts. In addition, ethanol producers export to ethanol fuel to Canada from the Midwest and to other international markets from the U.S. Gulf Coast.

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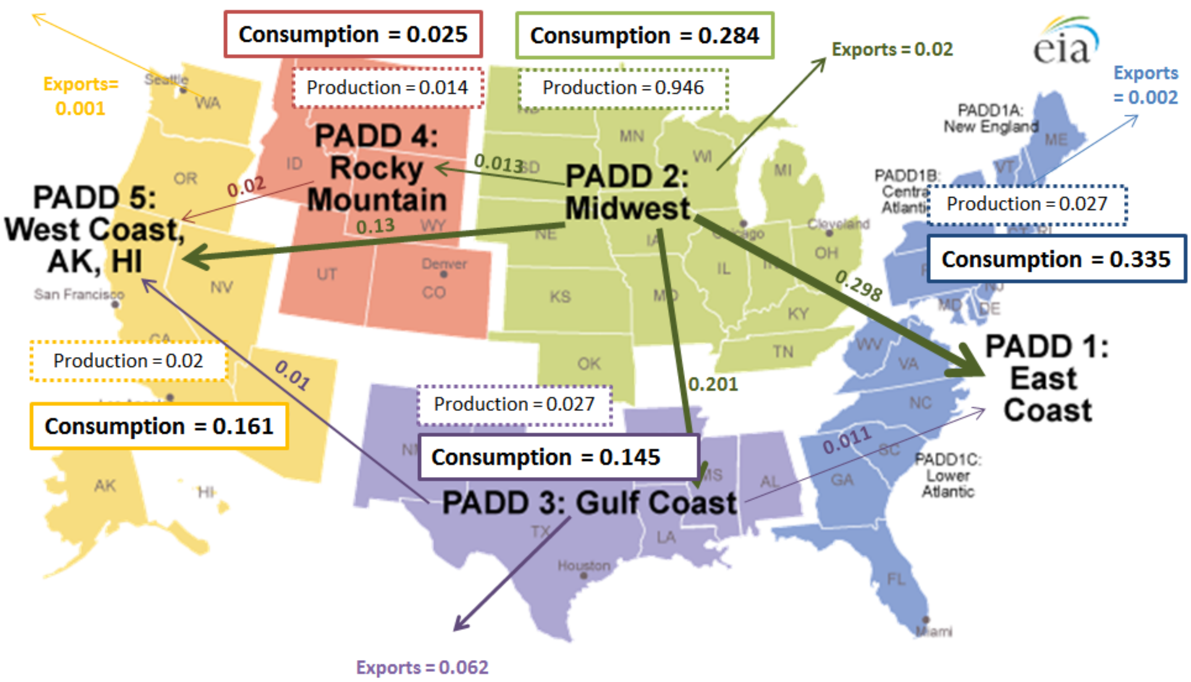
12 For production and exports, see: U.S. Department of Agriculture (USDA) Economic Research Service, Feed Grains Database, https://www.ers.usda.gov/data-products/feed-grains-database/.

13 We used the Illinois North Central No. 2 Yellow Corn spot prices listed in Bloomberg as a representative corn price.

14 Wendong Zhang, "Four Reasons Why We Aren't Likely to See a Replay of the 1980s Farm Crisis," *Agricultural Policy Review*, ISU CARD, Spring 2017.

15 The Department of Agriculture reports that 5,600 million bushels of corn were used for ethanol in 2017, as shown in Figure 7 above. We calculated the income for corn growers by multiplying this quantity by the average Illinois North Central No. 2 Yellow Corn spot price in 2017 of $3.32/bushel.

Figure 8: Regional Fuel Ethanol Production, Consumption, and Trade, 2017 (Million Barrels per Day)



Sources and notes: U.S. EIA. Consumption is calculated by adding net imports and net movement between regions to production.

According to the 2018 U.S. Energy and Employment Report, the biofuels industry currently employs nearly 105,000 workers, with about 34,500 of those jobs in the corn ethanol fuels sector, as shown in Figure 9 below. About 72% of corn ethanol employment is in agriculture or wholesale trade sectors.[16]

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16 *U.S. Energy and Employment Report*, May 2018, p. 59. The U.S. DOE formerly produced this report, which now has been undertaken by a partnership between the National Association of State Energy Officials (NASEO) and Energy Futures Initiative. Available at: https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5afb0ce4575d1f3cdf9ebe36/1526402279839/2018+U.S.+Energy+and+Employment+Report.pdf

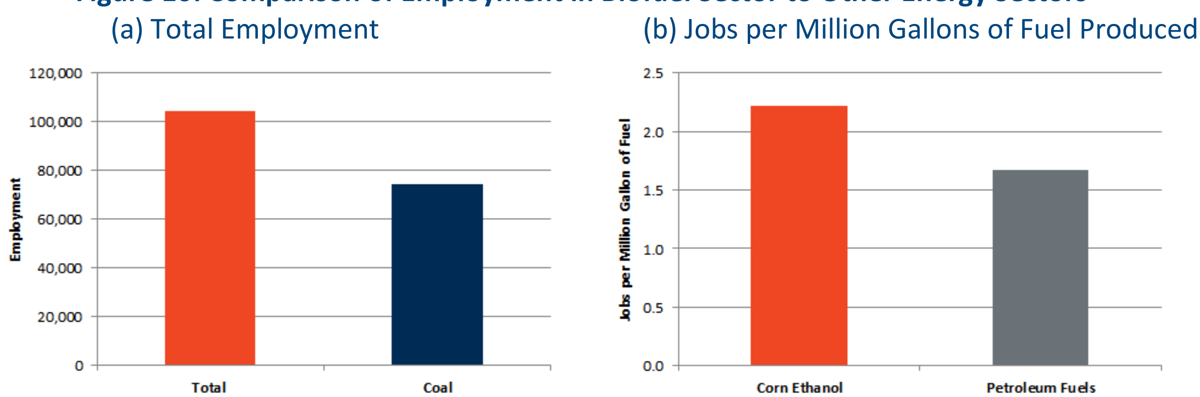
Figure 9: Biofuel Employment Statistics

Sector	Jobs
Corn Ethanol	34,522
Cellulosic Biofuels	31,428
Biodiesel	20,083
Other Biofuels	18,414
Total	**104,447**

Source: U.S. Energy Employment Report (Energy Futures Initiative).

To put these employment figures into perspective, we compare biofuel-related employment to the levels of employment in the coal and petroleum fuels sectors. First, Figure 10a shows that the total U.S. employment related to biofuels (over 104,000 jobs) is about two-thirds as large as coal-related jobs, including both coal mining and coal-fired electricity generation. Second, while total employment related to petroleum fuels is significantly larger due to the relative scale of production, Figure 10b shows that the average employment per million gallons of fuel produced is slightly higher for corn ethanol (2.2 jobs per million gallons of fuel) than petroleum fuels (1.7).

Figure 10: Comparison of Employment in Biofuel Sector to Other Energy Sectors



Source: U.S. Energy Employment Report (Energy Futures Initiative).

Two U.S. Department of Agriculture (USDA) studies highlight the importance of ethanol production to rural income and employment.

- A 2012 USDA report examined ethanol fuel plants as a case study for enhancing rural income and wealth found that an additional ethanol plant producing 100 million gallons per year would generate $203 million in annual sales, employ 39 full-time equivalent workers, and pay $2.4 million in annual wages.[17] The report found that indirect effects were harder to quantify, but the study cited findings that an average ethanol plant induces 65 to 211 jobs and economic output of $8 million to $33 million, while increasing local corn prices about $0.12/bushel.

- A 2013 USDA study found that ethanol demand has driven 32% of the total change in employment in regions with new ethanol facilities over the proceeding eight-year period. At the time, the authors estimated that ethanol had created more jobs than investments in windpower and that ethanol plants had a larger impact on county-level employment. They also estimated that each ethanol job resulted in 2.6 to 3.2 additional indirect jobs.[18]

A more recent study concluded that full implementation of the RFS2 standards would be costly due to biodiesel being the marginal fuel to achieve the Advanced Renewable Fuel requirement.[19] However, the same analysis determined that an increase in corn-based ethanol production beyond 15 billion gallons per year would provide a net welfare gain for the U.S. of $2.6 billion per year due to increased corn prices and reduced crude oil prices.

Ethanol is supplied by a growing U.S. energy industry that provides income and employment for U.S. workers and supports the exports of ethanol and petroleum products. It will continue to contribute to energy independence, security and dominance provided that the federal government provides a supportive policy framework.

IV. Conclusion: The Effects of Increased Ethanol Production on U.S. Energy Independence, Security, and Dominance

Over the past decade, U.S. domestic crude oil, petroleum products, and ethanol supply expanded. These gains in domestic supply improved trade balances and the U.S. is now a net exporter of petroleum products (including gasoline and diesel) and ethanol. Based on our analysis above, we conclude that the increase in domestic ethanol production and use has helped reduce energy

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17 John Pender, *et al.*, Rural Wealth Creation: Concepts, Strategies, and Measures, Economic Research Report No. 131, March 2012, p. 12.

18 Jason Brown, *et al.*, Emerging Energy Industries and Rural Growth, Economic Research Report No. 159, November 2013.

19 GianCarlo Moschini, *et al.*, The Renewable Fuel Standard in Competitive Equilibrium: Market and Welfare Effects, 17-WP-575, http://www.card.iastate.edu/products/publications/pdf/17wp575.pdf, June 2017.

imports and/or increase energy exports, has strengthened U.S. energy independence and security, and aligns with the concept of energy dominance.

Energy independence has long been a topic of discussion for energy and national security analysts, and there is widespread agreement that actual energy independence is a limited, and not altogether desirable or even achievable, objective. For example, a country that becomes a net exporter, or even only exports a commodity or refined product, does not experience "independence" since domestic economic activity still depends on global market demand and prices for that good. As a large crude oil importer and exporter, the United States remains tied to the world oil price. Domestic crude and product prices will rise or fall as global market conditions dictate, including shifts in U.S. commodity futures markets that translate directly to movements in the price of crude, gasoline, and diesel. Since retail prices closely follow futures prices, disruptions in supply any place in the world will directly affect prices paid by U.S. consumers. Regardless of the merits of the objective of energy independence, the trends in U.S. domestic production of ethanol have contributed to a decreased reliance on imported crude oil and petroleum products and brought domestic production more closely in line with domestic consumption.

However, the concept of **energy security** is more tangible and depends largely on a country's ability to withstand and adapt to sudden shocks in energy prices or in extreme cases, physical availability. Energy markets have changed dramatically since the enactment of EISA in 2007, and any assessment of the performance of the RFS in meeting its objective of increasing energy security must account for those changes. The effects of ethanol use are different today from those anticipated in the previous era, which was characterized by tight global crude oil and petroleum product markets. In a report issued in January 2014, Verleger found that the increased volumes of ethanol supplied between 2007 and 2013 had the effect of removing a significant slice of the demand for petroleum product from the very tight global markets that prevailed during that time.[20] In that market, ethanol use had an outsized impact on moderating the world crude oil price along the steep global supply curve.

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20 Philip K. Verleger, Jr., The Renewable Fuel Standard: How Markets Knock Down Walls, January 2014.

Between 2014 and 2016, crude prices fell dramatically from over $100/barrel to less than $50/barrel because of a combination of U.S. production gains and OPEC (primarily Saudi) decisions to attempt to defend market shares.[21] As a result, the price-moderating effect of U.S. ethanol use in current petroleum markets estimated by Verleger in 2014 had fallen as the global supply curve was pushed out and become less steep. In the past year, however, crude prices have climbed to over $75/barrel as a result of the OPEC production agreement reached in late 2016, along with geopolitical uncertainties that arose in various supply regions in the Middle East and Venezuela. There are additional pressures arising from looming requirements for low-sulfur fuel oil for oceangoing vessels instituted by the International Maritime Organization (IMO), which could alter refinery slates and constrict global fuel supplies.[22] In such an environment, the role of U.S. domestic ethanol to dampen world oil price impacts rise in importance again.

In addition to the price moderation impact, the other primary effect of increased ethanol use over the past decade has been to augment overall domestic energy supply and thus support increased petroleum product exports. This market outcome aligns both with energy security considerations and the emerging paradigm of energy dominance.

Ethanol contributes directly to energy security by enhancing the resilience of U.S. energy markets, and reducing the adverse economic effects of oil price shocks that will continue to occur periodically. Blending more renewable fuels with petroleum "stretches" the available petroleum supply, and in periods of significant petroleum price shocks, the retail gasoline price impact is moderated in proportion to the ethanol content (assuming the ethanol price remains constant). Increasing the RVO increases the flexibility of the distribution system if more stations carry higher ethanol blends (*i.e.*, E15 and E85). When more consumers have access to higher ethanol blends and can take advantage of relative prices between E10 and E15 or E85 they can adjust to petroleum price shocks by purchasing more E15 or E85, helping to counteract the petroleum price spike by lowering petroleum fuel demand.[23] Such flexibility can allow more

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21 U.S. EIA, Europe Brent Spot Price FOB, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=M.

22 See Philip K. Verleger, Jr., "$200 Crude, the Economic Crisis of 2020, and Policies to Prevent Catastrophe" *Petroleum Economics Monthly,* Volume XXXV, April/May 2018.

23 See Marc Chupka, *et al.*, Peeking Over the Blendwall: An Analysis of the Proposed 2017 Renewable Volume Obligations, July 11, 2016. Available at:

Continued on next page

renewable fuels to be used when market conditions dictate and lesser amounts (constrained by the RVO level) when ethanol trades at a premium to gasoline. In this way, the renewable fuels program provides a needed counterbalance to the increased integration of the U.S. petroleum industry in the world market.

Finally, the new Administration has promoted a concept of **"energy dominance"** that involves expanding the domestic supply of coal, oil and natural gas to promote energy exports in order to maintain high domestic energy production levels and thereby increase domestic economic activity and jobs. Maximization of domestic income and jobs from energy production and export also implies a preference for exporting domestic value-added products (and the additional income and employment) that arise from exporting refined or manufactured goods rather than exporting raw commodities. In this regard, the introduction of an additional 600,000 barrels per day of domestically produced ethanol into the U.S. vehicle fuel supply since 2007 augmented overall U.S. product supply, which enabled high-value product exports to expand. In aiming to achieve energy dominance, ethanol should be considered as an equally valid domestic energy producing sector, capable of expansion and supporting these current energy policy objectives directly (via ethanol exports) and indirectly (via increased petroleum product exports), while generating income and employment on par with other energy industries.

Ethanol production and exports rose substantially over the past decade. This corn-based energy source is based on domestically supplied raw material, which is processed into a vehicle fuel component in the U.S. and then distributed across the country for consumption, with some volumes destined for export. Along the way ethanol production transformed the corn-producing regions of the country into a significant energy supply resource. This provides a significant source of energy jobs and income in the rural areas of the U.S. and helps diversify the market for corn production. As a growing domestic energy industry, ethanol production resembles the economic profile of the traditional oil and gas sectors that the current Administration supports in pursuit of its agenda of "American energy dominance."

Continued from previous page

http://www.brattle.com/system/publications/pdfs/000/005/341/original/Peeking_Over_the_Blendwall_-_An_Analysis_of_the_Proposed_2017_Renewable_Volume_Obligations.pdf?1468609273

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Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 11

Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2019 and Biomass-Based Diesel Volume for 2020

Docket # EPA-HQ-OAR-2018-0167

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August 17, 2018

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I. Introduction and Executive Summary

Growth Energy respectfully submits these comments on the Environmental Protection Agency's proposed rule entitled "Renewable Fuel Standard Program: Standards for 2019 and Biomass-Based Diesel Volume for 2020."[1] Growth Energy is the leading association of ethanol producers in the country, with 100 producer members and 82 associate members who serve the nation's need for renewable fuel. Growth Energy has submitted comments on EPA's prior major rulemakings implementing the Renewable Fuel Standard ("RFS") program. For the reasons explained below, Growth Energy urges EPA to: (1) maintain an implied non-advanced volume of at least 15 billion; (2) change its approach to small refinery exemptions to deny extensions to refineries that have not been continuously exempt, to make up for all exempt volumes, and to bring more transparency to the RIN market; (3) revise its method for projecting liquid cellulosic biofuel volume for 2019; (4) remove regulatory barriers to expanded use of E15; (5) continue to decline to issue a general waiver of the total volume requirement based on severe harm to the economy; and (6) promptly remedy the vacated general waiver of the 2016 total volume requirement.

To date, the RFS program has been an overwhelming success. In 2007, Congress expanded the RFS program "to increase the production of clean renewable fuels" and "[t]o move the United States toward greater energy independence and security."[2] Over the ensuing decade, the program has done that, beyond what Congress even expected. Conventional renewable fuel—which has grown dramatically under the RFS program and which is by far the most prevalent renewable fuel—substantially reduces GHG emissions relative to fossil fuel. In fact, it does so far more than Congress originally expected and nearly as much as advanced biofuel. When Congress revised the RFS program in 2007, it expected conventional renewable fuel to reduce GHG emissions by 20% relative to fossil fuel.[3] According to the U.S. Department of Agriculture, however, conventional renewable fuel currently reduces GHG emissions by 43%—nearly the 50% reduction needed to qualify as advanced biofuel.[4] By increasing the use of conventional ethanol, the RFS program has therefore facilitated use of even cleaner fuel than Congress had conceived when it created the program. And as detailed below, the growth in conventional renewable fuel has also increased the country's energy independence and security by reducing our dependence on foreign oil and diversifying our energy sources, while creating American jobs, revitalizing rural economies, and introducing much-needed competition into a monopolized vehicle-fuels market. Consequently, EPA should certainly not reduce the implied non-advanced volume below 15 billion.

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[1] *Renewable Fuel Standard Program: Standards for 2019 and Biomass-Based Diesel Volume for 2020*, 83 Fed. Reg. 32,024 (proposed July 10, 2018) ("NPRM").

[2] Energy Independence and Security Act of 2007, Pub. L. No. 110-140, preamble, 121 Stat. 1492, 1492 (Dec. 19, 2007).

[3] 42 U.S.C. § 7545(*o*)(2)(A)(i).

[4] *Compare* ICF, *A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol*, at 152 (Jan. 12, 2017), *with* 42 U.S.C. § 7545(*o*)(1)(B)(i).

Beyond that, however, EPA should adjust its proposal in several important respects. Foremost, EPA should revamp its handling of small refinery exemptions in several ways. First, EPA should cease granting petitions to "extend" exemptions to small refineries that have not been exempt in every prior compliance year. EPA's contrary practice is plainly foreclosed by the statute; once a refinery's exemption lapses, there is nothing to "extend" in the future.

Second, EPA should adjust volume requirements upward to fully account for extensions of small refinery exemptions granted after the volume requirements for the covered year were finalized. EPA reports that, because of such retroactive extensions, obligated parties have been relieved of the obligation to submit 2.25 billion RINs for 2016 and 2017. EPA's current policy—doing nothing to make up those volumes—violates its fundamental statutory duty to "ensure" through this rulemaking that the volume obligations are met. Doing nothing actually ensures the required volumes are *not* met, which jeopardizes the RFS program's efficacy, particularly when EPA grants extensions on a massive scale. Instead, EPA can and should, when finalizing RVOs for a given compliance year, raise the required volumes by (i) the projected volume of retroactive extensions for the upcoming year and (ii) the actual volume of any (unaccounted-for) retroactive extensions granted in prior years.

Third, EPA should mitigate the adverse effects of extending small refinery exemptions on the predictability and transparency of the RIN market. Not granting extensions to ineligible refineries, and adjusting volume requirements to fully make up for retroactive extensions, are good places to start. EPA should also stop issuing new RINs to refineries whose extension petitions are determined to have been denied erroneously, as well as systematically disregarding the Department of Energy's recommendations regarding extension petitions. Finally, EPA should conduct the exemption process in public view rather than in secret. EPA's exemption decision documents, as well as much information submitted by refineries that is integral to evaluating their extension petitions, may not be withheld under the Freedom of Information Act—as EPA itself concluded in 2016.

EPA should also revise its method for projecting the liquid cellulosic biofuel production for 2019. By setting projections based on past production, EPA incorrectly assumes that the industry's past determines its future. By failing to account for the fact that the industry is still in its early stages and likely to achieve rapid growth soon, EPA is systematically and impermissibly tilting its projections against growth instead of taking "'neutral aim at accuracy.'"[5] Using an average of the industry's production over the past two or three years does not remedy this problem. EPA should base its projections on a plant-by-plant evaluation of all relevant factors and should treat as a separate group facilities with proven technology for producing cellulosic ethanol from corn kernel fiber.

EPA should remove regulatory barriers to expanded use of E15. Consumers could use far more E15 than they currently do. More than 90% of vehicles on the road today can safely use E15, and the infrastructure to deliver it could be expanded quickly given the right RFS incentives. EPA could help unlock the potential for E15 growth by extending the 1psi Reid Vapor Pressure waiver to E15, recognizing that under the Clean Air Act, E15 is "substantially

[5] *Americans for Clean Energy v. EPA*, 864 F.3d 691, 727 (D.C. Cir. 2017) (quoting *American Petroleum Institute v. EPA*, 706 F.3d 474, 476 (D.C. Cir. 2013)).

similar" to certification fuels in all material respects, and finalizing its Guidance for E85 Flexible Fuel Vehicle Weighting Factor for Model Years 2016-2019 Vehicles Under the Light-Duty Greenhouse Gas Emissions Program (and in doing so revise the proposed treatment of E15).

Growth Energy appreciates that EPA has proposed to maintain an implied non-advanced volume of 15 billion rather than reduce it through a general waiver due to severe economic harm. EPA's longstanding interpretation of this general waiver provision is correct, and there is no evidence that adherence to the proposed volume requirements would cause widespread severe economic harm—indeed, the industry has been subject to the same 15-billion implied non-advanced requirement for several years and no severe economic harm has occurred. And the industry could actually achieve markedly higher volumes with the right RFS incentives. EPA should also be mindful that any risk of severe economic harm is eliminated by the availability of various compliance flexibilities, including the RIN bank, and that it could not exercise such a waiver without first accounting for the many significant benefits accruing because of the growth in renewable fuel use spurred by the RFS volume requirements.

Finally, EPA should immediately address the D.C. Circuit's vacatur of EPA's general waiver of the 2016 total volume requirement. That judicial decision was issued more than one year ago, and EPA has no justification for continued delay, particularly given the annual nature of RFS RVO-setting. EPA could easily remedy the vacatur by adding the 500 million RINs covered by the vacated general waiver to the total 2019 volume requirement it would otherwise impose.

II. THE ADMINISTRATION'S ENERGY POLICY OBJECTIVES ARE PROMOTED BY AT LEAST MAINTAINING THE CURRENT VOLUME OF CONVENTIONAL RENEWABLE FUEL

The proposed levels of conventional renewable fuel use *promote* U.S. energy independence and security, as well as this administration's goal of "American energy dominance." Here, we explain why that is so with respect to ethanol and the total volume requirement, but similar analysis could apply with respect to advanced renewable fuels and the advanced volume requirement.

A. The Administration Seeks to Achieve U.S. Energy Independence, Security, and Dominance

As explained in a report prepared by Chupka, Hagerty and Verleger, U.S. energy independence and security are not realistically achieved by cutting off energy imports or otherwise isolating U.S. energy production and consumption from the rest of the world.[6] The United States unavoidably participates in global energy markets. Domestic prices for crude oil and petroleum products, for example, "will rise or fall as global market conditions dictate, including shifts in U.S. commodity futures markets that translate directly to movements in the

[6] Chupka, Hagerty & Verleger, *Blending In: The Role of Renewable Fuel in Achieving Energy Policy Goals – 2018 Updated Edition*, at 18 (Aug. 17, 2018) ("Chupka, Hagerty & Verleger Report") (attached as Exhibit 1).

price of crude, gasoline, and diesel."[7] Similarly, because "retail prices closely follow futures prices, disruptions in supply any place in the world will directly affect prices paid by U.S. consumers."[8]

In this environment, energy independence and security are primarily characterized by other circumstances. Among those are a decreased reliance on energy imports, robust energy exports, and greater balance between domestic energy production and domestic energy consumption.[9] U.S. energy markets should also exhibit a "resilience" against "the adverse economic effects of oil price shocks that will continue to occur periodically."[10] And domestic production of raw energy and "value-added products," i.e., refined and manufactured goods, should support domestic economic growth.[11]

Perhaps recognizing the United States' essential participation in global energy markets, the President has recently prioritized achieving not only energy independence and security, but also a broader policy of "American energy dominance."[12] He explained: "[M]y administration will seek not only American energy independence that we've been looking for so long, but American energy dominance. … We will export American energy all over the world, all around the globe. These energy exports will create countless jobs for our people, and provide true energy security to our friends, partners, and allies all across the globe."[13] To achieve energy dominance, President Trump proposed several actions, including "expand[ing]" sources of "renewable" energy (referring specifically to nuclear energy), "boost[ing] American energy exports," and "bring[ing] new opportunity to the heartland."[14]

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[7] *Id.*

[8] *Id.*

[9] *Id.*

[10] *Id.* at 19.

[11] *Id.* at 20.

[12] Unleashing American Energy. The White House Office of the Press Secretary, Remarks by President Trump at the Unleashing American Energy Event, U.S. Department of Energy, Washington, D.C. (June 29, 2017), https://www.whitehouse.gov/the-press-office/2017/06/29/remarks-president-trump-unleashing-american-energy-event.

[13] *Id.*

[14] *Id.*

B. Reducing the Implied Volume for Conventional Renewable Fuel Would Impede the Achievement of These Policy Objectives

1. Ethanol has helped rebalance energy trade in the United States' favor

Since 2000, domestic fuel ethanol production has increased dramatically and steadily (except for the bad-harvest year of 2012), from barely 100,000 barrels per day to over 1,000,000 barrels per day.[15] This expansion altered the energy trade balance in important ways.

More ethanol was consumed domestically, yet more ethanol was exported. The increase in ethanol production thus both "expanded the overall domestic supply of fuel" and helped the U.S. become a net exporter of ethanol.[16]

Rather than "crowd[ing] out some other sources of petroleum supply," this expansion also strengthened the country's position with respect to petroleum markets by supporting the reduction of imports and the increase of exports of petroleum products and crude oil.[17] For example, oil refinery capacity has increased by about 1 million barrels per day since 2007, while oil refinery utilization today is near its post-2000 peak (91% vs. 93% in 2004), corresponding to increased oil refinery production.[18] With U.S. consumption of transportation fuel holding relatively constant, the "overall trend in gasoline trade volumes … is a pronounced reduction in imports and a significant increase in exports"—whereas in 2007 gasoline imports were about six times as large as exports, in 2016 the United States "became a net exporter for the first time since 1961."[19] During the same period, the United States also became a net exporter of other petroleum products, by an even wider margin.[20] These developments have coincided with a period in which U.S. crude oil production has increased markedly, exports of crude oil have increased, and imports of crude oil have decreased.[21] Although these markets are complex and the causes of these changes are varied, it is significant that they occurred during this period of such substantial increase in U.S. ethanol production.

The availability of increased ethanol can also soften the economic blow to the United States of oil price spikes. For example, when global crude oil and petroleum product markets were tight a few years ago, the increased availability of ethanol "moderat[ed] the world crude oil price."[22] Even when the global petroleum supply is not as tight, high availability of ethanol can mitigate the effect of occasional oil price shocks: when consumers have greater access to higher-

[15] Chupka, Hagerty & Verleger Report at 3-4.

[16] *Id.* at 4-5, 7-8.

[17] *Id.* at 4-5, 7.

[18] *Id.* at 5-6.

[19] *Id.* at 6.

[20] *Id.* at 8-9.

[21] *Id.* at 9-11.

[22] *Id.* at 18.

ethanol blends, they can "take advantage of relative prices between E10 and E15 or E85 … by purchasing more E15 or E85."[23]

2. Ethanol has stimulated substantial economic development in rural Midwestern areas and provided various other economic benefits

In addition to supporting the rebalancing of energy trade balance in the United States' favor, increased ethanol has spurred significant growth in domestic agriculture, which has facilitated broader economic growth especially in rural Midwestern areas.

Most directly, "increased demand for corn-based ethanol has significantly increased production of grain corn and increased energy-related jobs in the U.S."[24] Ninety-three percent of the increase in corn production since 2000 is the result of increased domestic ethanol demand.[25] Corn grown for ethanol production in 2017 accounted for about $18.6 billion in income for corn growers.[26] The increased agricultural income resulting from increased corn production has provided a buffer against some recent declines in corn prices.[27]

The process of producing ethanol from that corn enlarges the economic benefits of ethanol. More than 90% of ethanol production occurs in the Midwest.[28] According to the U.S. Department of Energy, the biofuels industry employs nearly 105,000 people, about 34,500 of whom work in the corn ethanol fuels sector, meaning that the ethanol industry supports slightly more jobs than the petroleum industry on a per-gallon-produced basis.[29] A study by the U.S. Department of Agriculture found that increasing an ethanol plant's annual production by 100 million gallons would generate $203 million in sales and add 39 full-time jobs.[30] Ethanol production also supports economic growth indirectly: according to the U.S. Department of Agriculture, each ethanol job creates 2.6 to 3.2 indirect jobs.[31] So significant is the impact of higher ethanol production that, according to another study by the U.S. Department of Agriculture, ethanol demand accounts for 32% of the total change in employment in areas where

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[23] *Id.* at 19.

[24] *Id.* at 12.

[25] *Id.* at 13.

[26] *Id.* at 14.

[27] *Id.*

[28] *Id.* at 14.

[29] *Id.* at 15-16.

[30] *Id.* at 16-17.

[31] *Id.* at 17 (citing John Pender, *et al*., U.S. Dep't of Agriculture, *Rural Wealth Creation: Concepts, Strategies, and Measures*, Economic Research Report No. 131, 12 (Mar. 2012), *available at* https://pdfs.semanticscholar.org/5219/21ce70f3ea7cb18d57d5f6d03c43ef0a22d4.pdf).

new ethanol facilities are established.[32] Given the significance of conventional renewable fuel to the Administration's goal of energy independence, EPA should not allow the implied non-advanced volume to fall below 15 billion.

III. EPA Should Change Its Approach to Small Refinery Exemptions to Comply with Its Statutory Mandate and to Bring More Transparency to the RIN Market

In the proposed rule, EPA revealed the staggering volumes of renewable fuel that were waived for the 2016 and 2017 compliance years due to its grant of unprecedented numbers of petitions to extend small refinery exemptions.[33] Those exemptions were based on an apparent finding that compliance would impose a "disproportionate economic hardship" on the refinery.[34] EPA stated that "approximately 1,460 million RINs … were not required to be retired by small refineries that were granted hardship exemptions for 2017" and that "approximately 790 million RINs … were not required to be retired by small refineries that were granted hardship exemptions for 2016."[35] EPA subsequently disclosed that it granted 19 of 20 extension petitions for 2016 and all 29 extension petitions for 2017 that it has reviewed so far (it is still processing four 2017 petitions).[36]

EPA had granted no petitions for 2016 and 2017 by the time it finalized the percentage obligations for those compliance years.[37] All the petitions for those years were thus granted after the percentage obligations were finalized. When setting percentage obligations for a given year, EPA accounts for the petitions it has *already* granted *for that compliance year* by excluding the gasoline and diesel produced by exempt refineries, effectively reallocating the exempt obligations to non-exempt obligated parties.[38] But EPA never makes any adjustment or correction to account for petitions granted *after* the percentage obligations are set for the

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[32] *Id*. (citing Jason Brown, *et al*., U.S. Dep't of Agriculture, *Emerging Energy Industries and Rural Growth*, Economic Research Report No. 159 (Nov. 2013)).

[33] NPRM at 32,029.

[34] 42 U.S.C. § 7545(*o*)(9)(B)(i).

[35] NPRM at 32,029.

[36] Letter from Assistant Administrator of EPA, William L. Wehrum, to Senator Charles E. Grassley, at 1 (July 12, 2018) ("Wehrum Letter") (attached as Exhibit 2).

[37] *Renewable Fuel Standard Program: Standards for 2014, 2015, 2016 and Biomass-Based Diesel Volume for 2017*, 80 Fed. Reg. 77,420, 77,511 (Dec. 14, 2015) ("2014-16 RFS Rule"); *Renewable Fuel Standard Program: Standards for 2017 and Biomass-Based Diesel Volume for 2018*, 81 Fed. Reg. 89,746, 89,800 (Dec. 12, 2016) ("2017 RFS Rule"); *Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019*, 82 Fed. Reg. 58,486, 58,523 (Dec. 12, 2017) ("2018 RFS Rule").

[38] 40 C.F.R. § 80.1405(c).

compliance year covered by the exemptions.[39] Consequently, under EPA's policy, the extensions EPA granted for 2016 and 2017 reduced the required volumes for those two years by a combined 2.25 billion RINs; absent a change to EPA's policy, those volumes will never be made up.

The evidence that EPA has revealed so far shows clearly that EPA has repeatedly purported to "extend" an exemption that had long since expired. And given the sheer number of extensions that EPA has granted in recent years, EPA appears to take the view that it can be typical for a refinery to suffer a "disproportionate" hardship, which makes no sense.[40]

EPA's newfound willingness to freely grant extensions, and its refusal to account for the ones it grants retroactively, threatens the efficacy of the RFS program. Yet, the NPRM states that EPA is "not soliciting comments on how small refinery exemptions are accounted for in the percentage standards formulas in 40 CFR 80.1405, and any such comments will be deemed beyond the scope of this rulemaking."[41] That is patently unreasonable given the effect that EPA's recent approvals of extension petitions have on the annual volume obligations and the RFS program overall.[42] It is also contrary to Assistant Administrator Wehrum's statement that EPA is "interested in ensuring the [exemption] program is implemented in a fair and effective manner,"[43] as well as EPA's solicitation of comment on "potential regulatory changes … to address perceived vulnerabilities in the RIN market."[44] Indeed, as EPA appears to recognize, "the impact of small refinery exemptions" has contributed significantly to such vulnerabilities in the market.[45] Given that EPA has refused to publicly disclose information about any specific extension and insisted that a recently filed petition for review of its standards for evaluating extension petitions must be dismissed for lack of a final agency action, EPA's refusal to solicit

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[39] NPRM at 32,057 ("any exemptions … that are granted after the final rule is released will not be reflected"); *see also Regulation of Fuels and Fuel Additives: 2011 Renewable Fuel Standards*, 75 Fed. Reg. 76,796, 76,804 (Dec. 9, 2010) ("2011 RFS Rule").

[40] *Cf. Sinclair Wyo. Refining Co. v. EPA*, 887 F.3d 986, 997 (10th Cir. 2017) ("The EPA must compare the effect of the RFS Program compliance costs on a given refinery with the economic state of other refineries.").

[41] NPRM at 32,057.

[42] *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Ins. Co.*, 463 U.S. 29, 43 (1983) (agency must "examine the relevant data and articulate a satisfactory explanation for its action including a rational connection between the facts found and the choice made"; agency acts arbitrarily by "entirely fail[ing] to consider an important aspect of the problem").

[43] Wehrum Letter at 2.

[44] NPRM at 32,027.

[45] *Id.*

comments on retroactive extensions also seems aimed at shielding its exemption practices from scrutiny.[46]

Consequently, Growth Energy addresses EPA's approach to retroactive extensions. Growth Energy explains that: (A) EPA is statutorily permitted to grant an extension petition for a given year only if the refinery was exempt for all prior years; (B) EPA is statutorily required to account for extensions granted after the percentage obligations for the covered year are finalized, by setting RVOs to reflect (i) the projected volume of extensions to be granted for that year after the RVOs are finalized based on the most recent experience and (ii) the actual volume of extensions that were granted during the prior year in excess of prior projections and thus not accounted for in the prior RVOs; (C) EPA lacks authority to grant retroactive RINs to small refineries whose extension application was incorrectly denied; and (D) EPA should carefully consider the Department of Energy's recommendation on extension petitions. These proposed changes would bring much-needed stability and clarity to the RIN market and the RFS program.

A. EPA Is Statutorily Permitted to Grant an Extension Petition Only If the Refinery Was Exempt for All Prior Years

The recent disclosure of 2016 and 2017 exemptions makes clear that EPA has been granting extension petitions to refineries that have not been continuously exempt under RFS2. For example, only about thirteen refineries were exempt for 2011 and 2012,[47] but nineteen have been granted an extension for 2016 and 29 have been granted an extension for 2017 (with several petitions pending).[48] Moreover, EPA said that as of 2017, "there are 38 refineries eligible for RFS small refinery hardship relief."[49] EPA's position violates the plain statutory text. The number of extensions can never rise from one year to the next because it is impossible to "extend" something that does not exist. Rather, EPA may grant extensions only to refineries that have been exempt continuously since 2010, when the initial "[t]emporary exemption" would otherwise have expired under subparagraph (A) of Section 7545(*o*)(9).[50]

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[46] Respondent's Motion to Dismiss 10-15, *Advanced Biofuels Association v. EPA*, No. 18-1115, Doc. 1740614 (D.C. Cir. July 13, 2018); *see also* 42 U.S.C. § 7607(b)(1) (petition for review challenging "any other nationally applicable regulations promulgated, or final action taken, by the Administrator under this chapter" must be filed in the United States Court of Appeals for the District of Columbia).

[47] U.S. Dep't of Energy, *Small Refinery Exemption Study*, at vii, 26, 37 (Mar. 2011) ("DOE Study"), https://www.epa.gov/sites/production/files/2016-12/documents/small-refinery-exempt-study.pdf; *Regulation of Fuels and Fuel Additives, 2012 Renewable Fuel Standards*, 77 Fed. Reg. 1,320, 1,323 (Jan. 9, 2012) ("2012 RFS Rule"); *see* 42 U.S.C. § 7545(*o*)(9)(B)(i).

[48] Wehrum Letter at 1.

[49] EPA, *Periodic Reviews for the Renewable Fuel Standard Program*, at 11 n.33 (Nov. 2017) ("Periodic Reviews"), EPA-HQ-OAR-2017-0627-0003.

[50] 42 U.S.C. § 7545(*o*)(9)(A).

Congress authorized EPA to grant "petition[s] … for an *extension* of the exemption under subparagraph (A) for the reason of disproportionate economic hardship."[51] "Extend" means "to prolong in duration" or to "cause to last longer,"[52] and correspondingly "extension" means "enlargement in duration."[53] In other words, the inescapable meaning of this statutory provision is that EPA may grant a petition for an *extension* to cover a certain year only if "the exemption under subparagraph (A)" continues to exist up to that year. Otherwise, there is nothing to "prolong" or make last "longer." For example, EPA may grant a refinery's petition for 2016 only if the refinery was (validly) exempt for 2015, which in turn requires that the refinery have been (validly) exempt for 2014 and in prior years. EPA "must … give effect to th[is] unambiguously expressed intent of Congress."[54]

The foundational exemption that must continue to exist in order for EPA to grant a petition for an "extension"—the exemption under subparagraph (A)—encompasses two stages. Congress created the initial, blanket "[t]emporary exemption" for all small refineries through 2010.[55] Next, in the same subparagraph, Congress directed EPA to "extend th[at] exemption … for a period of not less than 2 additional years" for any "small refinery that the Secretary of Energy determines … would be subject to a disproportionate economic hardship if required to comply with" the volume requirements.[56] Fifty-nine refineries appear to have been covered by the initial, blanket exemption imposed by Congress through 2010.[57] Thirteen of those 59 refineries then received a 2-year extension based on a determination by the Department of Energy ("DOE") that compliance would subject them to disproportionate economic hardship.[58] Tellingly, the DOE-based "[e]xtension of [the] exemption[s]" was continuous with the initial,

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[51] *Id.* § 7545(*o*)(9)(B)(i) (emphasis added).

[52] *Extend*, Oxford English Dictionary, 4b, http://www.oed.com/view/Entry/66923?redirectedFrom=extend#eid; *Extend*, Oxford Living Dictionary, 1.1, https://en.oxforddictionaries.com/definition/extend.

[53] *Extension*, Oxford English Dictionary, 9d, http://www.oed.com/view/Entry/66936?redirectedFrom=extension#eid.

[54] *ACE*, 864 F.3d at 712 (quoting *Utility Air Regulatory Grp. v. EPA*, 134 S. Ct. 2427, 2445 (2014)).

[55] 42 U.S.C. § 7545(*o*)(9)(A)(i) ("The requirements of paragraph (2) shall not apply to small refineries until calendar year 2011.").

[56] *Id.* § 7545(*o*)(9)(A)(ii).

[57] The 59 blanket exemptions are based on DOE's explanation that a survey was sent on September 27, 2010, to 59 refineries that, at that time, "h[e]ld a waiver from EPA under the RFS2 program." DOE Study at 26; *see also id.* at vii. Because all small refineries that met the statutory definition of "small refinery" would have been exempt through 2010 and the hardship petition would not have applied then, the necessary inference is that 59 refineries would have been exempt pursuant to the initial, blanket exemption.

[58] *Id.* at vii, 26, 37; 2012 RFS Rule at 1,323; *see* 42 U.S.C. § 7545(*o*)(9)(B)(i).

blanket exemption: the congressionally mandated exemption ran through the end of 2010, and the DOE-based extension covered 2011 and 2012.

Because an "extension of the exemption under subparagraph (A)" could be made for a given year only if the "[t]emporary exemption" specified in subparagraph (A)—the initial, blanket exemption followed by the extension based on DOE's hardship determination—was previously extended up to that year through an unbroken chain of extensions, the exemptions extended pursuant to DOE's study became the *ceiling* for any subsequent "extensions" that EPA could grant upon a petition by an individual refinery. In other words, the thirteen refineries that received the blanket exemption and the DOE-based exemption were the *only* ones eligible for an extension upon petition to EPA. Although EPA's secrecy prevents Growth Energy from determining the precise ceiling today, it is clearly no higher than *twelve*. That is because EPA has revealed that it *evaluated* only twelve extension petitions for 2014.[59] If EPA validly granted all twelve—an unlikely event—those twelve would have been the only refineries eligible for an extension in 2015 and beyond.

This is so regardless of when the extension petition is filed.[60] For example, if a refinery files its petition in 2018 to extend the exemption for the 2017 compliance year, EPA may grant the petition only if the refinery was continuously exempt through 2016 by virtue of the congressionally mandated blanket exemption, the DOE-based extension, and extension petitions granted for 2013-2016.

EPA has suggested that the DOE-based extension and individual extension exemptions provide two alternative paths to extensions. For example, EPA declared: "Congress provided that small refineries could receive a temporary extension of the exemption beyond 2010 based *either* on the results of a required DOE study, *or* based on an EPA determination of 'disproportionate economic hardship' on a case-by-case basis in response to small refinery petitions."[61] Accordingly, EPA apparently "approved a number of individual small refinery petitions" for years covered by the DOE-based extension.[62] That interpretation of the statute is wrong. As explained above, the statute says that individual petitions may be used to extend the "exemption under subparagraph (A)," which includes *both* the initial, blanket exemption *and* the DOE-based extensions. In other words, the two types of extensions provided by the statute work

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[59] Periodic Reviews at 11 n.33.

[60] *See* 42 U.S.C. § 7545(*o*)(9)(B)(i) ("small refinery may at any time petition").

[61] 2017 RFS Rule at 89,800 (emphasis added); 2018 RFS Rule at 58,523; *accord* NPRM at 32,056; *see also* 40 C.F.R. § 80.1441(e)(1), (2).

[62] 2012 RFS Rule at 1,323.

serially—once DOE-based extensions have been made, the individual petitions may be used only to further extend the DOE-based extensions and then further extensions from there.[63]

Consequently, even if "extend" as used in the statute allowed a refinery to be eligible for an extension in one year when it had not received an extension for all prior years—that is, even if "extend" were consistent with a gap in the exemption extensions—EPA's current approach would still contradict the statute and many of the recently granted extensions would be unlawful. Because the statute specifies that the object of a petition to EPA is "an extension of the exemption under subparagraph (A),"[64] and subparagraph (A) provides for both the blanket exemption *and* the DOE-based extension,[65] only those refineries that had received *both* of those would be eligible to petition EPA later for an extension. And as noted above, only thirteen refineries received the DOE-based extension, so (even under this incorrect interpretation of "extend" that permits a gap), only those thirteen refineries could ever receive a further extension by petition to EPA.

B. EPA Must Account for Retroactive Extensions

Almost all of the extension petitions that EPA has granted so far were granted after the RVOs for the covered year were finalized. That, however, did not relieve EPA of the duty to ensure that the RVOs are met. EPA must adjust the RVOs to fully account for any retroactive extensions. Specifically, when setting RVOs for a given year, EPA should first raise the required volume by (i) the projected volume of extensions to be granted retroactively for that compliance year (i.e., expected to be granted after the RVOs are finalized) and (ii) the actual volume of any extensions granted during prior years that have not been accounted for in prior RVOs.

"After EPA determines the volume requirements for the various categories of renewable fuel, it has a statutory mandate to 'ensure[]' that those requirements are met."[66] EPA's current do-nothing policy regarding retroactive extensions ensures the opposite—that the specified volume requirements will never be met. So far, EPA has exempted refineries from producing 1.46 billion RINs in 2017 and 790 million RINs in 2016—7.5% and 4.3% of those years' total

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[63] Even if EPA's two-track view were valid, it would only (modestly) increase the ceiling for later extensions: thirteen (per DOE) *plus* however many refineries were granted extensions for *both* 2011 *and* 2012 by EPA upon individual extension petitions. The two-track view would not alter the rule that EPA may grant an extension petition for a given year only if the refinery was continuously exempt for all prior years under RFS2. Accordingly, at least some of EPA's recent grants of extension petitions would still be unlawful.

[64] 42 U.S.C. § 7545(*o*)(9)(B)(i).

[65] *Id.* § 7545(*o*)(9)(A)(ii).

[66] *ACE*, 864 F.3d at 698-699 (quoting 42 U.S.C. § 7545(*o*)(3)(B)(i)); *see also id.* § 7545(*o*)(2)(A)(i) (directing EPA to "ensure that transportation fuel sold or introduced into commerce … on an annual average basis, contains at least" the applicable volumes of renewable fuel).

volume requirements.[67] Because all of the petitions for those years were granted after EPA had finalized the applicable RVOs, those volumes will be lost under EPA's current policy. Especially in the face of the such large aggregate exemptions, EPA cannot plausibly claim to be *ensuring* that the volume requirements are met. Indeed, the Office of Management and Budget ("OMB") recently stated that "[c]urrent procedures ensure RVO isn't met."[68]

EPA recently recognized as much. In earlier drafts of the 2019 proposed rule, EPA proposed to take "a different approach" toward retroactive extensions in order to "implement" its statutory mandate to "ensure[]" the required volumes are met.[69] EPA admitted that its "grant of small refinery exemptions affects the amount of transportation fuel subject to the renewable fuel obligation for that year."[70] To "address this effect" and "facilitate the satisfaction of the RFS program [volume] requirements," EPA proposed in the earlier drafts that it would adjust its RVO formula to account prospectively for the "[p]roject[ed] … total exempted volume based on the most recent exemption data."[71]

Anticipatorily accounting for expected future extensions when setting RVOs for the covered year would reduce or eliminate the volumes lost because of retroactive extensions, thereby going a long way toward "ensur[ing]" that the required volumes are met. As EPA acknowledged, such an approach is also consistent with "a reasonable interpretation" of existing regulations because the regulations account for the gas and diesel volumes "'*projected* to be produced by exempt small refineries.'"[72] EPA, however, abandoned the proposal without explanation—even though OMB had approved of the proposal and concluded that EPA should "[i]nclude an estimate for 2019 small refinery waivers based on the waivers granted over the past two years."[73]

Further, when finalizing RVOs, EPA should increase volume requirements by the amount covered by any previously granted retroactive extensions that have not already been accounted for through other adjustments to RVOs, such as the projection just described. Because EPA

[67] 2017 RFS Rule at 89,747; 2014-2016 RFS Rule at 77,422.

[68] Email from Tia Sutton to Chad Whiteman regarding RE EO 12866 Comments on EPA RFS RVO 2019/2020 BBD NPRM (2060-AT93), at 7, 15 (June 5, 2018) ("June 5 OMB Comments"), EPA-HQ-OAR-2018-0167-0103; *see also* Email from Chad Whiteman to Tia Sutton and Benjamin Hengst regarding EO 12866 Comments on EPA RFS RVO 2019/2010 BBD NPRM (2060-AT93), at 3-4, 12 (May 23, 2018), EPA-HQ-OAR-2018-0167-0103.

[69] Email from Tia Sutton to Chad Whiteman regarding Revised version of 2019 RVO NPRM, at 74 (June 19, 2018), EPA-HQ-OAR-2018-0167-0103; Email from Tia Sutton to Chad Whiteman regarding Updated version of 2019 RVO NPRM, at 74 (June 21, 2018), EPA-HQ-OAR-2018-0167-0103 ("June 21 Version").

[70] June 21 Version 74.

[71] *Id.*

[72] *Id.*

[73] June 5 OMB Comments 7.

would have perfect knowledge about the extent of extensions to that point (unlike when projecting), doing so would *fully* "ensure" that the volume requirements are met.[74] True, that would not ensure that the requirements are met *in the applicable year* to the extent that any extension petitions were granted during that year (after RVOs were set). But it would ensure that the volume requirements are met in the aggregate (i.e., over the arc of the RFS program), which would serve Congress's stated goal of introducing specified volumes of renewable fuel into the nation's transportation fuel supply far better than EPA's do-nothing policy. EPA in fact has repeatedly used the similar technique of "combin[ing]" two years' volume requirements in order to "ensure" that *both* years' requirements are met, and the courts have approved.[75]

Another mechanism available to EPA to account for retroactive extensions is the ability to flow a cellulosic waiver through to the advanced and total volume standards. As discussed further below, EPA should not use the cellulosic waiver to reduce those standards to the extent that it projects future retroactive exemption extensions or has granted such extensions in prior years without making up the exempt volumes.[76]

EPA's do-nothing policy has the effect of unlawfully creating a new waiver, contrary to Congress's intent. The statute specifies that an "exemption" merely relieves the exempt refinery of the compliance obligation—"The [volume] requirements … shall not apply to" the exempt refinery.[77] Congress provided a different mechanism to reduce national volume requirements: waivers. But EPA may do so under specific, limited circumstances, none of which involves the disproportionate economic hardship suffered by small refineries.[78] Yet, the acknowledged effect of EPA's do-nothing policy is precisely to reduce the volume requirements rather than to merely relieve certain refineries of their obligations, and thus it aggrandizes to EPA a new waiver authority. EPA has no power to do that. Congress's "expressi[on]" of certain types of waivers "excludes another [type of waiver] left unmentioned,"[79] and "the fact that EPA thinks a statute would work better if tweaked does not give EPA the right to amend the statute."[80]

EPA previously said that it would not account for retroactive extensions because "there is no [statutory] provision for changing the percentage standards once they are set" or for "ensuring that the percentage standards actually result in the specified volumes actually being

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[74] This ex post accounting should cover unaccounted-for RINs in *all* prior years, not just the most recent one.

[75] *National Petrochemical & Refiners Ass'n v. EPA*, 630 F.3d 145, 153, 156 (D.C. Cir. 2010) (the "combined" 2009-2010 rule fulfilled EPA's duty to "ensure" that volume requirements are met); *Monroe Energy, LLC v. EPA*, 750 F.3d 909, 919-921 (D.C. Cir. 2014).

[76] *See infra* Part IV.

[77] 42 U.S.C. § 7545(*o*)(9)(A)(i).

[78] *Id.* 7545(*o*)(7)(A) & (D)-(E), (8).

[79] *NLRB v. SW General Inc.*,137 S. Ct. 929, 940 (2017) (quotation marks omitted).

[80] *ACE*, 864 F.3d at 712.

consumed."[81] In support, EPA noted that in setting RVOs, the statute allows EPA to "use projections of gasoline and diesel volume for the next year which might turn out the be too high or too low."[82] Rather, EPA said, "the Act is best interpreted to require issuance of a single annual standard in November that is applicable in the following calendar year, thereby providing advance notice and certainty to obligated parties regarding their regulatory requirements."[83]

Although it is important to provide the market with notice and certainty, that does not justify EPA's do-nothing policy because retroactively revising RVOs is not the only way to account for retroactive extensions. The remedial actions proposed here would not undermine the predictability of the volume requirements. EPA should adopt these changes.

C. EPA Should Not Issue Retroactive RINs to Remedy Any Incorrect Prior Denial of an Extension Petition

While refusing to adjust RVOs to account for extension petitions it grants after it has finalized the RVOs for the covered year, EPA nonetheless appears willing to adjust refineries' balance sheets by granting them RINs when it approves their extension petition after the covered compliance year. In the past, EPA allowed refineries to "un-retire" RINs if their extension petition was granted after they had already complied with their RVOs for the covered year.[84] Recently, however, it has been reported that EPA has "allowed" some refineries in that position "to generate new 2018 vintage RINs to replace the RINs [they] previously submitted to meet" RVOs for the earlier compliance years covered by the extensions.[85]

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[81] 2012 RFS Rule at 1,340.

[82] *Id*.

[83] *See, e.g.*, 2011 RFS Rule at 76,804; 2012 RFS Rule at 1,340; *Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards*, 78 Fed. Reg. 49,794, 49,825 (Aug. 15, 2013).

[84] Carryover RIN Bank Calculations for 2019 NPRM, at 3 n.3 (June 11, 2018) ("While EPA has granted these additional small refinery exemptions since the 2017 compliance deadline, the RINs retired by these small refineries in the 2017 compliance year had not yet been un-retired at the time of the most recent update."), EPA-HQ-OAR-2018-0167-0043; Email to Chad Whiteman regarding E.O. 12866 Review 2019 RVO NPRM – memo requests, at 2 ("Carryover RIN Bank Calculations for 2018 Final Rule" from November 2017 discussing the "expected un-retirement of … RINs" based on EPA's grant of "additional small refinery hardship petitions for exemption from the 2016 RFS standards"), EPA-HQ-OAR-2018-0167-0103.

[85] *See* Jarrett Renshaw & Chris Prentice, *Exclusive: U.S. EPA grants refiners biofuel credits to remedy Obama-era waiver denials*, Reuters, May 31, 2018 ("Reuters Retroactive Credits Article"), https://www.reuters.com/article/us-usa-biofuels-waivers-exclusive/exclusive-epa-grants-refiners-biofuel-credits-to-remedy-obama-era-waiver-denials-idUSKCN1IW1DW; Timothy Puko & Christopher M. Matthews, *EPA Gives $30 Million-Plus in Ethanol Credits to Oil Refiners, Angers Corn Growers*, Wall St. J., May 31, 2018, https://www.wsj.com/articles/epa-gives-30-million-plus-in-ethanol-credits-to-oil-refiners-angers-corn-growers-1527802062.

Presumably, this supposed RIN generation does not mean that the refinery is producing or importing new gallons of renewable fuel. That is not typically what refineries do, and anyway that would not be an effective way to implement an exemption extension because, even if the refinery could recoup the cost of generating the new RIN by selling it, that revenue would not offset the cost of generating (or acquiring) the RIN previously used to show compliance unnecessarily. Rather, we suspect that EPA has simply been issuing new RINs to these refineries. If that is true, it is unlawful. EPA regulations specify the ways that a RIN can be generated, and generating a new RIN that either is not associated with a newly produced or imported gallon of renewable fuel or is associated with a gallon of renewable fuel that already generated another RIN (a two-for-one) is not among them.[86]

D. EPA Should Carefully Consider DOE's Recommendations on Extension Petitions

It has been reported that, in deciding to grant 19 extension petitions for 2016 and 29 for 2017, EPA repeatedly disregarded DOE's contrary or more limited recommendations.[87] Although EPA is statutorily charged with deciding whether to grant or deny an extension petition, Congress intended that EPA should carefully consider DOE's views on each petition.[88] EPA's apparent systematic departure in fully extending exemptions where DOE had recommended no extension or only a partial extension is inconsistent with that duty.[89] EPA should ensure that it consistently and carefully considers DOE's recommendations.

[86] *See* 40 C.F.R. §§ 80.1425-80.1429.

[87] Jarrett Renshaw & Chris Prentice, *Exclusive: Trump's EPA ignored Energy Department calls to limit biofuel waivers*, Reuters (June 26, 2018) ("Reuters DOE Article") (EPA "consistently granted full waivers in cases where the energy department recommended only partial exemptions, and, at least once, granted a full approval when the energy department advised an outright rejection."), https://www.reuters.com/article/us-usa-epa-biofuels-exclusive/exclusive-trumps-epa-ignored-energy-department-calls-to-limit-biofuel-waivers-idUSKBN1JM17T.

[88] *See* 42 U.S.C. § 7545(*o*)(9)(B)(ii) ("In evaluating a petition under clause (i), the Administrator, in consultation with the Secretary of Energy, shall consider the findings of the study under subparagraph (A)(ii) and other economic factors."); *accord* EPA, *Financial and Other Information to be Submitted with 2016 RFS Small Refinery Hardship Exemption Requests*, at 2-3 (Dec. 6, 2016) ("Evaluation Criteria Guidance") ("The EPA will consult with DOE during its evaluation of each petition …."), https://www.epa.gov/sites/production/files/2016-12/documents/rfs-small-refinery-2016-12-06.pdf.

[89] *Cf. Ergon-W. Va., Inc. v. EPA*, 2018 WL 3483282, at *8 (4th Cir. July 20, 2018) ("Although the EPA is statutorily required to consider the DOE's recommendation, it may not turn a blind eye to errors and omissions apparent on the face of the report ….").

E. Improving EPA's Approach to Extension Petitions Would Improve the RIN Market's Functioning

In the NPRM, EPA requested comment on "regulatory changes … to address perceived vulnerabilities in the RIN market."[90] In general, Growth Energy urges EPA to develop better methods for gathering accurate, complete, and timely data regarding RIN transactions, and to increase transparency into the current state of the RIN market to mitigate the risk of market manipulation. A specific and essential way in which EPA could improve functioning of the RIN market is to reform its handling of small refinery exemptions—including in the ways discussed above.

The substantive flaws in EPA's treatment of extension petitions discussed above harm the RIN market. EPA's practice of granting extension petitions to refineries that have not been continuously exempt since 2010 undermines the predictability that would come with the number of extensions available for one year not being permitted to exceed the number of extensions granted in the prior year. EPA's refusal to adjust volume requirements for retroactive extensions deprives the market of the confidence Congress intended it to have that, ultimately, the required annual volumes of renewable fuel would be used. EPA's apparent practice of allowing refineries to generate new RINs when it grants an extension petition after the refinery has already complied for the covered year disrupts the market by unexpectedly introducing new RINs into the market that do not reflect the actual production of renewable fuel, which in turn artificially depresses RIN prices or interferes with the market's ability to accurately value RINs. And EPA's apparent systematic disregard of DOE's recommendations on extension petitions denies the market of the stabilizing check that respectful consideration of those recommendations could provide.

Additionally, EPA's approach to extension petitions unnecessarily poses a serious threat to the functioning of the RIN market because EPA conducts nearly the entire process in secret. Even in the face of numerous FOIA requests,[91] EPA refuses to disclose promptly or *at all* the basic information regarding exemption extensions, including:

- The fact that EPA has granted an extension;
- The identity of the exempt refinery and its owner;
- The volume exempted, whether individually or in the aggregate[92];

[90] NPRM at 32,027.

[91] Growth Energy has submitted three FOIA requests seeking records relating to extension petitions. *See* EPA-HQ-2018-006398 (submitted Apr. 9, 2018); EPA-HQ-2018-006524 (submitted Apr. 12, 2018); EPA-HQ-2018-009898 (submitted July 23, 2018). Other entities have submitted many similar requests.

[92] Not until EPA issued the 2019 NPRM did it reveal the number of exempt RINs for 2016 and 2017. *See* NPRM at 32,029.

- The year covered by the extension;
- The standards EPA applied to decide whether to grant or deny the extension petitions;
- EPA's analysis relating to whether the refinery qualifies as a "small refinery";
- EPA's analysis relating to whether compliance would subject the refinery to a "disproportionate hardship"; or
- Whether and to what extent EPA has allowed a refinery to "un-retire" RINs or has allowed a refinery to generate new RINs in connection with a retroactive extension.[93]

EPA has no authority to withhold this information, whether as confidential business information ("CBI") under Exemption 4 or deliberative process information under Exemption 5—as EPA has already recognized.

This information is not CBI, for several reasons. First, this information was not "obtained from a person"[94] but rather was "'generated within the Government.'"[95] As EPA itself has noted, "data generated within the government" and "basic facts related to government decisions are … not entitled to CBI treatment under FOIA Exemption 4" because, plainly, they are not obtained from outside the government.[96] That is true even for EPA's analyses, notwithstanding that they presumably are based on data obtained from a refinery[97] or might

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[93] *See, e.g.*, Wehrum Letter at 1 ("EPA is unable to provide information that is fully responsive to your request, as we treat both the names of individual petitioners and EPA's decision on those petitions as Confidential Business In formation (CBI) ….").

[94] *National Parks & Conservation Ass'n v. Morton*, 498 F.2d 765, 766 (D.C. Cir. 1974); *see* 5 U.S.C. § 522(b)(4).

[95] *Center for Auto Safety v. U.S. Dep't of Treasury*, 133 F. Supp. 3d 109, 119 (D.D.C. 2015) (quoting *Board of Trade v. Commodity Futures Trading Comm'n*, 627 F.2d 392, 404 (D.C.Cir.1980), *abrogated on other grounds by U.S. Dep't of State v. Washington Post Co.*, 456 U.S. 595 (1982)).

[96] *Renewable Enhancement and Growth Support Rule*, 81 Fed. Reg. 80,828, 80,909 (Nov. 16, 2016).

[97] *Philadelphia Newspapers, Inc. v. Department of Health & Human Servs.*, 69 F. Supp. 2d 63, 66-67 (D.D.C. 1999) (Argument that agency "audit of [company's] records was based on raw data obtained from [company] … does not work. … An audit is not simply a summary or reformulation of information supplied by a source outside the government. It also involves analysis, and the analysis was prepared by the government. The [agency] charts were not 'obtained from a person,' and they may not be withheld under Exemption 4."); *see also Center for Auto Safety*, 133 F. Supp. 3d at 123.

"allow[] one to back into information about" the refinery.[98] Consequently, EPA has already concluded that, with respect to extension petitions, "the petitioner's name, the name and location of the facility for which relief was requested, the general nature of the relief requested, the time period for which relief was requested, and the extent to which the EPA granted or denied the requested relief" are "not entitled to treatment as CBI."[99] Yet, EPA continues to treat this information as CBI and its proposal to publicly release such information is moribund.[100]

Second, even if any of the information were "obtained from a person," it would not be CBI because it is not "confidential."[101] This information, to the extent it is obtained from a non-government person, is submitted involuntarily under EPA's regulations governing exemption petitions.[102] Accordingly, the information would qualify as confidential only if its disclosure would either "impair the Government's ability to obtain necessary information in the future" or "cause substantial harm to the competitive position of the person from whom the information was obtained."[103] Neither is the case. EPA could continue to obtain the same information in the future under the regulations that require it.[104] Nor would refineries suffer substantial competitive harm from disclosure. Indeed, HollyFrontier—one of the few exempt refineries whose identity was reported—routinely discloses basic facts about its extension exemptions in its securities filings.[105] And in litigation, refineries and EPA have publicly disclosed basic facts regarding EPA's decisions on extension petitions, including the name and location of the refinery that sought the extension, the years for which it sought the extension, the fact that the refinery

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[98] *Bloomberg, L.P. v. Board of Governors of Fed. Reserve Sys.*, 601 F.3d 143, 148 (2d Cir. 2010) ("[D]ocuments that show what loans the Federal Reserve Banks actually made" are not covered by Exemption 4 because "[t]he fact that information *about* an individual can sometimes be inferred from information *generated within an agency* does not mean that such information was *obtained from* that person within the meaning of FOIA.").

[99] *Renewable Enhancement and Growth Support Rule*, 81 Fed. Reg. at 80,909.

[100] *Id.*

[101] *National Parks*, 498 F.2d at 766; *see* 5 U.S.C. § 522(b)(4).

[102] *See* 40 C.F.R. §§ 2.201(h)(i)(2), 80.1441(e)(2)(i), (iii); Evaluation Criteria Guidance at 2-3; *see also Forest Cty. Potawatomi Cmty. v. Zinke*, 278 F. Supp. 3d 181, 202 (D.D.C. 2017) (even though a "tribe's "decision to apply for a license to operate an off-reservation casino is plainly voluntary," the tribe submitted the documents at issue to the government "as required by the gaming application process, and so [the documents] were submitted involuntarily").

[103] *National Parks*, 498 F.2d at 770; *see also Critical Mass Energy Project v. Nuclear Regulatory Comm'n*, 975 F.2d 871, 878-879 (D.C. Cir. 1992) (en banc).

[104] *See National Parks*, 498 F.2d at 770; *Forest Cty.*, 278 F. Supp. 3d at 203; 40 C.F.R. § 2.208(e) (information is not entitled to confidential treatment if was not voluntarily submitted and its disclosure would not cause competitive harm).

[105] *See, e.g.*, Form 10-K, Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934, HollyFrontier Corporation (Feb. 21, 2018), at 76.

received the initial, blanket exemption, and the fact that the refinery was exempt in other prior years.[106]

Moreover, this information is not protected by the deliberative process privilege. That privilege protects an agency's documents only if they are "both 'predecisional' and 'deliberative.'"[107] A "document [is] predecisional if it was generated before the adoption of an agency policy and deliberative if it reflects the give-and-take of the consultative process."[108] Records setting forth EPA's decision on any extension petition and the basic facts inherent in that decision are obviously neither predecisional nor deliberative. The standards EPA applies does not meet those conditions, either.[109] Even EPA's analyses of whether the refinery meets the requirements for an extension, including whether the refinery would be subject to disproportionate economic hardship, are not predecisional and deliberative to the extent they are "adopted … as the agency position on" the petitions rather than the "personal opinions of the writer" that "reflect internal deliberations on the advisability of any particular course of action."[110]

Instead, EPA's refusal to release this information impermissibly creates a body of "secret law" regarding both EPA's process for evaluating extension petitions and the volume requirements that actually apply in the covered compliance year.[111] An agency is not "permitted to develop a body of 'secret law,' used by it in the discharge of its regulatory duties …, but hidden behind a veil of privilege because it is not designated as 'formal,' 'binding,' or 'final.'"[112] Thus, agencies "must disclose their 'working law,' i.e., the 'reasons which [supplied] the basis for an agency policy actually adopted'" or "'binding agency opinions and interpretations' that the agency 'actually applies in cases before it.'"[113] The standards and process that EPA used to evaluate the extension petitions are precisely such "reasons," "opinions or interpretations" that

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[106] Petition for Review, *Ergon-West Virginia, Inc. v. EPA*, No. 17-1839, Doc. 3-3 (4th Cir. July 17, 2017); Petition for Review 8, 10, *Sinclair Wyoming Refining Co. v. EPA*, No. 16-9532, Doc. 01019636438 (10th Cir. June 10, 2016); Petition for Review 4, *Lion Oil Co. v. EPA*, No. 14-3405, Entry ID 4209931 (8th Cir. Oct. 24, 2014); Petition for Review 4, *Hermes Consol., LLC v. EPA*, No. 14-1016, Doc. 1478886 (D.C. Cir. Feb. 3, 2014).

[107] *Public Citizen, Inc. v. Office of Mgmt. & Budget*, 598 F.3d 865, 874 (D.C. Cir. 2010); *see also Renegotiation Bd. v. Grumman Aircraft Eng'g Corp.*, 421 U.S. 168, 184 (1975); *NLRB v. Sears, Robuck & Co.*, 421 U.S. 132, 150 (1975); *see* 5 U.S.C. § 522(b)(5).

[108] *Public Citizen*, 598 F.3d at 874.

[109] *Id.* at 875 ("an agency's application of a policy to guide further decision-making does not render the policy itself predecisional").

[110] *Id.* at 874-875.

[111] *Coastal States Gas Corp. v. Department of Energy*, 617 F.2d 854, 867 (D.C. Cir. 1980).

[112] *Id.*

[113] *Electronic Frontier Found. v. DOJ*, 739 F.3d 1, 7 (D.C. Cir. 2014); *see Coastal States*, 617 F.2d at 867-868.

constitute EPA's working law. So are exemptions from nationally applicable volume requirements. EPA must therefore disclose the standards, as well as the final decisions themselves, irrespective of whether the documents containing those standards are formal, binding, or final.

Despite the clear *and acknowledged* lack of justification for withholding the requested information, EPA appears to be treating as presumptively confidential whatever the submitting refinery requests to be treated as confidential. That violates EPA's own FOIA regulations. Under those regulations, EPA is to make an "initial" or "preliminary determination" regarding whether the information "may be entitled to confidential treatment" or, instead, "clearly is not entitled to confidential treatment."[114] If the information may be entitled to confidential treatment, EPA is to refer the matter to the appropriate EPA legal office for final determination.[115] But if the information clearly is not entitled to confidential treatment, EPA *must* disclose it.[116] Insofar as EPA previously concluded that information relating to small refinery exemption petitions is "not entitled to treatment as CBI,"[117] EPA cannot reasonably conclude now that it "may be entitled to confidential treatment." That information most certainly is not. The mere fact, then, that the refinery requested confidential treatment is not enough; EPA must disclose it forthwith, without proceeding to a "final administrative determination" by the "appropriate EPA legal office."[118]

Finally, whatever the legality of EPA's secrecy, its practice of withholding this information is highly detrimental to RIN markets. It is fundamental that markets cannot work effectively when the supply of the good—here, RINs—cannot be ascertained; markets require transparency, as EPA has repeatedly recognized.[119] For example, as a commenter observed during last year's rulemaking on the 2018 RVOs, secretly granting retroactive exemptions can cause RIN prices to rise artificially as demand for RINs exceeds the supply that will actually be needed,[120] only to plummet once EPA eventually discloses the size of exemption extensions for a given compliance year, as happened recently when the market learned that EPA had granted 48 retroactive extension petitions for 2016 and 2017.[121] Former Administrator Pruitt recently acknowledged the imperative for transparency in the RIN market, testifying to Congress that it is

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[114] 40 C.F.R. § 2.204(d)(1), (2).

[115] *Id.* §§ 2.204(d)(1)(iii), 2.205(a)(1).

[116] *Id.* § 2.204(d)(2); *see id.* § 2.205(f)(5).

[117] *Renewable Enhancement and Growth Support Rule*, 81 Fed. Reg. at 80,909.

[118] 40 C.F.R. §§ 2.204(d), 2.205(a)(1).

[119] NPRM at 32,027; 2017 RFS Rule at 58,525; EPA, Renewable Fuel Standards for 2018 and Biomass-Based Diesel Volume for 2019, Response to Comments, at 14 (Dec. 2017) ("Response to Comments on 2018 RFS Rule"), EPA-HQ-OAR-2017-0091-4990.

[120] BP Products North America Comments, at 7 (Aug. 31, 2017), EPA-HQ-OAR-2017-0091-3953.

[121] Reuters Retroactive Credits Article.

in "everyone's best interest to get more clarity and confidence in how this RIN trading platform and relief needs to occur."[122] The 2019 NPRM also acknowledges this when it notes that EPA is considering providing periodic updates on "the impact of small refinery exemptions" in order to mitigate the "lack of transparency and potential manipulation in the RIN market."[123] EPA should heed its own observations and open its exemption extension decisions to the public.

IV. EPA Should Lessen the Cellulosic Waiver Flow-Through by the Size of the Small Refinery Exemption Extensions

When there is a shortfall in projected cellulosic production, EPA should lessen the flow-through of the cellulosic waiver it would otherwise implement by an amount equal to any past and future small-refinery exemption extensions that would not otherwise be accounted for through RVO adjustments. Doing so would be an available mechanism for EPA to fulfill its fundamental statutory duty to "ensure" that the volume requirements are met.[124]

It is true that doing so may result in the implied non-advanced volume exceeding 15 billion. But EPA's view that the cellulosic waiver for the advanced and total standards must be lockstep and that the 15 billion implied non-advanced volume is a cap is wrong.[125] The statute permits EPA to "reduce" the advanced standard "by the same *or a lesser volume*" than it reduces the cellulosic standard.[126] Congress used the same language with respect to the total standard, specifying that EPA may "reduce the applicable volume of renewable fuel … by the same or a lesser volume."[127] Nothing in the statute requires EPA to maintain a constant cellulosic waiver for both the advanced and total standards. And nothing in the statute indicates that Congress intended for the implied non-advanced volume of 15 billion to be a cap.

V. EPA's Proposed Method for Projecting Liquid Cellulosic Biofuel for 2019 Is Flawed

Developing the commercial production of cellulosic biofuel is "central to the [RFS] program's objective of reducing greenhouse gas emissions."[128] Although cellulosic production has not increased as quickly as Congress expected, it has—as EPA has observed—"continued to

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[122] *The Fiscal Year 2019 EPA Budget: Hearing Before the H. Subcomm. on Environment Comm. on Energy and Commerce*, 115th Cong. 50-51, 62-63 (2018), https://democrats-energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/20180426-EE%20The%20FY%2019%20Environmental%20Protection%20Agency%20Budget.pdf.

[123] NPRM at 32,027.

[124] *Supra* Part III.

[125] *See, e.g.*, NPRM at 32,039 (proposing to "apply the same reduction to the statutory volume target for total renewable fuel" as for the advanced standard).

[126] 42 U.S.C. § 7545(*o*)(7)(D)(i) (emphasis added); *see Monroe Energy*, 750 F.3d at 915.

[127] 42 U.S.C. § 7545(*o*)(7)(D)(i).

[128] *API*, 706 F.3d at 476.

increase" in "the past several years," reaching "record levels in 2017" and "continu[ing] to increase in 2018."[129] Having accurate cellulosic projections is imperative for the industry and the success of the RFS program that Congress created. If cellulosic projections are too low, D3 RIN prices could fall precipitously, undermining the very incentive Congress intended to create to spur growth.[130]

When determining cellulosic biofuel projections, EPA must "take 'neutral aim at accuracy.'"[131] That means, the D.C. Circuit declared recently, that "EPA's methodology [may] not reflect a 'non-neutral purpose' to favor *or disfavor* growth in the cellulosic biofuel industry," i.e., "systematically err[] on the side of overestimation" or underestimation.[132] EPA's proposed method for projecting 2019 cellulosic production violates this standard.

"Consistent with" the method EPA used to project the 2018 production of liquid cellulosic biofuel, EPA proposes to group producers based on whether they have previously achieved consistent commercial-scale production, determine an aggregate range of likely production for each group, and then apply a percentage (or a "percentile value," as EPA calls it) to each group's range to project aggregate production."[133] And, like the 2018 method, EPA would set the percentiles based on the actual past production volumes in each group.[134]

As Growth Energy explained in its comment on last year's proposal, this method, by necessarily tying cellulosic projections to the industry's past performance, incorrectly assumes that the industry's past determines its future.[135] EPA actually recognizes the inherent inaccuracy of its historical method, noting that it is "especially true" that "actual production will differ from [its] projections" because "liquid cellulosic biofuel industry … is currently in the early stages of commercialization."[136] Yet, EPA believes its method is "neutral" because it uses "historical data that is free of any subjective bias."[137] But "neutral aim" requires the absence of *objective* or *systematic* bias, not just *subjective* bias. EPA fails to understand that its method's inability to account for the cellulosic industry's nascence means that it *systematically* '"tilt[s]'" the

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129 NPRM at 32,030.

130 *ACE*, 864 F.3d at 710.

131 *Id*. at 727 (quoting *API*, 706 F.3d at 476).

132 *Id.* (citing *API*, 706 F.3d at 478 (emphasis added)).

133 NPRM at 32,034.

134 *Id.* at 32,035.

135 Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019, at 4, 6-12 (Aug. 31, 2017) ("2018 Growth Energy Comment") (attached as Exhibit 3), EPA-HQ-OAR-2017-0091-3681; *see also* Argus Consulting Services, *Reviewing EPA methodology for potential cellulosic biofuels production for 2018*, at 14-23 (Aug. 2017) ("2018 Argus Report") (attached as Exhibit 4) .

136 NPRM at 32,036.

137 *Id.* at 32,032.

projections against growth,[138] undercutting the significant investments made in the cellulosic industry and Congress's goals.

This flaw is not remedied by EPA's proposed adjustment to the 2018 method, whereby EPA would now set the percentile values equal to the *average* (i.e., mean) of past production volumes in each group.[139] EPA does this in the name of "improv[ing] the accuracy of the production projection," based on its belief that "[u]sing data from multiple years is likely more representative of the future performance of these groups of companies than data from any single year."[140] Moving from one data point to two (or three) data points, however, does not make the resulting forecast statistically significant—either way, the sample is surely too small. Nor does it account for the industry's potential for rapid growth. As EPA noted, liquid cellulosic production has "increased in recent years,"[141] for example, growing by 172% from 2016 to 2017.[142]

EPA should instead base its projection on a plant-by-plant evaluation of *all* relevant factors (or at least a more finely tuned set of groupings) in order to fully account for the technological, financial, managerial, political, and legal factors determining each plant's production. Growth Energy stands ready and willing to assist EPA in collecting any needed data and to provide technical assistance to perform such assessments. Short of that, EPA should return to the earlier method of applying the 25th percentile for the new facilities and the 50th percentile for the consistent facilities.

EPA should also create a new group for liquid cellulosic producers that are currently producing cellulosic ethanol from corn kernel fiber at existing plants and apply the 50th percentile to project their production.[143] In last year's rulemaking, EPA declined to do so because, EPA said, it lacked "sufficient data" to determine whether the lower risk associated with producing cellulosic ethanol from corn kernel fiber at a facility currently producing ethanol from starch "justif[ied] the use of different projection methodologies."[144] EPA noted, however, that it "may include projected production from these sources in the future as appropriate."[145]

Now is the time to start accounting for these sources. EPA's concern about insufficient data, if ever warranted, is not warranted today. EPA itself acknowledged that "technologies that convert corn kernel fiber require little to no additional processing equipment and can theoretically ramp-up production more quickly than stand-alone cellulosic biofuel production

[138] *ACE*, 864 F.3d at 727.

[139] NPRM at 32,035-32,036.

[140] *Id.* at 32,036.

[141] *Id.* at 32,030.

[142] Calculating the Percentile Values Used to Project Liquid Cellulosic Biofuel Production for 2019, at 1-2 (May 2018), EPA-HQ-OAR-2018-0167-0012.

[143] 2018 Growth Energy Comment at 11-12; 2018 Argus Report at 19-23.

[144] Response to Comments on 2018 RFS Rule at 57.

[145] *Id.* at 47.

facilities."[146] Edeniq and POET, for example, have consistently produced liquid cellulosic biofuel for several years. Although EPA cited the "uncertainty with respect to the number of facilities that will pursue the use of this technology,"[147] that uncertainty readily can be mitigated by soliciting input from the likely facilities. Indeed, EPA has already committed to "continue to work with all companies interested in generating cellulosic RINs to address any outstanding technical and regulatory issues."[148] Relatedly, several notable producers have not yet received the requisite regulatory approval to generate RINs based on their corn kernel fiber technology. There is no good reason for EPA's foot dragging; EPA should promptly grant the approvals and take into account the additional volumes that would be generated from those producers in its 2019 projections—which industry sources estimate to be 300 million gallons immediately.[149]

Finally, EPA proposes to use the same method to project CNG/LNG derived from biogas ("RNG" or "biogas") as in 2018: a straight-line extrapolation of the actual industry-wide year-over-year growth rate.[150] But as Growth Energy explained in its comment on the 2018 NPRM, that method also "turn[s] the task of projecting future production volumes of [RNG] into little more than extending the past," and therefore does not reflect neutral aim at an accurate projection for an industry poised to grow rapidly.[151] EPA should instead return to the method it used to project RNG for 2017.[152]

VI. EPA SHOULD REMOVE REGULATORY BARRIERS TO EXPANDED USE OF E15

Aside from setting high volume requirements, EPA should remove regulatory barriers to expanded E15 use. Growth Energy discusses two actions EPA should take.

First, EPA should extend the 1 pound per square inch (psi) Reid Vapor Pressure (RVP) allowance under the waiver provisions of 42 U.S.C. § 7545(h)(4) to blends of gasoline and 15 percent ethanol (E15). The 9.0 psi RVP limit under 42 U.S.C. § 7545(h)(1) applies from May to September. Unless made using low-RVP gasoline blendstock, E15's volatility will exceed 9.0 psi. Because low-RVP blendstock is scarce, EPA's denial of a 1-pound waiver effectively prevents the sale of E15 during the summer months.

Section 7545(h)(4) permits EPA to waive the 9.0 psi limit by one pound, setting a maximum RVP limit of 10 psi for "fuel blends containing gasoline and 10 percent denatured anhydrous ethanol." EPA has previously interpreted that phrase to cover "blends of 9-10%

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[146] *Id.* at 57.

[147] *Id.*

[148] *Id.* at 47.

[149] Edeniq, *Produce Cellulosic Ethanol in Existing Plants with Edeniq's Pathway Platform*, at 1 (Aug. 9, 2016), https://ethanol.org/Edeniq%20Kacmar%20ACE%202016%20final.pdf.

[150] NPRM at 32,036-32,037.

[151] Growth Energy 2018 Comment at 5-6.

[152] *Id.* at 12.

ethanol."[153] Although there is no scientific basis for having different RVP limits for E15, as E15 has a similar volatility to E10 and would behave similarly in terms of evaporative emissions and effects on emissions-control devices,[154] EPA has interpreted section 7545(h)(4) not to permit a one-pound RVP waiver for E15.[155]

EPA's interpretation is clearly unreasonable. In light of the statutory structure and purpose of Section 7545(h), the language of Section 7545(h)(4) plainly should be read to apply to *all* blends containing 10 percent ethanol, including blends containing more than that concentration. E15 contains 10 percent ethanol, just as the statute requires, plus an additional five percent. It therefore meets the 10 percent requirement. By analogy, consider a traffic regulation stating that "you must have four people in your car to use the high-occupancy-vehicle lane." Just as it would be unreasonable to prohibit cars with five or more passengers from using the HOV lane, it is unreasonable to interpret Section 7545(h)(4) to prohibit ethanol blends containing more than 10 percent ethanol from eligibility for a 1-pound RVP waiver. The purpose of Section 7545(h)(4) is to promote higher concentrations of ethanol in gasoline, like the purpose of HOV lanes is to promote higher concentrations of people in cars. Thus, it is clear that Congress intended for Section 7545(h)(4) to establish a minimum rather than a maximum ethanol concentration threshold for the RVP waiver.

Alternatively, and consistent with the purpose of Section 7545(h)(4), EPA could invoke Section 7545(h)(4)'s "deeming compliant" clause to extend the one-pound RVP waiver to E15.[156] In the E15 misfueling rule, EPA wrote that this clause "is not written as a free standing RVP limit that acts separate and apart from the 1 psi waiver for 9-10% blends of ethanol."[157] That interpretation would nullify the "deeming" clause, whose obvious purpose is to bring within the statute behavior that otherwise would not qualify. Thus, by its terms this clause encompasses *any* fuel that complies with the terms of paragraphs (A)-(C). In particular, paragraph (B) contemplates a separate potential ceiling that Section 7545(f) may impose on ethanol content—a ceiling that exceeded 10 percent when EPA granted the waiver for E15.

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[153] *Regulations To Mitigate the Misfueling of Vehicles and Engines with Gasoline Containing Greater Than Ten Volume Percent Ethanol and Modifications to the Reformulated and Conventional Gasoline Programs*, 76 Fed. Reg. 44,406, 44,435 (July 25, 2011) ("Misfueling Regulation").

[154] *See* Growth Energy Comments on E15 Misfueling Regulation, at 15 (posted Jan. 4, 2011), EPA-HQ-OAR-2010-0448-0083.

[155] Misfueling Regulation at 44,434-44,435.

[156] That clause provides that a party "shall be deemed to be in full compliance with the provisions of the subsection and the regulations promulgated thereunder if it can demonstrate that—(A) the gasoline portion of the blend complies with the Reid vapor pressure limitations promulgated pursuant to this subsection; (B) the ethanol portion of the blend does not exceed its waiver condition under subsection (f)(4) of this section; and (C) no additional alcohol or other additive has been added to increase the Reid Vapor Pressure of the ethanol portion of the blend." 42 U.S.C. § 7545(h)(4).

[157] Misfueling Regulation at 44,433.

Congress thus contemplated that the RVP allowance would extend to blends containing more than 10 percent ethanol.

Second, EPA must update its interpretation of "substantially similar" under Section 7545(f)(1) of the Clean Air Act to reflect current certification fuels. Done properly, such an interpretation would allow for the introduction of E15 year-round without the need for a waiver under Section 7545(f)(4).

EPA has not issued a new interpretive rule since 2008, despite mandating use of E15 as a mileage accumulation fuel for evaporative durability testing and changing the certification standardized test fuel from Indole (E0) to E10.[158] Whether a proposed fuel meets the definition of "substantially similar" requires identifying the relevant comparator fuel, which, under the plain language of Section 7545(f)(1), must include "any" fuel or fuel additive used in the certification of "any" model-year 1975 or later vehicle or engine under Section 7525. EPA's current interpretation fails to meet this requirement because it fails to account for the fact E15 is currently used as a test fuel. Indeed, EPA's current interpretation also fails to account for the fact that E10 is used as a standardized test fuel.

To remedy this failure, EPA should revise its "substantially similar" definition to reflect that E15 is substantially similar to certification fuels in all material respects. E15 is substantially similar to E10 certification fuel with respect to its physical and chemical properties. The ethanol additive is identical, and both E10 and E15 meet the current ASTM standard. E15 is also substantially similar to E10 certification fuel with respect to evaporative and exhaust emissions. In fact, it produces lower evaporative emissions than E10 when using the same base gasoline, and available data indicate that compared with E10, E15 has lower exhaust emissions of carbon monoxide (CO) and hydrocarbons (HC), among other pollutants, particularly for current motor vehicle fleet technology.[159] Finally, service accumulation for

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[158] *See Regulation of Fuels and Fuel Additives: Revised Definition of Substantially Similar Rule for Alaska*, 73 Fed. Reg. 22,277 (Apr. 25, 2008).

[159] *See* Stefan Unnasch and Ashley Henderson, Life Cycle Associates, *Change in Air Quality Impacts Associated with the Use of E15 Blends Instead of E10*, LCA.6091.94.2014 (July 2014), http://cleartheairchicago.com/files/2014/09/E15-Clean-Air-Benefits-Study.pdf (literature review examining emissions of NOx; CO; PM; non-methane HC; ozone potential; and cancer risk from air toxics); *see also id.* at 6 ("The most significant changes from a change from E10 to E15 include a reduction in cancer risk from vehicle exhaust and evaporative emissions, a reduction in the potential to form ozone or photochemical smog, and a reduction in greenhouse gas (GHG) emissions."); Robert L. McCormick, *et al.*, Nat'l Renewable Energy Lab (NREL), *Review and Evaluation of Studies on the Use of E15 in Light-Duty Vehicles*, 32-34, 39-41 (Oct. 2013), https://ethanolrfa.org/wp-content/uploads/2015/09/RFA-NREL-Review-and-Evaluation-of-E15-Studies-Pages-17-to-29.pdf; Letter from Robert L. McCormick, NREL, and Janet Yanowitz to Kristy Moore, "Effect of Ethanol Blending on Gasoline RVP Memo" (March 2012), https://ethanolrfa.org/wp-content/uploads/2015/09/RVP-Effects-Memo_03_26_12_Final.pdf.

evaporative emissions durability is evaluated in the certification process using fuel that contains the highest ethanol concentration currently available in any state, i.e., E15.

Finally, EPA should finalize its Guidance for E85 Flexible Fuel Vehicle Weighting Factor for Model Years 2016-2019 Vehicles Under the Light-Duty Greenhouse Gas Emissions Program, which it proposed in March 2013, and in doing so revise the proposed treatment of E15.[160] The draft guidance would in effect penalize FFVs for using E15 by not treating it as an alternative fuel (unlike E85). When E15 consumption is high, those volumes of E15 would be considered as having been blended into the base gasoline pool and the amount of alternative fuel is reduced significantly. More importantly, automobile manufacturers receive no greenhouse gas emissions credit for using E15 (or higher blends). Ethanol's greenhouse-gas emissions performance is substantially better than baseline gasoline (i.e., E0) on a life-cycle basis,[161] so moving from E10 to E15 or higher blends would yield additional greenhouse-gas benefits for light-duty vehicles. Issuing revised guidance to count E15 and medium-blend fuels as alternative fuel for purpose of calculating the "F" factor would more accurately reflect these blends' environmental benefits and would encourage car makers to produce more FFVs.

VII. EPA CORRECTLY DID NOT PROPOSE TO ISSUE A GENERAL WAIVER FOR SEVERE ECONOMIC HARM

EPA did not propose to issue a general waiver based on severe economic harm. That is the right decision; such a waiver is not warranted. EPA has consistently rejected requests for severe economic harm waivers—including most recently in the 2018 Rule—because it correctly recognized that this waiver provision is meant for very narrow circumstances that have never been met. In fact, in 2018 EPA determined that it did not even need to reconsider its prior interpretation of the general waiver provision because the circumstances did not demonstrate severe economic harm under *any* reasonable interpretation of the term. EPA's longstanding interpretation is correct, and the circumstances have only further strengthened the determination that a severe economic harm waiver is not appropriate for 2019.

If EPA *were* inclined to issue such a general waiver, however, it would be required first to present an actual "comprehensive and robust analytical basis" for that decision—not the passing invitation for comment included in the current NPRM—and provide an opportunity for public comment on *that* analysis.[162] Only then could EPA have a lawful basis for exercising this authority.

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[160] *Draft Guidance for E85 Flexible Fuel Vehicle Weighting Factor for Model Years 2016- 2019 Vehicles Under the Light-Duty Greenhouse Gas Emissions Program*, 78 Fed. Reg. 17,660 (Mar. 22, 2013).

[161] *See supra* at 1.

[162] *Notice of Decision Regarding the State of Texas Request for a Waiver of a Portion of the Renewable Fuel Standard*, 73 Fed. Reg. 47,168, 47,183-47,184 (Aug. 13, 2008) ("Texas Waiver Decision").

A. EPA Has Consistently Interpreted the Severe Economic Harm Waiver to Apply Only in Very Narrow Circumstances and It Should Adhere to That Interpretation

1. 2008 and 2012 Waiver Decisions

Under the RFS statute, EPA may waive an RFS volume requirement if it determines "after public notice and opportunity for comment, that implementation of the requirement *would severely harm* the economy or environment of a State, a region, or the United States."[163] EPA considered the severe harm standard at length in 2008, under the George W. Bush administration when it denied the State of Texas's request for such a waiver of the 2008/2009 standards.[164] Then, in 2012, EPA revisited and reaffirmed that interpretation under the Obama administration, again denying a severe harm waiver.[165] Those well-reasoned decisions set forth several longstanding principles that continue to control the determination of whether EPA may—and should—issue a waiver:

First, "implementation of the RFS program *itself* must be the cause of the severe harm."[166] It is not sufficient to show even that "implementation of the program would *significantly contribute* to severe harm" in combination with other factors unrelated to the RFS's implementation.[167] Thus, as EPA explained, if the market were experiencing a certain kind of severe harm (e.g., prohibitively high crop prices), and the RFS program was a significant contributor to that harm but there were other contributing factors, too (e.g., drought or insufficient farmland), that would *not* suffice to make the waiver available.[168]

Second, the statute sets a "high threshold" for issuance of a waiver: "'severe' indicates a level of harm that is greater than marginal, moderate, or serious, though less than extreme."[169] In fact, "severe[] harm" is "clearly a much higher threshold than [the] 'significant adverse impacts'" standard applied by EPA in the ozone nonattainment context.[170] As EPA previously determined, for example, even "the substantial negative economic impacts suffered as a result of [2011's] historic drought," which had "taken a large toll on many States and sectors of the

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[163] 42 U.S.C. § 7545(*o*)(7)(A)(i) (emphasis added).

[164] Texas Waiver Decision.

[165] *Notice of Decision Regarding Requests for a Waiver of the Renewable Fuel Standard*, 77 Fed. Reg. 70,752 (Nov. 27, 2012) ("2012 Waiver Decision").

[166] Texas Waiver Decision at 47,171 (emphasis added).

[167] *Id.* (emphasis added).

[168] *Id.*

[169] *Id.* at 47,172.

[170] *Id.*

economy," including raising the price of U.S. corn and other feedstocks, did not qualify as severe harm to the economy.[171]

Third, it is not enough that severe harm *might* result, or even that severe harm is *likely* to result. Rather, EPA must have a "high degree of confidence" that severe harm *would* result but for a waiver.[172] As EPA has explained, "in situations where there is not such a high degree of confidence, a waiver might disrupt the expected growth in use of renewable fuels but there would be no clear expectation that a waiver would provide a benefit by reducing any harm."[173]

Fourth, the statute's use of the word "economy" means that the harm must be considered in light of the economy as a whole, not any one sector of it (e.g., the oil industry, or the poultry industry). EPA has explained: "[I]t would be unreasonable to base a waiver determination solely on consideration of impacts of the RFS program to one sector of the economy, without also considering the impacts of the RFS program on other sectors of the economy or on other kinds of impact. It is possible that one sector of the economy could be severely harmed, and another greatly benefited from the RFS program; or the sector that is harmed may make up a quite small part of the overall economy."[174]

Fifth, EPA has "discretion in determining whether to grant or deny a waiver request, even in instances where EPA finds that implementation of the program would severely harm the economy or environment of a State, region or the United States."[175] Because a waiver "will always … be national in character," EPA has decided that even if the qualifying "severe harm" is limited to a certain state or region, EPA should not as a matter of policy exercise that discretion without "look[ing] broadly at all of the impacts of implementation of the program, and all of the impacts of a waiver," including "the nationwide effects" of a waiver.[176]

Sixth, although EPA recognized that it may be appropriate to *deny* a severe harm waiver summarily, it is not proper to *grant* one without a "comprehensive and robust analytical basis for any claim that the RFS itself is causing harm, and the nature and degree of that harm," and without the public having notice of and an opportunity to comment on the details of that analysis.[177]

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[171] 2012 Waiver Decision at 70,753, 70,775.

[172] Texas Waiver Decision at 47,172.

[173] *Id.*

[174] *Id.*

[175] *Id.*

[176] *Id.*

[177] *Id.* at 47,183-47,184.

2. 2017 and 2018 Waiver Decisions

EPA next considered the severe harm waiver in the course of the 2017 and 2018 RVO rulemakings. Both times, EPA correctly concluded that the standard for a general waiver due to severe economic harm was not met.

In the 2017 RVO rulemaking, EPA set the total renewable fuel volume requirement to 19.28bg, and set the implied volume for conventional renewable fuels—most of which would be starch ethanol—to 15.00bg.[178] EPA judged those volumes "reasonably attainable,"[179] taking into account all factors potentially affecting the ability of the market to produce, dispense, and consume renewable fuel, including the potential for market disruptions and price effects as well as "factors related to the likely constraints on imports, distribution and use, and global GHG impacts of incremental growth."[180] The analysis underlying the final 2017 volume requirements, therefore, left no room to conclude that implementing those requirements would severely harm the economy, as EPA recognized: "In light of our finding that the volume requirements and associated standards being finalized are reasonably attainable, it follows that the final requirements will not cause severe economic harm, so further reductions on that basis are not necessary."[181]

EPA reached the same conclusion in setting the 2018 total requirement at 19.29bg and the implied conventional requirement at 15.00bg.[182] After providing commenters two opportunities to present a basis to conclude that a severe economic harm waiver was warranted—in the notice of proposed rulemaking and a subsequent request for further comment[183]—EPA found that no commenter "provided compelling evidence that the proposed RFS volume

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[178] 2017 RFS Rule at 89,747, 89,773, 89,780-89,781.

[179] *Id.* at 89,774, 89,780-89,782. Although under EPA's now-vacated approach to the general waiver, it assessed the "maximum achievable" volume of renewable fuel, EPA assessed the "reasonably attainable" volume of renewable fuel—a potentially lesser amount—in deciding how much of the cellulosic waiver to flow through to the advanced and total volume requirements. *See id.* at 89,774 n.103, 89,777-89,779 n.119.

[180] *Id.* at 89,763, 89,773-89,775; 2014-2016 RFS Rule at 77,435, 77,440-77,452.

[181] EPA, Renewable Fuel Standards for 2017 and Biomass-Based Diesel Volume for 2018, Response to Comments, at 53 (Dec. 2016), EPA-HQ-OAR-2016-0004-3753.

[182] 2018 RFS Rule at 58,487-88, 58,517-18.

[183] 82 Fed. Reg. 34,206, 34,229 (July 1, 2017) ("2018 NPRM"); 82 Fed. Reg. 46,174, 46,179 (Oct. 4, 2017) ("2018 Request for Further Comment"). Growth Energy provided comments in response to both requests. Those comments are attached and incorporated into this comment. *See* 2018 Growth Energy Comment; Supplemental Comments of Growth Energy, Archer Daniel Midlands Company and Biotechnology Innovation Organization (Oct. 19, 2017) ("2018 Growth Energy Supplemental Comment") (attached as Exhibit 5), EPA-HQ-OAR-2017-0091-4886.

requirements would be likely to cause severe economic harm to a region, State, or the U.S." and the arguments presented in support for a waiver were "unconvincing."[184]

EPA divided its analysis into several parts. First, as in 2017, EPA concluded that the finalized 2018 requirements were "reasonably attainable."[185] It determined that it was reasonable to assume the market could reach a poolwide ethanol concentration of 10.13% in 2018, the same concentration that EPA had determined was reasonable to attain in the 2017 final rule.[186] EPA noted that "the national average ethanol content of gasoline rose from 9.91% in 2015 to 10.02% in 2016" and that an "increase to 10.13% in 2017, as projected in the 2017 final rule, would be a smaller increment than that which occurred between 2015 and 2016," let alone what might occur from 2017 to 2018.[187] EPA then determined that, at that level of ethanol consumption, the market could reach the finalized requirements by simply increasing use of biomass-based diesel consistent with its historical average growth (which increase would not be subject to any production, feedstock, distribution, or consumption constraints) and otherwise sustaining past levels of use of other non-ethanol renewable fuels.[188]

Second, EPA explained that refineries that claimed that RIN costs were creating significant economic burdens and distress "did not provide sufficient evidence that the purchase of RINs, as opposed to other market factors, is responsible for the compan[ies'] difficult economic circumstances, or why they cannot recoup the cost of RINs through higher prices of their products."[189] In reaching this conclusion, EPA relied in part on several of its prior analyses showing that refiners are able to recover their RIN costs by charging blenders higher blendstock prices.[190] For instance, in its November 2017 denial of the petition to change the point of obligation, EPA carefully reviewed available literature and found that independent studies by

[184] 2018 RFS Rule at 58,517-58,518.

[185] *See generally* David Korotney, U.S. EPA, Office of Transportation and Air Quality, *Market impacts of biofuels* (Nov. 27, 2017) ("2018 Market Impacts Memorandum"), EPA-HQ-OAR-2017-0091-4963.

[186] *Id.* at 5-6.

[187] *Id.* at 5-6.

[188] *Id.* at 6-11.

[189] 2018 RFS Rule at 58,517.

[190] David Korotney, U.S. EPA, Office of Transportation and Air Quality, *Assessment of waivers for severe economic harm or BBD prices for 2018*, 5-6 (Nov. 30, 2017) ("2018 Severe Economic Harm Memorandum"), EPA-HQ-OAR-2017-0091-4925 (citing Dallas Burkholder, Office of Transportation and Air Quality, EPA, *A Preliminary Assessment of RIN Market Dynamics, RIN Prices, and Their Effects* (May 14, 2015) ("May 2015 Burkholder Memorandum"), EPA-HQ-OAR-2017-0091-0008, and EPA, *Denial of Petitions for Rulemaking to Change the RFS Point of Obligation* (Nov. 22, 2017) ("Denial"), EPA-HQ-OAR-2016-0544-0525). EPA also has reiterated this point in other places. *See, e.g.*, Dallas Burkholder, et al., *Screening Analysis for the Renewable Fuel Standard Program Renewable Volume Obligations for 2018* (June 28, 2017), EPA-HQ-OAR-2017-0091-0097.

Knittel et al. and Argus Consulting Services presented "compelling evidence" of this conclusion.[191] EPA's determination was consistent with other papers that were in the record.[192] It also found that refineries' submissions to the contrary were unpersuasive.[193] EPA further noted that "refining margins in the United States have decreased significantly in recent years due to an excess supply" and thus EPA believed that "it is most likely these lower refining margins, rather than any cost associated with the RFS program, that are currently negatively impacting the domestic refining industry."[194] In fact, "total refining capacity has significantly increased since 2013 when D6 RIN prices first rose above a few cents per RIN," which is "notable because aggregate U.S. refining production would be expected to decline as the RFS program displaces petroleum fuels with renewable fuels."[195] Outside expert analysis supports this determination: as

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[191] Denial at 25-26 (citing Christopher R. Knittel, Ben S. Meiselman, and James H. Stock, *The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard* (Nov. 2016) (attached as Exhibit 6); Christopher R. Knittel, Ben S. Meiselman, and James H. Stock, *The Pass-Through of RIN Prices to Wholesale and Retail Fuels under the Renewable Fuel Standard, Analysis of Post-March 2015 Data* (Nov. 23, 2016); Argus Consulting Services, *Do Obligated Parties Include RIN Costs in Product Prices?* (Feb. 2017) (attached as Exhibit 7)). EPA carefully rebuffed the oil industry's attempts to undermine these analyses. *Id.*

[192] *See, e.g.*, Bruce A. Babcock, Gabriel E. Lade, and Sebastien Pouliot, *Impact on Merchant Refiners and Blenders from Changing the RFS Point of Obligation*, CARD Policy Brief 16-PB 20 (Dec. 2016) (attached as Exhibit 8), http://www.card.iastate.edu/products/publications/pdf/16pb20.pdf; Edgeworth Economics, *Economic Issues Associated with a Change of the RFS Point of Obligation* (Feb. 22, 2017) (attached as Exhibit 9), EPA-HQ-OAR-2016-0544-0193.

[193] Denial at 24-25. EPA explained that some oil industry comments simply assumed that RIN costs were not passed through to blenders at all. *Id.* at 24. Another oil industry comment purported to show that blenders were retaining a portion of the RIN value by examining correlations between RIN prices and estimated blender margins, but EPA found that "there are many other factors that impact blender margins other than RIN prices that were changing simultaneously," none of which were "addressed in the study." *Id.* And yet another such comment suffered from "fundamental flaws," such as using gasoline prices from South Dakota but ethanol data from Chicago. *Id.* at 24 n.66.

[194] 2018 Severe Economic Harm Memorandum at 5 & n.10 (additionally stating that "individual refiners may have been impacted by factors such as unusually high price spreads between varying types of crude oil from 2011-2014 and the recent legislative changes allowing crude oil exports [from] the United States").

[195] 2018 Severe Economic Harm Memorandum at 6. EPA also explained why this decision is fully consistent with its decision to grant small refinery exemptions: "The granting of hardship exemptions to small refineries has focused on the disproportionate hardship conditions of an individual refinery, and therefore the granting of such exemptions does not indicate that the RFS program is causing severe harm to 'the economy of a State, a region, or the United States.'" Response to Comments on 2018 RFS Rule at 24. Indeed, concluding otherwise would read the term "severe" out of the statute, and would ignore the nationwide analysis of costs and benefits that is required for the severe economic harm provision.

explained above, a recent study found that the RFS program has not taken away from domestic refining capacity but rather freed up that capacity to expand U.S. exports.[196]

Third, EPA similarly rejected claims of harm by small retailers.[197] As EPA explained in its denial of the petition to change the point of obligation, these claims were rooted in the faulty assumption that large retailers with blending operations have been experiencing "windfall profits" due to RIN sales that have allowed them to outcompete small retailers.[198] That assumption failed for the same reason noted above—it ignored the fact that refineries are passing RIN costs to blenders through higher blendstock prices. EPA supported this conclusion not only with the studies cited above but also with its analysis of reported income by blenders such as MurphyUSA.[199] EPA explained that "we believe that the significant challenges faced by many small retailers are rather the result of challenges in the retail fuels market such as a declining demand for refined transportation fuels (particularly gasoline), increased competition from large retailers and high-volume retail outlets, a lack of flexibility in fuel purchasing options relative to larger (often unbranded) retailers, and many others."[200]

Fourth, EPA found that consumers of transportation fuel are not being harmed by the RFS program because EPA has long found that "higher RIN prices do not result in higher prices for transportation fuel."[201] As EPA found in a 2015 docket memorandum and then reiterated in 2017, RIN prices generally decrease the effective price of renewable fuel, while increasing the effective price of fossil fuel.[202] "[T]hese two price impacts generally offset one another for fuel blends such as E10 with a renewable content approximately equal to the required renewable fuel percentage standard."[203]

Fifth, EPA rejected the frivolous argument advanced by the oil industry that simply exceeding a poolwide concentration of 9.7% ethanol in gasoline causes severe economic harm.[204] As EPA explained, "the market exceeded 9.7% in 2013 and every year since," reaching 10.02% in 2016, yet "[t]here were no claims by commenters, and EPA is not aware of any other persuasive indicators in the record, to suggest that severe economic harm was occurring to a State, a region or the United States in 2013 through 2016."[205]

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[196] *See supra* Part I.

[197] 2018 Severe Economic Harm Memorandum at 6.

[198] Denial at 31-32.

[199] *Id.* at 27-31.

[200] *Id.* at 32.

[201] Response to Comments on 2018 RFS Rule at 23.

[202] May 2015 Burkholder Memorandum at 14-21; Denial at 20-21.

[203] Denial at 21.

[204] 2018 Severe Economic Harm Memorandum at 3-4.

[205] *Id.* at 3-4.

Sixth, EPA conducted a high-level investigation of a number broad economic indicators in 2017—fuel prices, fuel supply, crop prices, and refinery closures—and found that all were more favorable in 2017 than in prior years, such as 2012, when EPA had concluded that no severe harm was occurring.[206] Moreover, EPA found that even if these indicators were to have worsened, that could not be determined to be caused by the RFS program.[207] EPA also looked at crop-based feedstock futures prices and projected gasoline demand, and found no basis to conclude that conditions in 2018 would be any different than 2017.[208]

Finally, EPA declined to reconsider its prior interpretation of the severe harm waiver set forth in the 2008 and 2012 waiver decisions. Although EPA had solicited comment on whether that interpretation should be reconsidered,[209] EPA stated that no reconsideration was necessary: "we believe the evidence in the record would be insufficient to support a finding of severe economic harm under *any* reasonable interpretation of the phrase advanced by commenters, so do not find it necessary to assess changes to our interpretation of the phrase at this time."[210]

3. These principles remain sound

Unlike in 2018 when it requested further comment on the issue, EPA has not signaled in this NPRM that it is considering departing from these principles (and so EPA cannot do so in this rulemaking). In any event, the principles are correct, and EPA cannot and should not depart from them. They resulted from EPA's careful and extensive analysis of the statute's language, context, purpose, and history.[211] Indeed, they are not only textually required; they are critical to the functioning of the RFS program. The program depends on market participants having the long-term certainty that EPA will adhere to the statutorily prescribed volume requirements, so that they can make investments in the necessary infrastructure with an expectation that the investment will pay off.[212] Thus, EPA recognized that Congress did not intend to provide in the severe harm provision an "open-ended and wide ranging waiver."[213] Rather, EPA found that "implementing a more limited waiver provision … will better implement Congress's overall desire to promote the use of renewable fuels, reflected in enacting the expanded RFS program and mandating the increased utilization of renewable fuels over a number of years."[214] The D.C. Circuit has since reinforced these points when it pointedly rejected the notion that Congress

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206 2018 RFS Rule at 58,518; 2018 Severe Economic Harm Memorandum at 7-13.

207 2018 Severe Economic Harm Memorandum at 10-11, 13.

208 2018 RFS Rule at 58,518; 2018 Severe Economic Harm Memorandum at 14-15.

209 2018 Request for Further Comment at 46,179.

210 2018 RFS Rule at 58,518 n.139 (emphasis added); 2018 Severe Economic Harm Memorandum at 15-16.

211 Texas Waiver Decision at 47,170-47,172; 2012 Waiver Decision at 70,756, 70,773-70,775.

212 *See* 2014-2016 RFS Rule at 77,433, 77,456, 77,459-77,460; *Monroe Energy*, 750 F.3d at 917.

213 Texas Waiver Decision at 47,171.

214 *Id.*

provided a "boundless general waiver authority."[215] Such a broad waiver authority would interfere with "how the Renewable Fuel Program is supposed to work" through "increasing requirements [that] are designed to force the market to create ways to produce and use greater and greater volumes of renewable fuel each year."[216]

There are additional reasons to adhere to EPA's longstanding principles. For example, the principle that implementation of the RFS program *itself* must be the cause of the severe harm simply reflects the common notion of "but for" causation: if the severe harm would not result *but for* the implementation of the program, it cannot be said that implementation "would … harm" the economy (or the environment).[217] Put another way, if a general waiver would not prevent the harm, EPA may not issue the waiver. That makes eminent sense; Congress would not have set up volume requirements to force the market to increase renewable fuel use only to allow EPA to negate the requirements unnecessarily. As both the D.C. Circuit and EPA have observed repeatedly, Congress did not enact "a very open-ended and wide ranging waiver provision."[218] And the D.C. Circuit further confirmed that the statute sets a high threshold for issuance of a waiver when it recognized that "lesser degrees of economic harm," such as heightened RIN prices and other compliance costs, do not satisfy the "severely harm" prong of the general waiver provision (or the "inadequate domestic supply" prong, for that matter).[219]

B. Implementation of the Proposed 2019 Volume Requirements Would Not Cause Severe Economic Harm

The principles described above regarding the proper interpretation of the severe economic harm waiver provision ensure that the severe harm waiver may be invoked only if EPA is *highly confident* that without a waiver, the RFS program would cause *severe* and *widespread* harm. Under that interpretation—which, as just explained, was correct—it is clear that such a waiver is unavailable for 2019. Nonetheless, in setting the 2018 RVOs EPA declined to issue a severe economic harm waiver without even applying these principles because it found

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[215] *ACE*, 864 F.3d at 711; *see also National Petrochemical & Refiners Ass'n*, 630 F.3d at 149 ("The EISA authorized the waiver of the volume requirements only in limited circumstances.").

[216] *ACE*, 864 F.3d at 710.

[217] *See, e.g.*, *Burrage v. United States*, 571 U.S. 204, 209-216 (2014) (holding that "ordinary meaning" of phrases like "results from," "because of," and "based on" "requires proof that the harm would not have occurred in the absence of—that is, but for—the defendant's conduct," not merely that the harm resulted "from a combination of factors to which [defendant's conduct] merely contributed," and noting "no case has been found where the defendant's act could be called a substantial factor when the event would have occurred without it" (quotation marks and citations omitted)).

[218] Texas Waiver Decision at 47,171; *see ACE*, 864 F.3d at 711 (rejecting interpretation that would accord EPA "boundless general waiver authority").

[219] *ACE*, 864 F.3d at 712 (quotation marks omitted).

that there was no basis for a waiver under *any* interpretation of the statutory language.[220] EPA could take the same approach, and reach the same conclusion, for 2019.

1. EPA Should Simply Apply Its Reasoning from the 2018 RVO Rulemaking to Conclude That a 2019 Waiver Is Inappropriate

EPA is clearly correct when it concludes in the 2019 NPRM that the proposed requirements of 19.88bg of total renewable fuel, and 15.00bg of implied conventional renewable fuel, are "reasonably attainable."[221] EPA reaches this conclusion by assuming that the poolwide ethanol concentration can be 10.11% in 2019, and then assuming that BBD volumes can reach 3.2bg in 2019.[222] These assumptions are reasonable. As EPA notes, a 10.11% poolwide ethanol concentration is the same level that the market *actually* achieved in 2017.[223] And the 3.2bg BBD calculation is based on simply assuming that historical growth rates continue on top of the volume EPA determined was achievable for 2018 (which was the same level EPA determined was achievable for 2017).[224]

Moreover, EPA's well-supported reasoning and conclusions in the 2018 Rule and the denial of the petition to the change the point of obligation—that refiners, small retailers, and consumers are not experiencing economic harm, let alone severe harm—all apply with equal force today.[225] These are now long settled determinations by the agency and there is no material change in circumstances that would justify revisiting them.

Insofar as EPA found it useful to examine several broad economic indicators in concluding that there would be no severe economic harm in finalizing the 2018 RVOs, those same indicators support the same conclusion today. Just as EPA found in setting the 2018 RVOs,[226] retail gasoline, retail diesel, corn, corn futures, soybean, and soybean futures prices

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[220] 2018 Severe Economic Harm Memorandum at 15-16.

[221] *See generally* David Korotney, U.S. EPA, Office of Transportation and Air Quality, *Market impacts of biofuels in 2019* (June 26, 2018) ("2019 Market Impacts Memorandum"), EPA-HQ-OAR-2018-0167-0025.

[222] *Id.* at 3, 6-7.

[223] *Id.* at 3.

[224] *Id.* at 7-8.

[225] *Supra* Part VII.A.2.

[226] 2018 Severe Economic Harm Memorandum at 8-14.

today remain well lower than they were in 2012 when EPA found no severe economic harm.[227] Similarly, U.S. supplies of finished gasoline and diesel are comparable to the amounts from a year ago,[228] and total operating refinery crude oil distillation capacity is comparable to last year's (and above where it was in any prior year).[229] Finally, projected gasoline demand has increased yet again,[230] meaning that "we would expect the market to be able to consume more ethanol as E10, and at least the same volume of ethanol overall, in [2019] as compared to" 2018.[231]

For these reasons, the logic that compelled EPA to deny a severe economic harm waiver in the 2018 Rule is only stronger today and thus compels the same conclusion for 2019.

2. A Severe Economic Harm Waiver Could Not Be Exercised Without Accounting for the Available Compliance Flexibilities, Including the RIN Bank, Small Refinery Exemptions, and the Ability to Carry Deficits Forward, Which Prevent Severe Economic Harm

Another strong reason that implementation of the proposed total volume requirement would not cause severe harm to the economy is the availability of important compliance flexibilities for obligated parties to mitigate such harm, including a large bank of carryover RINs, the ability to carry over RIN deficits, and small refinery exemptions. EPA would have to account for these flexibilities in evaluating whether the waiver can and should be exercised.

That EPA must assess the potential for severe harm in light of all compliance circumstances follows from both the text and purpose of the statute. Use of other waiver authorities and compliance flexibilities is part of the "implementation" of the volume

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227 *See* USDA, National Agricultural Statistics Service, *Charts and Maps*, https://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/ (last visited Aug. 17, 2018); U.S. Energy Information Administration, *Gasoline and Diesel Fuel Update*, https://www.eia.gov/petroleum/gasdiesel/ (last visited Aug. 17, 2018); CME Group, *Corn Futures Quotes*, https://www.cmegroup.com/trading/agricultural/grain-and-oilseed/corn.html (last visited Aug. 17, 2018); CME Group, *Soybean Futures Quotes*, https://www.cmegroup.com/trading/agricultural/grain-and-oilseed/soybean.html (last visited Aug. 17, 2018).

228 *See* U.S. Energy Information Administration, *Petroleum & Other Liquids: Product Suppled*, https://www.eia.gov/dnav/pet/pet_cons_psup_dc_nus_mbbl_m.htm (last visited Aug. 17, 2018).

229 *See* U.S. Energy Information Administration, *Petroleum & Other Liquids: Number and Capacity of Petroleum Refineries*, https://www.eia.gov/dnav/pet/pet_pnp_cap1_dcu_nus_a.htm (last visited Aug. 17, 2018).

230 *Compare* 2019 Market Impacts Memorandum at 5 (showing that 14.36bg of ethanol could be consumed as E10 in 2019 according to April Short-Term Energy Outlook) *with* 2018 Market Impacts Memorandum at 5 (showing that 14.31bg of ethanol could be consumed as E10 in 2018 according to October Short-Term Energy Outlook).

231 2018 Severe Economic Harm Memorandum at 14.

requirements.[232] Because the statute's various waiver authorities and compliance flexibilities could mitigate or eliminate harm, it cannot be said with any degree of confidence—let alone the requisite "high degree of confidence"—that implementation of a volume requirement "would" result in harm without accounting for the full range of those waiver authorities and compliance flexibilities. Were it otherwise, EPA could use the severe harm waiver to undermine the RFS program's ability to force market growth in renewable fuels by reducing volume requirements unnecessarily—something, again, the D.C. Circuit recently made clear the statute should not be interpreted to permit.[233]

EPA recognized this point in 2012, when it concluded that it was necessary to consider carryover RINs (also called "rollover RINs") as part of the analysis of whether severe economic harm would result. EPA explained: "the availability of rollover RINs can significantly affect the potential impact of implementation of the RFS volume requirements."[234] Accordingly, EPA modeled the availability of "one rollover RIN [as] equivalent to one liquid gallon of ethanol: both equally satisfy the RFS requirements, and thus both are sources of ethanol to draw upon in the model."[235] EPA noted that "if significant numbers of rollover RINs (i.e., 2.0 billion or more) are available [academic] studies suggest that the effect of a waiver [in potentially reducing purported harm] is significantly smaller."[236]

EPA underscored this general point in the 2018 Rule as well, when it rejected the arguments of the oil industry that it should assess the severe harm condition against the *statutory* volumes, noting that it would be "reasonable" to assess the severe harm waiver only after

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[232] 42 U.S.C. §7545(*o*)(7)(A)(i).

[233] That the D.C. Circuit concluded that carryover RINs need not be considered for purposes of the "inadequate domestic supply" prong of the general waiver does not alter this conclusion. *See ACE*, 864 F.3d at 714 (noting that the text "inadequate domestic supply" was controlling in its analysis of carryover RINs). The D.C. Circuit's analysis turned on the ambiguity of the word "supply" in a different statutory provision; there is no ambiguity that EPA must conclude that implementation of the RFS (which necessarily includes its flexibilities) would cause severe economic harm.

[234] 2012 Waiver Decision at 70,759.

[235] *Id.* at 70,758.

[236] *Id.* at 70,759.

reducing the volumes pursuant to the cellulosic waiver authority.[237] In so doing, EPA properly characterized the question as whether volumes lower than the finalized requirements would be "*necessary* to prevent causing severe economic harm."[238] That could not be true if existing RFS flexibilities would allow the market to address any purported harms that may arise.

Accordingly, to apply the severe economic harm waiver, EPA would have to take into account other waiver authorities like the cellulosic waiver, the market's ability to use existing carryover RINs, its opportunity to use carryover deficits, and the availability of other relief such as small refinery exemptions, and *still* conclude that, nonetheless, implementation of the statutory requirements would cause severe harm to the economy.

No such conclusion is possible today. According to EPA, the market generated 18.7 billion net RINs in 2017,[239] and EPA estimates that there are currently approximately 3.06 billion carryover RINs (far more than the 2 billion RINs EPA considered significant in 2012).[240] Thus, even if the market simply maintained its 2017 level of net RIN generation—a level that plainly did not cause severe economic harm—the market could achieve the proposed volume of 19.88 billion RINs in 2019 and still have more than 1.89 billion RINs in the carryover bank. And that does not even consider the possibility of carryover deficits.

Nor can there be any argument that reducing the bank—by that amount or more—somehow "would" cause severe economic harm. EPA has said that the purpose of the bank is to create a buffer to address unforeseen circumstances such as natural disaster.[241] EPA's concern is that such circumstances *might* occur, which in turn *might* result in a RIN shortfall that (EPA erroneously claims) *might not* be adequately addressed through carryover deficits.[242] The layers and layers of speculation required before the reduction or elimination of the bank could lead to

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[237] This interpretation is not just reasonable but required. Although the statute authorizes EPA to waive a volume requirement "in whole or in part," that language does not vest EPA with discretion to reduce the volume requirement to whatever level it sees fit or to any point other than the one necessary to avoid the triggering *severe* harm, any more than it permits EPA to reduce a volume requirement due to "inadequate domestic supply" past the point of "domestic supply." Such power would contravene the D.C. Circuit's conclusion that the statute cannot be interpreted to accord EPA "boundless general waiver authority." *ACE*, 864 F.3d at 711. On the contrary, the phrase "in whole or in part" emphasizes that EPA must calibrate the size of the waiver to go no further than necessary to avoid the condition that triggered the waiver (whether that be a partial or complete waiver).

[238] 2018 Severe Economic Harm Memorandum at 6-7 (emphasis added).

[239] EPA, 2017 Supply (Mar. 13, 2018), EPA-HQ-OAR-2018-0167-0003.

[240] NPRM at 32,029.

[241] 2014-2016 RFS Rule at 77,483.

[242] *Id.* at 77,483-77,484.

tangible severe economic harm is far below the required "high degree of confidence" that severe harm "would" result.[243]

Finally, as explained above, EPA has recently been using small refinery exemptions to effectively lower volume requirements by hundreds of millions or even billions of RINs. As also explained above (and elsewhere[244]), EPA's approach to evaluating petitions to extend small refinery exemptions is impermissible for various reasons. But if EPA were to (impermissibly) persist in granting petitions without accounting for all exempt volumes, then that practice would be another factor indicating that the proposed requirements would not cause severe economic harm.[245]

3. A Severe Economic Harm Waiver Could Not Be Exercised Without Accounting for the Significant Benefits of the RFS

As noted above, EPA has correctly concluded that merchant refiners, small retailers, and consumers are not being harmed by the RFS program. But even if any of these groups were experiencing some economic harm, that would not rise to the level of "severe" harm required by the statute.[246] Any government policy encouraging certain market outcomes is likely to benefit some industry participants at the expense of others. Congress of course knew this when it made the policy judgment that rapid expansion of renewable fuel usage across the country was in the nation's economic, environmental, and security interests. The severe harm waiver applies only in the event of overall catastrophic economic circumstances, not the very economic transfers that Congress expected and intended to occur between discrete groups as part of the RFS program.

Thus, consistent with the fourth principle described above, *supra* at 30, EPA has properly concluded that in applying the severe economic harm waiver, it cannot look to harms purportedly suffered by some groups while ignoring the economic benefits provided by the RFS program overall.[247] EPA further underscored that point in the 2018 Rule, when it reasoned that, before exercising a waiver, it would need to "take into account any negative economic impacts to farmers and biofuel producers from a waiver."[248]

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[243] Texas Waiver Decision at 47,172.

[244] *See Petition for Review of 40 C.F.R. §80.1405(c), EPA Docket No, EPA-HQ-OAR-2005-0161, promulgated in 75 Fed. Reg. 14,670 (Mar. 26, 2010); Petition for Reconsideration of Periodic Reviews for the Renewable Fuel Standard Program, 82 Fed. Reg. 58,364 (Dec. 12, 2017)*, June 4, 2018 (attached as Exhibit 10); *Advanced Biofuels Assoc. v. EPA*, No. 18-1115 (D.C. Cir.); *Renewable Fuel Assoc. v. EPA*, No. 18-9533 (10th Cir.).

[245] That is so even if EPA were to reallocate all exempt volumes to the subsequent year's volume requirements, as argued above. *Supra* Part III.B. A system of small refinery exemptions with reallocation would function much like RIN deficit carryovers.

[246] 2018 Growth Energy Comment at 24.

[247] Texas Waiver Decision at 47,172.

[248] 2018 RFS Rule at 58,517-58,518 n.138.

In Part II, *supra*, we describe the substantial benefits of the RFS: increased renewable fuel production and use in the United States helps achieve balanced energy trade, provides a cushion against oil price spikes, and spurs significant growth in domestic agriculture and rural economies, especially in the Midwest.[249] Prior comments by Growth Energy have also marshaled numerous studies showing how implementation of the RFS program has minimal or no adverse effect on feed and retail food prices: corn ethanol uses only the starch of the corn and thus has co-products that *add* to the feed supply, and retail food prices are driven more by crude oil prices than the price of individual crops like corn.[250]

These benefits outweigh any purported harms being borne by obligated parties or other market participants due to existing RIN prices or compliance obligations.

4. EPA Continues to Understate Achievable Renewable Fuel Volumes

By assuming that the market could reach in 2019 the same poolwide ethanol concentration that it achieved in 2017, EPA's analysis assumes that the market could reasonably attain just 163 million gallons of ethanol incremental usage over E10 in 2019.[251] Growth Energy recognizes that EPA set at least this level of attainable consumption mindful that it did not need to justify more consumption to conclude that no severe economic harm would occur.[252] Nevertheless, we comment to underscore that substantially more consumption of ethanol is in fact reasonably attainable.

a. E85 distribution and consumption capacity

As Growth Energy explained in its 2017 and 2018 comments, and as Americans for Clean Energy, Growth Energy, and others explained in the litigation challenging the 2014-2016 RFS rule, E85 has rarely—and never consistently—been priced below E10 on an energy-parity

[249] *See also* 2018 Growth Energy Comment at 38-42; 2018 Growth Energy Supplemental Comment at 15-16; Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017, at 75-77 (July 27, 2015) ("2014-2016 Growth Energy Comment") (attached as Exhibit 11), EPA-HQ-OAR-2015-0111-2604.

[250] 2014-2016 Growth Energy Comment at 77-78.

[251] *See* 2019 Market Impacts Memorandum at 5-6 (assuming that the market would consume 14.527bg of ethanol in 2019 after recognizing that the market could consume 14.364bg if all consumption was E10).

[252] *See id.* at 4 (stating that "there was not a need to precisely estimate the growth in the use of ethanol that can occur between 2018 and 2019" because the amount of ethanol use in 2018 was itself "sufficient to allow attainment of the 2019 total renewable fuel volume requirement under the proposal").

basis.[253] That is because the RFS has never been set at levels requiring substantial use of E85,[254] and so E85 retailers have found that their profit-maximizing strategy has been to treat E85 as a premium product, targeting price-insensitive consumers such as government fleets and individuals willing to pay more for E85 in view of its environmental, economic, and security benefits.[255] This in turn means that price reductions in E85 have not historically generated substantial observed consumer response; all that happened, at most, is E85 went from *much more expensive* than E10 to merely *more expensive* than E10.[256]

Although the market thus has not had occasion to test the upper bounds of E85 potential, Growth Energy submitted, in connection with its comment on the proposed RFS rule for 2017, expert reports by Stillwater Associates and the Brattle Group, as well as rigorous prior academic research by several economics professors, demonstrating through data and economic modeling how the market can be expected to react *if and when* the standards are set high enough that substantial E85 usage is necessary for the market to reach equilibrium.[257] First, consistent with EPA's recognition that price is the most important factor for consumers when buying transportation fuel, and consistent with EPA's recognition of what economic theory would predict,[258] those reports and papers showed, through data and rigorous modeling, how the consumer demand curve would exhibit accelerating consumer response as E85 prices fell below energy parity with E10.[259] Indeed, any other demand curve would lead to implausible results as the E85 discount approaches 100%.[260] Second, the Stillwater and Brattle reports explained how, if the RFS standards are set high enough, E85 stations will find that rather than competing monopolistically with other E85 stations for the small portion of price-insensitive E85 consumers, they will be far better off discounting E85 below E10 and thus competing directly with E10 in order to capture traffic from the substantially larger, price-sensitive E10 customer base.[261]

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253 2018 Growth Energy Comment at 19-21; Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2017 and Biomass-Based Diesel Volume for 2018, at 12 (July 11, 2016) ("2017 Growth Energy Comment") (attached as Exhibit 12), EPA-HQ-OAR-2016-0004-3499; Final Petitioner-Intervenors Br. 7, *Americans for Clean Energy, Inc. v. EPA*, No. 16-1005, Doc. 1661227 (D.C. Cir. Feb. 14, 2017).

254 2017 Growth Energy Comment at 9, 11-14, 23-25.

255 *Id.* at 8.

256 *Id.* at 6.

257 *See id.* at 14-16, 22-28.

258 *2014 Standards for the Renewable Fuel Standard Program*, 78 Fed. Reg. 71,732, 71,760 (Nov. 29, 2013); David Korotney, *Correlating E85 consumption volumes with E85 price*, at 4 ("2016 Korotney Memorandum"), EPA-HQ-OAR-2015-0111-3666.

259 2017 Growth Energy Comment at 14-16.

260 *Id.* at 6-8.

261 *Id.* at 22-28.

EPA declined to follow this commonsense logic supported by data, for no other reason than EPA's evident risk aversion. Without coherent explanation, EPA decided that, where a linear or weakly nonlinear relationship explains the data as well as a more strongly nonlinear relationship, then the linear or weakly nonlinear model should be selected to project E85 demand.[262] But there is no reason to believe that is the right choice when EPA's analysis lacks data from consistent pricing below parity, and particularly when that choice contravenes economic theory, rigorous research, and common sense.

EPA also previously has insisted, in the absence of data from a time when substantial E85 volume was necessary to meet the RFS mandate, on a 22% cap on the E85 discount to E10, refusing to heed economic theory and expert conclusions that E85 prices will decline until the market finds an equilibrium that matches the requisite constraints. Instead, EPA has treated these prices as external "constraints" that must be "achieved." As Brattle explained, basic economic theory teaches that "[n]either the E85 price discount nor the RIN price that would be necessary to achieve a particular E85 price discount are exogenous constraints but instead are endogenous results of policy choices, namely the RVO level EPA sets and the volume of E85 sales necessary to meet that RVO level."[263]

Because EPA has not attempted to quantify the amount of E85 it actually believes is reasonably attainable in the 2019 NPRM, it is unclear whether EPA continues to maintain this approach. It would be wrong to do so. EPA's prior view essentially created a Catch-22 at odds with congressional intent, as EPA declined to push the market to reach higher volumes because they have not been historically achieved. Higher volumes will be achieved when EPA allows the RFS to actually push the market as Congress intended.

EPA's assessment of E85 infrastructure is similarly flawed. EPA continues to claim that the number of retail stations offering E85 and the number of vehicles that can use E85 are limits on E85 consumption.[264] This unexplained assertion is wrong: EPA itself has found that there were sufficient E85 stations and flex-fuel vehicles ("FFVs") with reasonable access to those

[262] *See* David Korotney, *Updated correlation of E85 sales volumes with E85 price discount*, at 6-8 (Nov. 18, 2016) ("2017 Korotney Memorandum") (rejecting nonlinear forms simply because they do not appear to *add* to the explanatory power of the original dataset, while not explaining why the default linear or weakly nonlinear assumption should be treated as the default), EPA-HQ-OAR-2016-0004-3752; 2016 Korotney Memorandum at 13-16 (similarly rejecting nonlinear form simply because it purportedly did no better than the linear form, while not explaining why the linear form is thus the better choice).

In fact, EPA's use of a weakly nonlinear form in 2017 made even less sense than the linear form EPA chose in 2016. As EPA conceded, the weakly nonlinear form "demonstrates a weaker consumer response to price" than the original form at large E85 discounts. 2017 Korotney Memorandum at 5.

[263] *See* Brattle Group, *Peeking Over the Blendwall: An Analysis of the Proposed 2017 Renewable Volume Obligations*, 3 (July 11, 2016) (attached as Exhibit 13).

[264] 2019 Market Impacts Memorandum at 2-3.

stations to deliver 1.3bg gallons of E85, or 860mg of incremental ethanol in E85.[265] And EPA has never rebutted the analysis Growth Energy submitted in prior RFS rulemakings showing that there is sufficient E85 station infrastructure to deliver more than 1bg of ethanol in E85 to nearby FFVs.[266] That analysis has recently been updated and reaches the same conclusions.[267] Of course since those analyses, the number of E85 stations has increased markedly due to the BIP and Prime the Pump programs, as EPA acknowledges,[268] and the number of FFVs on the road has continued to increase.[269] Insofar as EPA were to base a severe economic harm waiver on inadequate infrastructure, it would need to explain how, notwithstanding this record evidence and its prior reasoning, it has a high degree of confidence that severe harm would result.

b. E15 distribution and consumption capacity

Likewise, EPA's prior assessments of E15 consumption are wrong (even without the regulatory relief for E15 described above, *supra* Part VI). In both its 2014-2016 and 2017 comments, Growth Energy set forth extensive analysis showing that E15 infrastructure is capable of rapid expansion once EPA sets the standards at levels that actually require substantial E15 growth.[270] That analysis is still valid. In fact, with the addition of new opportunities for terminal-blended E15, the potential for E15 growth is even larger today.[271] Yet EPA has consistently downplayed the potential for E15 expansion based on EPA's improper adherence to what has historically been achieved.[272] EPA has further cramped its estimates of potential E15 growth by indulging baseless concerns about retailer misfueling.[273]

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[265] David Korotney, *Application of one-in-four E85 access methodology to 2014* (Nov. 21, 2013), EPA-HQ-OAR-2013-0479-0026.

[266] 2017 Growth Energy Comment at 28-33; 2014-2016 Growth Energy Comment at 33-37.

[267] Stillwater Associates LLC, *Potential Increased Ethanol Sales through E85 for the 2019 RFS*, at 5-6 (Aug. 17, 2018) ("2019 Stillwater Report") (attached as Exhibit 14).

[268] 2019 Market Impacts Memorandum at 3-4; 2019 Stillwater Report at 4.

[269] Air Improvement Resource, Inc., *Analysis of Ethanol-Compatible Fleet for Calendar Year 2019* (Aug. 16, 2018) (attached as Exhibit 15).

[270] 2017 Growth Energy Comment at 33-37; 2014-2016 Growth Energy Comment at 41-52.

[271] *See* 2018 NPRM at 34,236.

[272] *Id.*

[273] 2018 NPRM at 34,232; *see* 2017 Growth Energy Comment at 17 (citing Stillwater Associates LLC, *Infrastructure Changes and Cost to Increase RFS Ethanol Volumes Through Increased E15 and E85 Sales in 2017*, at 24 (July 11, 2016) (attached as Exhibit 16)).

c. Ethanol production capacity

The industry could also produce substantial additional volumes of ethanol to support increased consumption. In 2017, 15.845bg of ethanol were produced domestically.[274] To meet the total volume requirement, only about 14.466bg of that production were consumed domestically, while the remaining 1.379bg were exported.[275] Thus, even without any growth in production capacity in 2018 or 2019, the market could support roughly an additional 1.379bg of domestic ethanol usage in 2019 simply by consuming ethanol domestically rather than exporting it to foreign markets.[276] Setting a higher total standard would create the economic incentive to do so. And that is not even accounting for the availability of foreign ethanol for importation.

Or the market could increase its production capacity to generate hundreds of millions of additional volumes of ethanol. It would not be difficult to do so. Production capacity can be increased rapidly in response to demand. And feedstock supplies would not be a meaningful limitation: it is projected that the industry could produce at least an additional 400mg of ethanol in 2019 (over the 2018 production) *without increasing corn acres or diverting corn from non-ethanol uses*.[277] That is possible because of expected improvements in average corn yields and corn conversion rates. Despite the demand for ethanol under the RFS program, fewer corn acres were planted and harvested in the United States in 2017 (90.200 mil and 82.700 mil) than in 2007, when RFS2 was enacted (93.527 mil and 86.520 mil).[278] The first reason that the number of farmed corn acres has declined while ethanol production has increased during the RFS program is that the average corn yield per acre has increased by a significant margin over that period "due to new higher-yield varieties of corn with improved drought- and pest-resistance."[279] The growth rate for corn yield per acre over the past 10 years (17.19%) is nearly identical to the rate over the prior 10 years (18.94%),[280] and there is no reason to conclude that that trend will taper off, given continuing economic pressure on the agriculture industry to improve crop yields. The second reason is that the efficiency with which ethanol plants convert corn to ethanol has also increased—indeed, the annual rate of improvement in conversion efficiency has been nearly perfectly constant at 0.01 gal etoh/bushel corn for the past 35 years, and again economic pressures are likely to encourage the industry to continue to develop and implement new

[274] USDA, Bioenergy Statistics, Table 2, Fuel ethanol supply and disappearance calendar year, https://www.ers.usda.gov/data-products/us-bioenergy-statistics/.

[275] *Id.*

[276] EPA expects the net supply of ethanol RINs to remain constant between 2017 and 2019. *See* 2017 Supply; 2018 Market Impacts Memorandum at 7; 2019 Market Impacts Memorandum at 6.

[277] Stillwater Associates LLC, *The Corn Ethanol Production Impacts for 2019 RFS*, at 8 (August 17, 2018) (attached as Exhibit 17).

[278] *Id.* at 5.

[279] *Id.* at 6.

[280] *See id.*

technologies that maintain at least this rate of improvement in the near future.[281] If those trends in corn yields and corn conversion continue in 2019, and if the amount of corn used for food and other *non*-ethanol purposes in 2019 grows at the same rate as the population grows, the industry could produce an additional 400mg of ethanol in 2019.[282] Because that growth would account for increased demand for food and other non-ethanol uses, it would not be expected to raise prices for food or other corn-based goods.

5. The Existence of Doubt About Whether the Requirements Could Be Met Is Not a Valid Basis for Exercising the Waiver

Even if EPA were to conclude that sufficient volumes of E85 and E15 are not reasonably attainable under its method of analyzing the reasonably attainable volumes to decide how to exercise the cellulosic waiver flow-through authority, that conclusion would not amount to a finding of severe economic harm. EPA could reach such a conclusion only if harbored *no doubt* that the shortage of E85 and E15 *will* cause severe economic harm absent a waiver.

For purposes of the cellulosic waiver flow-through, EPA's position has been that reasonable doubt about achievable volumes may justify reducing volume requirements. In that context, EPA has described its burden as determining what volumes it has "*confidence*" the market could reasonably reach.[283] Thus, EPA has started with baseline volumes that it knows are achievable, e.g., the amounts achieved historically, and then asked what it confidently can say the market could achieve above that threshold in the next year. EPA has relied upon (misplaced) doubts such as those discussed above regarding the shape of the E85 demand curve, achievable relative pricing between E85 and E10, and E15 distribution infrastructure to justify lowering the volume requirement.

Regardless of whether that approach is sound under EPA's cellulosic waiver flow-through authority, it would be wholly improper to use doubt about the achievability of a volume requirement as the basis to reduce that volume requirement under the severe economic harm waiver power. In the severe harm waiver context, EPA bears a different burden.[284] As discussed above, the severe harm waiver may be invoked only if EPA has a "high degree of confidence" that severe harm *would* result; even confidence that severe harm would *likely* result is insufficient.[285] In other words, even if EPA may use the cellulosic waiver to reduce a volume requirement until it eliminates any doubt about its achievability, the presence of doubt cuts

[281] *Id.* at 6-7

[282] *Id.* at 8.

[283] 2018 NPRM at 34,235 (emphasis added); 2017 RFS Rule at 89,791; 2014-2016 RFS Rule at 77,481; *see also* 2014-2016 RFS Rule at 77,472 (limiting expected biodiesel volumes based on what EPA thinks it would be "prudent" to assume).

[284] To be clear, Growth Energy does not believe that EPA would even need to consider potential growth of E85 to *reject* outright use of a severe economic harm waiver. But certainly EPA could not decide to *apply* this waiver without fundamentally changing its analysis as described here.

[285] Texas Waiver Decision at 47,171.

decisively in the opposite direction in the context of the severe harm waiver: EPA may *not* reduce a volume requirement *unless* it eliminates any doubt that compliance would cause severe harm. Accordingly, inadequate data about whether there would be severe harm militates *against* waiving a volume. EPA seemed to recognize that in the 2018 Rule, when it said that the requisite finding was that setting volumes lower than proposed "would be *necessary* to prevent causing severe economic harm."[286]

C. No Additional Modeling Would Be Necessary to *Deny* a Waiver, But a Comprehensive Model Subject to Notice-and-Comment Would Be Necessary to *Grant* a Waiver

There are thus many independent reasons that EPA can and must reject the severe economic harm waiver out of hand, based on its prior legal analysis and the economic analysis it applied in the 2018 Rule, which remains sound for 2019. Yet in the NPRM, EPA appears to suggest that it may be considering attempting to apply an econometric model similar to what it used in 2008 and 2012 from Iowa State University to develop "quantitative estimates of the impact of a waiver on: Food expenditures for average and lowest quintile households; feeds costs for cattle, pigs, poultry and dairy; and gasoline prices and gasoline expenditures for average and lowest quintile households."[287]

There is no basis for EPA to undertake any such modeling enterprise. No model can change the underlying market realities discussed above: EPA's well-established findings that refiners, small retailers, and consumers are not experiencing harm, and the realities that all relevant economic indicators today are comparable to or more favorable than in 2012, when EPA concluded that no severe harm was occurring. Nor can any econometric model alter the legal realities that the severe economic harm waiver is reserved for the narrowest of circumstances, which are not, and have never been, present.

In any event, any such model would be highly sensitive to the many assumptions that would necessarily go into it. EPA would need to modify the model in various ways to account for various developments in the RFS program since 2008 and 2012. As noted above, EPA has recognized that it is not proper to *grant* a severe economic harm waiver without a "comprehensive and robust analytical basis for any claim that the RFS itself is causing harm, and the nature and degree of that harm," and without the public having notice of and an opportunity to comment on the details of that analysis.[288] Indeed, EPA repeatedly justified its 2008 and 2012 decisions on the basis that the model it used had been "subjected to external scrutiny independent of [its] own analysis."[289] If EPA is considering granting a waiver based on an econometric model, it must first publish the details and assumptions of that model so that interested parties can comment on them. Instead of incurring the substantial administrative burdens of what would

[286] 2018 Severe Economic Harm Memorandum at 7.

[287] NPRM at 32,048.

[288] Texas Waiver Decision at 47,183-47,184.

[289] 2012 Waiver Decision at 70,756.

inevitably prove to be a fruitless endeavor, EPA should and must simply reject the severe economic harm waiver altogether, as it did in 2017 and 2018.

VIII. EPA MUST IMMEDIATELY ADDRESS THE D.C. CIRCUIT'S VACATUR OF THE 2016 GENERAL WAIVER IN *AMERICANS FOR CLEAN ENERGY*

In July 2017—more than one year ago—the U.S. Court of Appeals for the D.C. Circuit granted the petitions for review filed by Growth Energy and others, vacated EPA's decision to reduce the 2016 requirements via a general waiver due to "inadequate domestic supply," and remanded the rule setting 2014-2016 RVOs to EPA for further consideration in light of its decision.[290] The D.C. Circuit took these steps after concluding that EPA's prior interpretation of that general waiver provision was "strained," "ma[de] little sense," "flout[ed] the statutory design," and "turn[ed] the Renewable Fuel Program's 'market forcing' provisions on their head."[291]

Despite this strong judicial rebuke, EPA still has taken *no* action to rectify the error that the D.C. Circuit identified and directed the agency to fix. Thus, since that judicial decision, EPA has finalized the 2018 RFS requirements and proposed RFS requirements for 2019, while failing to address its statutory duty to "ensure" that the *2016* requirements are met (now nearly three years after the statutory deadline).[292]

Nor has EPA provided any indication for how or when it plans to comply with the court's order. All EPA has done is to vaguely allude to this obligation on several occasions, as if acknowledging the existence of the obligation were equivalent to complying with it.[293] In the 2019 NPRM, EPA continues that practice, stating only that it is "considering a number of issues" raised by the remand and that it "understands that there is a compelling need to respond to the remand and intends to expeditiously move ahead with a separate rule to resolve this matter."[294]

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[290] *ACE*, 864 F.3d at 696-97.

[291] *Id.* at 708, 710, 712.

[292] *Id.* at 698-699 (quoting 42 U.S.C. § 7545(*o*)(3)(B)(i)).

[293] *See, e.g.*, 2018 RFS Rule at 58,494 (noting "possible impact of an action to address the remand in *ACE*"); EPA, EnviroFlash Announcements about EPA Fuel Programs, (Jan. 12, 2018) (recognizing uncertainty "and the fact that the EPA has not yet indicated its intentions with respect to the remand" in *ACE*) ("January 2018 EnviroFlash Announcement"), https://www.epa.gov/fuels-registration-reporting-and-compliance-help/enviroflash-announcements-about-epa-fuel-programs#compliance-deadline.

[294] NPRM at 32,027.

That is not enough. EPA must take action to address its clear legal duty to remedy its prior error and comply with the D.C. Circuit's order without any further delay.[295] There is no excuse for delay because EPA could easily remedy its prior error. As EPA itself has explained, "it would be appropriate for the EPA to allow use of current-year RINs (including carryover-RINs) to satisfy further obligations, if any, for a past compliance year that may result from the *ACE* remand."[296] Thus, EPA can and must simply add the 500 million RINs covered by the vacated general waiver to the total 2019 volume requirement it would otherwise impose. If EPA deems it necessary to provide an opportunity for notice-and-comment on the remedy, it should issue its proposal promptly so that the 2019 RVOs can reflect the remedy yet still be finalized by the statutory deadline of November 30, 2018.

IX. CONCLUSION

For the reasons set forth above, EPA should: (1) maintain an implied non-advanced volume of at least 15 billion; (2) change its approach to small refinery exemptions to deny extensions to refineries that have not been continuously exempt, to make up for all exempt volumes, and to bring more transparency to the RIN market; (3) revise its method for projecting liquid cellulosic biofuel volume for 2019; (4) remove regulatory barriers to expanded use of E15; (5) continue to decline to issue a general waiver of the total volume requirement based on severe harm to the economy; and (6) promptly remedy the vacated general waiver of the 2016 total volume requirement.

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[295] *See, e.g.*, *In re People's Mojahedin Organization Org. of Iran*, 680 F.3d 832, 837-838 (D.C. Cir. 2012) (ordering agency to act after it failed to meet original statutory deadline and then "failed to heed [court's] remand," which "effect[ively] … nullif[ied] [the court's prior] decision").

[296] January 2018 EnviroFlash Announcement.

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 12

Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019

Docket # EPA-HQ-OAR-2017-0091

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I. INTRODUCTION AND EXECUTIVE SUMMARY

Growth Energy respectfully submits these comments on the Environmental Protection Agency's proposed rule entitled "Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019."[1] Growth Energy is the leading association of ethanol producers in the country, with 86 members and 66 affiliated companies who serve the nation's need for renewable fuel. Growth Energy has submitted comments on EPA's prior major rulemakings implementing the Renewable Fuel Standard ("RFS") program. For the reasons stated below, Growth Energy urges EPA to: (1) modify its methodologies for projecting cellulosic biofuel production to ensure neutrality and accuracy; (2) revise the cellulosic waiver credit program to ensure the efficacy of the volume requirement; (3) decline to issue a general waiver of the total volume requirement based on severe harm to the economy or the environment; (4) decline to issue a waiver of the total volume requirement based on energy independence and security; (5) decline to issue a general waiver of the total volume requirement based on inadequate domestic supply of renewable fuel; (6) take actions to mitigate the risk of manipulation in the RIN market.

In 2007, Congress expanded the RFS program "to increase the production of clean renewable fuels" and "[t]o move the United States toward greater energy independence and security."[2] The RFS program has been an overwhelming success. It has created American jobs, revitalized rural America, introduced much-needed competition into a monopolized vehicle-fuels market, lowered the price at the pump, reduced greenhouse gas emissions, and made our nation more energy independent and secure by reducing our dependence on foreign oil.

Cellulosic biofuel is the most environmentally beneficial form of renewable fuel. Congress designed the ascending RFS volume requirements to spur the development of the cellulosic biofuel industry. Although the industry has not yet met the pace Congress mapped out, it has achieved consistently significant annual growth, and emerging technologies have poised the industry for accelerated growth.

EPA's proposal, however, jeopardizes that growth by weakening the force of the cellulosic volume requirement and thereby depressing the D3 RIN market. The proposal does this in two ways. First, EPA would revise the methodologies for projecting the production of liquid cellulosic biofuel and CNG/LNG derived from biogas—methodologies that it recently and repeatedly found are "reasonably accurate" and could not "reasonably be … improve[d]"[3]—in ways that enable the industry's past performance to determine the projections and thus the future volume requirements. In an industry whose technologies, investments, and performance are

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[1] *Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019*, 82 Fed. Reg. 34,206 (July 21, 2017) ("NPRM").

[2] Energy Independence and Security Act of 2007, Pub. L. No. 110-140, preamble, 121 Stat. 1492, 1492 (Dec. 19, 2007).

[3] Dallas Burkholder, *Assessment of the Accuracy of Cellulosic Biofuel Production Projections in 2015 and 2016*, at 4 (Nov. 2016) ("EPA November 2016 Assessment"), EPA-HQ-OAR-2016-0004-3687.

changing continually and vary from one producer to the next, "tak[ing] 'neutral aim' at accuracy"[4] requires a methodology that is more sensitive to the particularities of individual producers' circumstances. EPA should therefore assess likely production of both liquid cellulosic biofuel and CNG/LNG derived from biogas on a plant-by-plant basis (or at least a more finely tuned set of groupings) so as to fully account for the technological, financial, managerial, political, and legal factors determining each plant's production.

Second, EPA's administration of the cellulosic waiver credit program provides unwarranted incentive to obligated parties to purchase credits rather than gallons. EPA should reduce the number of credits available to a level meaningfully below the volume requirement, and should permit obligated parties to use credits for compliance only if they show that they first made a good faith effort to purchase gallons (or RINs).

Growth Energy does not advocate further changes to the proposed volume requirements but does strongly oppose any further waiver of the total volume requirement.

First, there is no basis for EPA to use its general waiver authority to reduce the total renewable fuel volume requirement. The high bar to show that implementation of the RFS "would severely harm the economy or environment"[5] is nowhere near satisfied. As EPA has recognized before, comparable levels of total renewable fuel and conventional renewable fuel have been achieved already without causing the economy severe harm; obligated parties' ordinary compliance costs do not qualify as severe harm. And the most recent and sophisticated studies on the environmental effects of renewable fuel confirm what Congress knew when it created the program: that on an all-in basis, starch ethanol is vastly superior to fossil-based fuels, and so a waiver would cause rather than prevent environmental harm.

Second, EPA has no authority to waive the total volume requirement to promote policies of U.S. energy independence and security, and in any event EPA should not do so. EPA may waive only for the reasons stated in the statute, and promoting energy independence and security is not among them. Moreover, a commitment to high levels of starch ethanol *furthers* U.S. energy independence and security, as well as what the President has termed "American energy dominance,"[6] by diversifying the nation's energy sources and generating strong economic growth, particularly in rural parts of the Midwest.

And third, EPA has no basis to waive the total volume requirement due to "inadequate domestic supply" of renewable fuel. As the D.C. Circuit recently held in *Americans for Clean Energy v. EPA*, EPA may consider only the amount of renewable fuel "available to refiners, blenders, and importers to meet the statutory volume requirements," not any "factors affecting availability of renewable fuel to market actors downstream from refiners, importers, and

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[4] *See American Petroleum Inst. v. EPA*, 706 F.3d 474, 476 (D.C. Cir. 2013) ("*API*").

[5] 42 U.S.C. § 7545(*o*)(7)(A)(i).

[6] Remarks by President Trump at the Unleashing American Energy Event (June 29, 2017) ("Unleashing American Energy"), *available at* https://www.whitehouse.gov/the-press-office/2017/06/29/remarks-president-trump-unleashing-american-energy-event.

blenders, such as fuel retailers or consumers."[7] There is no question that the supply of renewable fuel available to refiners, blenders, and importers is more than enough to meet the proposed total volume requirement.

Finally, EPA should take appropriate actions to mitigate the risk of manipulation in the RIN market in order to ensure its continued efficiency in promoting the rapid growth in renewable fuels that Congress intended to foster when it established the RFS.

II. EPA'S PROPOSED PROJECTION OF CELLULOSIC BIOFUEL PRODUCTION DOES NOT REFLECT NEUTRAL AIM AND IS SUBSTANTIALLY UNDERSTATED

When the RFS2 program was created, cellulosic biofuel was but a glint in Congress's eye.[8] That was the point: Congress would use the program to spur development of "the 'greenest' form of renewable fuel."[9] Developing the commercial production of cellulosic biofuel is "central to the [RFS] program's objective of reducing greenhouse gas emissions."[10] Although not yet as quickly as Congress had expected, the RFS program has done just that. After the initial difficulty with commercial-scale production experienced in 2010 and 2011, the cellulosic biofuel industry has increased its production continuously, from about 20,000 RINs in 2012, to about 800,000 RINs in 2013, then 33 million RINs in 2014, 140 million RINs in 2015, and 190 million RINs in 2016.[11] In the 2014-2016 RFS rule, EPA noted that "the cellulosic biofuel industry ha[d] made significant progress towards commercial scale production" in the preceding years.[12] EPA's 2017 rule and its proposed rule for 2018 also recognize that such progress has "continued."[13] Yet, EPA now proposes a lower volume for cellulosic biofuel in 2018 than it adopted in 2017, in the name of accurate projections.

EPA's new projections, however, are inherently inaccurate—more so than prior years'—and actually reflect an improper "'special tilt'" toward underestimating cellulosic volumes.[14] This is evident in several ways. First, EPA's proposed methodologies for projecting both liquid cellulosic biofuel and CNG/LNG derived from biogas ("RNG" or "biogas") necessarily tie projections to the industry's past performance. That is misguided for a nascent industry still drawing significant investment and poised for rapid expansion. EPA should instead assess likely production on a plant-by-plant basis (or at least a more finely tuned set of groupings) so as to

[7] *Americans for Clean Energy v. EPA*, 864 F.3d 691, 709 (D.C. Cir. 2017).

[8] *See API*, 706 F.3d at 476.

[9] *Americans for Clean Energy*, 864 F.3d at 723.

[10] *API*, 706 F.3d at 476.

[11] *Public Data for the Renewable Fuel Standard*, EPA, *available at* https://www.epa.gov/fuels-registration-reporting-and-compliance-help/public-data-renewable-fuel-standard.

[12] *Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017*, 80 Fed. Reg. 77,420, 77,499 (Dec. 14, 2015) ("2014-2016 RFS Rule").

[13] *Renewable Fuel Standard Program: Standards for 2017 and Biomass-Based Diesel Volume for 2018*, 81 Fed. Reg. 89,746, 89,750 (Dec. 12, 2016) ("2017 RFS Rule"); NPRM at 34,214.

[14] *Americans for Clean Energy*, 864 F.3d at 727 (quoting *API*, 706 F.3d at 478).

fully account for the technological, financial, managerial, political, and legal factors determining each plant's production. We stand ready and willing to assist EPA in collecting any needed data and technical assistance to perform such assessments.

Second, in the course of finalizing the 2017 RFS rule, EPA examined the accuracy of the methodology it used to project cellulosic volumes for 2015, 2016, and 2017, and found that in light of the methodology's actual performance, it was reasonably accurate and there was no basis to change it. EPA initially reiterated those conclusions in the course of preparing the NPRM for 2018 but then reversed course—without considering new data or information, without conducting a new analysis, and without offering a plausible explanation for the switch. That process does not satisfy EPA's procedural obligations for rulemaking, and it also strongly suggests that EPA was motivated instead by a non-neutral purpose, namely, to impermissibly disfavor cellulosic growth.

EPA should therefore revise its proposed methodologies to correct the "special tilt" by considering all relevant factors to project likely growth. Even if EPA's methodologies were to be driven by the past, however, there are more accurate ways to do so. EPA should start by reverting to the groupings and percentile values it used in prior years—for both liquid cellulosic biofuel and RNG projections. Then EPA should create a new group for producers of liquid cellulosic biofuel using new but proven commercial production technology, such as POET and those using Edeniq's technologies, which can produce cellulosic ethanol from corn kernel fibers. Even if EPA only used a grouping-and-percentile method for RNG and added a group for proven commercial production technology, while keeping the proposed percentile values for liquid cellulosic biofuel and reducing the prior years' percentile values for RNG to reflect their margin of error in 2016, EPA's projected 2018 cellulosic biofuel would be at least about 377 million.[15]

Having accurate cellulosic projections is imperative for the industry and the success of the RFS program that Congress created. As EPA once recognized, consistency in methodology is critical for the cellulosic biofuel market because it "add[s] to the sense of program stability the commenters describe as necessary for the development of the cellulosic biofuel industry, including investment in new commercial-scale cellulosic biofuel production facilities in the United States."[16] Further, if projections are too low, D3 RIN prices could fall precipitously, undermining the very incentive Congress intended to create to spur growth.[17]

[15] Argus Consulting, *Reviewing EPA methodology for potential cellulosic biofuels production for 2018*, at 20 tbl.11 (Aug. 2017) ("Argus 2017 Report") (attached as Exhibit 1). In preparing its projection analysis, Argus had limited access to some producers' confidential business data, including Edeniq's, and therefore insofar as EPA has greater access, its application of Argus' methodology would result in significantly higher projections. *Id.* at 22.

[16] *Renewable Fuel Standard Program–Standards for 2017 and Biomass-Based Diesel Volume for 2018: Response to Comments*, at 432 ("2017 Response to Comments"), EPA-HQ-OAR-2016-0004-3753.

[17] *Americans for Clean Energy*, 864 F.3d at 710.

A. EPA's Proposed Approach to Projecting Likely Cellulosic Production in 2018 Systematically Disfavors Growth

When determining cellulosic biofuel projections, EPA must "take 'neutral aim at accuracy.'"[18] That means, the D.C. Circuit declared recently, that "EPA's methodology [may] not reflect a 'non-neutral purpose' to favor *or disfavor* growth in the cellulosic biofuel industry," i.e., "systematically err[] on the side of overestimation" or underestimation.[19] EPA's proffered reason for proposing to change its approach to projecting cellulosic production is to increase the accuracy of its projections. But EPA's changes incorrectly assume that the industry's past determines its future. In a new industry that is growing quickly and, as EPA observes, "in the early stages of commercialization,"[20] that assumption impermissibly "tilt[s]" the projections against growth.[21]

With respect to liquid cellulosic biofuel, EPA proposes to group producers based on whether they have previously achieved consistent commercial-scale production, determine an aggregate range of likely production for each group, and then apply a percentage (or a "percentile value," as EPA calls it) to each group's range to project aggregate production.[22] To that extent, EPA's proposed methodology is the same as the one it used in the 2014-2016 rule and in the 2017 rule.[23] The proposal departs from past practice in the specific percentiles applied. For the 2015, 2016, and 2017 projections, EPA used the 25th and 50th percentiles, which reflected EPA's effort to account for the variability and relative risk of each group of producers.[24] For the proposed 2018 projection, however, EPA would use the 1st and 43rd percentiles, which reflect the industry's actual utilization in 2016.[25]

For RNG, EPA also used that percentile method for 2015, 2016, and 2017, but with higher percentile values: 50th and 75th.[26] Now, however, EPA proposes to abandon the percentile approach altogether and replace it with a model that applies an industry-wide constant growth rate to past actual production. Comparing a 5-month period in 2016 to the same period in 2017, EPA computes a historical RNG growth rate of 9.3%.[27] EPA then assumes that that rate of

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[18] *Id*. at 727 (quoting *API*, 706 F.3d at 478).

[19] *Id.* (quoting *API*, 706 F.3d at 478) (emphasis added).

[20] NPRM at 34,218; *accord* 2017 RFS Rule at 89,758.

[21] *Americans for Clean Energy*, 864 F.3d at 727.

[22] NPRM at 34,217-34,218.

[23] 2014-2016 RFS Rule at 77,503, 77,507-77,508; 2017 RFS Rule at 89,758.

[24] 2014-2016 RFS Rule at 77,506; 2017 RFS Rule at 89,759-89,760; *see Americans for Clean Energy*, 864 F.3d at 729.

[25] NPRM at 34,217. We understand that the percentiles do not correspond to "utilization" in the strict sense, *see* 2017 RFS Rule at 89,760, but we use the term as a convenient shorthand here.

[26] 2014-2016 RFS Rule at 77,506; 2017 RFS Rule at 89,760.

[27] NPRM at 34,219.

growth holds constant through 2017 and 2018, and proposes to apply that rate to the actual 2016 net cellulosic RIN generation.[28]

Thus, EPA's new proposed methodologies would turn the task of projecting future production volumes of cellulosic biofuel into little more than extending the past. To be sure, the proposed methodologies do allow for the possibility of some growth: for the liquid volumes, the production range could reflect increased past production or increased facility capacity; for the RNG volumes, the growth rate necessarily implies growth. But those allowances do not overcome the fact that the projected growth under the proposed model is determined ultimately by past performance. A neutral projection of growth in a nascent and dynamic industry must account for the potential for *accelerating* growth.

Indeed, just a couple months before issuing the NPRM, EPA declined to "downgrad[e] [its] projections for all liquid cellulosic biofuel facilities" because that "would effectively assume that all future liquid cellulosic biofuel facilities experience the same challenges and resulting low production volumes as liquid cellulosic biofuel facilities have in recent years."[29] That assumption, EPA observed, would not "be appropriate" because "much of the cellulosic biofuels industry is still in the early stages of commercialization, and it is likely that lessons learned at the first few liquid cellulosic biofuel production facilities can be applied to these and other facilities in future years."[30] The NPRM suggests that EPA has already forgotten that lesson.

B. For Reasons EPA Previously Recognized, Its Proposed Methodological Changes Lack a Reasonable Basis

EPA says that it revised the methodologies "with the objective of improving the accuracy of the projections."[31] Improving accuracy is a laudable goal, but in last year's final RFS rule, EPA determined that the methodology used for 2015, 2016, and 2017 "has produced reasonable projections,"[32] and the D.C. Circuit recently affirmed that methodology as reasonable."[33] To be sure, EPA is permitted to revise its methodologies, and the conclusion that the old method was reasonably accurate does not necessarily foreclose the possibility of another method being more accurate. But "[w]hen an agency changes its existing position, it … must at least … show that there are good reasons for the new policy."[34] In particular, "a reasoned explanation is needed for disregarding facts and circumstances that underlay or were engendered by the prior policy."[35]

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[28] *Id.*

[29] Dallas Burkholder, *Assessment of the Accuracy of Cellulosic Biofuel Production Projections in 2015 and 2016*, at 5 (May 22, 2017) ("EPA May 2017 Assessment"), attached as an exhibit to *Documentation of OMB Review*, EPA-HQ-OAR-2017-0091-0110.

[30] *Id.*

[31] NPRM at 34,214, 34,219.

[32] 2017 RFS Rule at 89,758.

[33] *See Americans for Clean Energy*, 864 F.3d at 728.

[34] *Encino Motorcars, LLC v. Navarro*, 136 S. Ct. 2117, 2125-2126 (2016).

[35] *Id.*

This is all the more so here given that EPA previously resolved to "adjust the methodology" only if it finds that the methodology "ceases to provide reasonably accurate projections in future years."[36] EPA's proposal strikingly fails to satisfy these requirements: the changes are not explained and there is no demonstration that the new methodologies would be more accurate than the prior one, let alone that the prior one is no longer reasonably accurate. In fact, EPA itself has previously rejected the very reasons it now offers to justify the methodological changes.

In the proposal, EPA notes that the prior method overestimated volumes for 2016. Specifically, EPA had projected 207 million gallons of RNG in 2016, but the industry actually generated 189 million, a shortfall of 9%.[37] And EPA had projected 23 million gallons of liquid cellulosic biofuel in 2016, but the industry actually generated 4.3 million, a shortfall of 81%.[38] Overall, EPA overestimated 2016 cellulosic RIN production by 16%. Thus, these were the error rates that apparently compelled EPA to revise its projection methodologies for 2018.

Nothing has changed since EPA last considered the accuracy of its 2015-2017 percentile method, while finalizing the 2017 RFS rule. At that time, EPA stated: "After reviewing the results of the methodology used by EPA to project cellulosic biofuel production in 2015 and 2016, we believe the methodology overall has resulted in reasonably accurate projections in these years and is appropriate for use in 2017."[39] EPA added that it did "not believe that we have sufficient information at this time to adjust the methodology in a way that would reasonably be expected to improve the overall accuracy of the results."[40] In other words, EPA's reaffirmation of the old methodology in the 2017 RFS rule is irreconcilable with its proposed abandonment of that method now: looking at the same error rates today as it did then, EPA now claims it is improving its methodology to address the inaccuracy of a methodology it previously concluded was "reasonably accurate" and whose accuracy could not "reasonably be expected to [be] improve[d]."[41]

As recently as mid-June this year, EPA was still committed to the 2015-2017 methodology. It had submitted to the Office of Management and Budget ("OMB") multiple drafts of the NPRM for 2018 using the 2015-2017 methodology, along with a supporting memorandum prepared in May concluding, as EPA had in the 2017 RFS rule: "After reviewing the results of the methodology used by EPA to project cellulosic biofuel production in 2015 and

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[36] 2017 RFS Rule at 89,758.

[37] Dallas Burkholder, *Assessment of the Accuracy of Cellulosic Biofuel Production Projections in 2015 and 2016*, at 3-4 (June 2017) ("EPA June 2017 Assessment"), EPA-HQ-OAR-2017-0091-0083.

[38] EPA June 2017 Assessment at 5.

[39] EPA November 2016 Assessment at 4.

[40] *Id.*

[41] *Id.* at 2-4. Because 2016 was not yet over, EPA estimated in November 2016 that the total cellulosic RIN production for that year would be 198 million, which yielded an error rate of 14%—negligibly different from the actual error rate of 16%.

2016, we believe the methodology overall has resulted in reasonably accurate projections in these years and is appropriate for use in 2018."[42] And EPA again explained that it "there is [not] sufficient information to suggest that a change in our cellulosic biofuel production methodology is warranted."[43]

Within a week, however, EPA reversed its position through a highly unusual process. In support of the switch, EPA prepared a new assessment of the accuracy of the 2015-2017 methodology with nearly verbatim language and data to the May 2017 assessment—except that EPA excised from the June 2017 assessment several key passages:

- EPA replaced the phrase "we believe the methodology overall has resulted in reasonably accurate projections in [2015 and 2016] and is appropriate for use in 2018" with the phrase "we believe the methodology overall has resulted in varying projections in these years."[44]

- EPA deleted the sentence "We therefore do not believe the results of our projection of liquid cellulosic biofuel in 2015 provides a sufficient basis for changing our methodology in 2018."[45]

- EPA deleted the entire last paragraph, in which EPA had concluded that it lacked "sufficient information" to warrant changing the methodology.[46]

This process—in which EPA converted an analysis that it had repeatedly relied upon to reach one conclusion into support for the opposite conclusion merely by erasing key conclusions from the original analysis, without a word acknowledging those changes—does not reflect reasoned analysis and explanation. It embodies arbitrary, capricious, and perhaps Orwellian regulatory action.[47]

In the NPRM itself, EPA attempts to explain the basis for its methodological changes, but those explanations do not account for EPA's prior analyses or hold up on their own. With respect to liquid fuel, the NPRM states: "We believe that new data warrants a change to the methodology for projecting liquid cellulosic biofuel in an effort to make the projections more accurate."[48] But EPA points to no data other than the 2015 and 2016 error rates—not new data

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[42] EPA May 2017 Assessment at 3. Unlike EPA's November 2016 assessment, which had to slightly predict the final 2016 RIN figures, the May 2017 assessment had the final 2016 data and therefore accounted for exactly the same error rates EPA now would rely on to revamp the methodology. *See id.*

[43] *Id.* at 5.

[44] *See* EPA June 2017 Assessment at 3.

[45] *Compare* EPA June 2017 Assessment at 4 *with* EPA May 2017 Assessment at 4.

[46] *Compare* EPA June 2017 Assessment at 5 *with* EPA May 2017 Assessment at 5-6.

[47] *See Encino Motorcars*, 136 S. Ct. at 2126.

[48] NPRM at 34,215; *see also id.* at 34,217.

at all. On the contrary, EPA noted in May that it expected the 2018 liquid projection to be *more* accurate than in the past under the 2015-2017 methodology because "an increasing proportion of the liquid cellulosic biofuel production (approximately 62% in 2018) is projected to be produced from small facilities."[49]

With respect to RNG, the NPRM states that the new industry-wide constant-growth-rate model "is warranted for purposes of this rule for two primary reasons: [1] the over-projection of [RNG] in 2016"—which, again, EPA already knew about when finalizing the 2017 RFS rule and when submitting the draft versions of the NPRM to OMB—and [2] "the relative maturity of the [RNG] industry relative to the liquid cellulosic biofuel industry" in terms of the "technology and market" for RNG.[50] To the extent the RNG market is more "mature" than the liquid market, EPA accounted for that long ago when it "decided to use higher percentile values to project likely production" of RNG.[51]

Beyond that, EPA is wrong that the RNG market has reached a level of maturity that would warrant an industry-wide constant-growth-rate model. In finalizing the 2017 RFS rule, EPA noted that production by the supposedly more "mature" RNG industry "has been much more variable month to month than for liquid fuels."[52] EPA now provides no evidence to the contrary. In fact, the evidence shows that RNG production has continued to be inconsistent month to month and year to year—for example, growth has historically ranged from 35% to 800%, far higher than EPA's proposed 9.3% and far too divergent to support a single constant rate.[53] Similarly, construction and investment timelines are not yet uniform, and economic incentives for production continue to fluctuate.[54] And, as EPA previously explained, it had already taken "appropriate actions" to improve the accuracy of RNG projection by, for example, excluding projected production from anaerobic digestion projects that have not previously generated cellulosic RINs.[55]

As a result, EPA's proposed industry-wide constant-growth-rate method for projecting RNG production is *less* accurate than the percentile method it would replace. That alone suffices to require its rejection. Argus subjected the proposed RNG methodology to a simple test: apply it to past data to see how well it would have predicted 2016 production.[56] The results are dismaying. Argus found that "the application of this technique would have resulted in a growth rate that was off by 109% from the actual year-over-year growth rate for 2016," and "a 28%

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[49] EPA May 2017 Assessment at 5.

[50] NPRM at 34,219.

[51] 2014-2016 RFS Rule at 77,506.

[52] EPA November 2016 Assessment at 2.

[53] *See* Argus 2017 Report at 10-13.

[54] *See id*.

[55] EPA May 2017 Assessment at 5.

[56] Argus 2017 Report at 8.

error" in the volume projection.[57] By comparison, the old percentile method's projection was off by 16%.[58] One reason for the proposed methodology's large error rate is that, in looking at past data, EPA accounted for the anomalously low January production volumes but disregarded the anomalously high December production volumes.[59]

C. Better Methodologies Would Yield Higher Projections

Even if it were appropriate to refine EPA's methodologies to reflect past performance, EPA should adjust its methodologies for both liquid cellulosic biofuel and RNG to obtain more accurate results. Any of the possible adjustments would result in higher projections of cellulosic volumes.

1. Liquid Cellulosic Biofuel

Besides using current data to compute the low and high ends of the production ranges for liquid cellulosic biofuel producers, EPA should at a minimum jettison its backward-looking percentile values and set new percentile values that reflect a fuller analysis of the risk factors affecting each producer's likely production. Simply maintaining the prior percentile values of 25 and 50 would be more accurate and defensible than the proposed percentile values.

Regardless of whether EPA adheres to the percentile values used for the 2015-2017 projections, it should create a new group for "producers with proven commercial production adding proven cellulosic technology."[60] This group would contain facilities currently producing cellulosic ethanol from corn kernel fiber at existing corn ethanol plants—principally Edeniq and POET.[61] As Argus explains, such facilities have "similar types and levels of risk associated with cellulosic biofuel production" to each other but different from the companies in the other groups of liquid cellulosic biofuel producers proposed by EPA.[62]

Corn kernel fiber technology has poised the industry for rapid growth in recent years. Although technology for converting corn kernel fiber feedstock to cellulosic ethanol has existed for some time, it was not able to convert on a commercial scale.[63] In the last few years, however, several cellulosic ethanol facilities have achieved commercial-scale conversion, including POET and Edeniq (or facilities using Edeniq's technology).[64] EPA also noted in the 2017 rule that "[c]ellulosic ethanol production levels increased from existing facilities in 2016, and significant

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[57] *Id.* at 8.

[58] *See supra* p. 7.

[59] Argus 2017 Report at 10; *see also* EPA November 2016 Assessment at 2.

[60] Argus 2017 Report at 19-20.

[61] *Id.* at 19.

[62] NPRM at 34,218; *see* Argus 2017 Report at 20-23.

[63] *Syngenta: Corn kernel fiber essential for cellulosic ethanol*, AGDAILY (Apr. 11, 2017), *available at* https://www.agdaily.com/crops/syngenta-corn-kernel-cellulosic-ethanol/.

[64] *See also* 2014-2016 RFS Rule at 77,499.

work continues to be done to enable the production of cellulosic ethanol at new facilities in 2017 and beyond."[65] In the June 14 draft of the proposed rule for 2018, EPA recognized corn kernel fiber conversion as "commercially successful technology,"[66] and though EPA removed that sentence in the NPRM, EPA nonetheless observed in the NPRM that "[m]ultiple companies, in addition to Edeniq and Quad County Corn Processors, are working to commercialize technology to convert corn kernel fiber to cellulosic ethanol at existing corn ethanol facilities."[67]

For this new group, EPA should use 50th percentile. That percentile value is based on EPA's own criteria for setting percentile values and specifically its explanation for why the 50th percentile is appropriate for new RNG facilities.[68] With respect to their corn kernel fiber technology, POET and Edeniq share many similarities in terms of risk factors with new RNG facilities. Like new RNG facilities, POET and Edeniq have "a significant history of producing" cellulosic ethanol based on corn kernel fiber conversion and "do not face the same ramp-up schedule or uncertainties as newly constructed facilities operating new technologies."[69] Indeed, POET and Edeniq already "aggregate and process the primary feedstock," much as new RNG facilities producing cellulosic biofuel RINs by cleaning biogas collected at landfills are "already actively acquiring their waste/feedstock and collecting the biogas."[70] Additionally, POET and Edeniq are already "handling, storing and distributing" ethanol, much as new RNG facilities are "currently storing, cleaning and [distributing] or utilizing" their biogas fuel onsite.[71]

It is true that POET cannot generate cellulosic biofuel RINs until the requested regulatory approval is granted, but EPA should promptly do that and count a full-year's production capacity for POET in its projections. POET has been working closely with EPA to expedite approval of its corn kernel fiber pathway petition. Prompt approval is vital because POET has already produced and stored 20 million gallons of cellulosic ethanol that will be recognized as cellulosic biofuel RINs once approval is granted. And given that POET has already been producing cellulosic biofuel and for other reasons just discussed, it would experience little appreciable ramp-up time upon approval and would therefore expect to produce up to 60 million gallons of cellulosic biofuel RINs through this pathway. Indeed, EPA's justification for excluding volumes from unapproved pathways in prior cellulosic biofuel projections—that "few of the facilities for which cellulosic pathway petitions have been submitted for consideration would be in a position to produce fuel in [the relevant upcoming compliance year] even if their petitions were approved

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65 2017 RFS Rule at 89,750.

66 *EO12866 RFS 2018 Annual Rule 2060-AT04 NPRM FRN 20170614 4pm final clean*, at 27-28 (June 23, 2017), attached as an exhibit to *Documentation of OMB Review*, EPA-HQ-OAR-2017-0091-0110.

67 NPRM at 34,214.

68 Argus 2017 Report at 20-21.

69 *Id.* at 21.

70 *Id.*

71 *Id.*

in the very near future"—does not apply to POET.[72] The only obstacle to having POET's volumes recognized as cellulosic biofuel is EPA's approval.

With corn kernel fiber-based cellulosic production from POET and Edeniq placed in a new group at the 50th percentile, and assuming the proposed percentile values of 1st and 43rd for the other groups, Argus projects liquid cellulosic production in 2018 would be 63 million, up from the 17 million proposed by EPA.[73]

2. Renewable Natural Gas

For reasons already discussed, EPA's projection of RNG would be more accurate if, at a minimum, it reverted to its 2015-2017 methodology. EPA already performed this analysis in May (including using the 50th and 75th percentiles that EPA used in prior years), and obtained a projection for RNG in 2018 of 340 million, much higher than the 238 million EPA now proposes.[74]

If EPA were to insist on tying the percentiles to historical performance (even though that would reflect a non-neutral purpose), it could do so by setting them equal to percentiles corresponding to the actual RINs produced in 2016, as EPA proposes to do for liquid cellulosic biofuel. Performing a modified version of that analysis (due to limited publicly available data), Argus estimated that the projection of RNG would be 311 million, with new facilities analyzed at the 45th percentile and currently generating facilities at the 56th percentile.[75]

III. CHANGES TO THE CELLULOSIC WAIVER PROGRAM ARE NECESSARY TO FURTHER CONGRESS'S GOAL OF INCREASING PRODUCTION OF CELLULOSIC BIOFUEL

EPA should modify its current CWC program. The RFS statute requires that for any calendar year in which EPA reduces the statutorily required volume of cellulosic biofuel, EPA

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[72] 2017 Response to Comments at 443 n.5.

[73] Argus 2017 Report at 20 tbl.11. Argus' analysis also reflects updated data regarding high and low ends of the ranges. However, Argus had limited access to some producers' confidential business data, including Edeniq's, and therefore insofar as EPA has greater access, its application of Argus' methodology would result in significantly higher projections. *Id.* at 22.

[74] EPA May 2017 Assessment at 5-6.

[75] Consistent with the approach EPA proposed for liquid cellulosic biofuel, Argus computed the error rate for the 2016 RNG projection: 10% (actual production was 189 million against a projection of 207 million). Argus 2017 Report at 17. Because of the lack of publicly available data on breakdown of actual 2016 production volumes between the two groups of RNG producers, Argus applied the 10% error rate to the 2016 RNG projections. *Id.* That is, Argus reduced by 10% the projected production of 32 million RINs for new RNG facilities and 175 million RINs for consistent RNG facilities, which resulted in 28.8 million RINs for new RNG facilities and 157.5 million RINs for consistent RNG facilities. Argus thus concludes that the 45th percentile and 56th percentile should be applied to the production ranges generated for new and consistent RNG facilities in 2016. Argus then applied those percentile values to project the 2018 RNG volume. *Id.*

"shall make available for sale cellulosic biofuel credits."[76] Pursuant to this authority, EPA has administered a Cellulosic Wavier Credit ("CWC") program since 2010, when the first cellulosic biofuel requirement was established.[77] The CWC program allows obligated parties to show compliance with their cellulosic biofuel RVOs by purchasing CWCs in lieu of RINs. A 2015 EPA regulation provides that "[t]he total cellulosic biofuel waiver credits available will be equal to the reduced cellulosic biofuel volume established by EPA for the compliance year."[78]

EPA's current practice is at odds with the RFS statute. EPA should (i) set the number of CWCs available meaningfully below the operative cellulosic biofuel volume requirement and (ii) require, as a condition of using CWCs to show compliance, that the obligated party make a good faith effort to purchase cellulosic biofuel gallons or RINs instead. Although Growth Energy recognizes that EPA did not request comment on the CWC program in its NPRM, refining the CWC program is essential to achieving Congress's goal of increasing the nation's use of renewable fuel and especially cellulosic biofuel—the most environmentally beneficial form of renewable fuel mandated by Congress.[79]

The CAA does not require that the number of CWCs be equal to the operative cellulosic volume requirement. The statute provides only that EPA "shall *limit* the number of cellulosic biofuel credits for any calendar year to the minimum applicable volume (as reduced under this subparagraph) of cellulosic biofuel for that year."[80] As EPA has recognized, the phrase "shall limit" sets a ceiling but not a floor on the number of CWCs: "EPA is required to provide a number of cellulosic credits for sale that is *no more than* the volume used to set the standard."[81]

Under that ceiling, EPA arguably has "considerable flexibility" in implementing the CWC program.[82] EPA, however, must exercise whatever discretion it has consistent with Congress's other applicable directives, including that EPA implement the CWC program in such a way as "'to assist market liquidity and transparency, to provide appropriate certainty for regulated entities and renewable fuel producers, and to limit any potential misuse of cellulosic biofuel credits to reduce the use of other renewable fuels.'"[83] Thus, as EPA has acknowledged,

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[76] 42 U.S.C. § 7545(*o*)(7)(D)(ii).

[77] *Regulations of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program*, 75 Fed. Reg. 14,670, 14,726-14,728 (Mar. 6, 2010) ("2010 RFS Rule").

[78] 40 C.F.R. § 80.1456(a)(2).

[79] *See* 42 U.S.C. § 7545(*o*)(1)(E) (defining "cellulosic biofuel" as having greenhouse gas emissions that are "at least 60 percent less than" the greenhouse gas emissions of conventional gasoline or diesel fuel); *see also Americans for Clean Energy*, 864 F.3d at 623 (noting cellulosic biofuel as "the 'greenest' form of renewable fuel mandated by the Renewable Fuel Program").

[80] 42 U.S.C. § 7545(*o*)(7)(D)(iii) (emphasis added).

[81] 2010 RFS Rule at 14,726 (emphasis added).

[82] *Id.* at 14,727.

[83] *Id.* (quoting 42 U.S.C. § 7545(*o*)(7)(D)(iii)).

it must administer the CWC program so as to "ensure that waiver credits are not overutilized at the expense of actual renewable volume" and to avoid "unintended consequences."[84]

EPA's current practice fails to meet these obligations and jeopardizes the force of the cellulosic biofuel volume requirement. EPA's policy of issuing as many CWCs as the required cellulosic biofuel volume has the presumably "unintended consequences" of undermining "certainty" and impairing "liquidity" regarding the cellulosic biofuel market. The industry has witnessed significant growth in recent years. For example, annual net cellulosic biofuel RINs increased from 0.81 million in 2013 to 33.07 million in 2014, to 140.26 million in 2015, and to 190.78 million in 2016.[85] And as shown above, both liquid cellulosic biofuel and RNG are expected to be produced in significantly higher volumes in 2018.

In order to sustain this growth trajectory and to continue to attract vital investment in cellulosic biofuel production capacity, producers of cellulosic biofuel need assurance that there will be market demand commensurate with their supply and that their product will elicit full-value off-take agreements. The ability of obligated parties to avoid cellulosic RINs entirely by buying CWCs undermines that prospect. Indeed, cellulosic biofuel producers have reported that obligated parties are not engaging in full-value off-take agreements for liquid gallons of cellulosic biofuel.

More broadly, given that Congress originally made CWCs available to account for the nascent nature of cellulosic biofuel production, EPA's continued adherence to its policy of issuing as many CWCs as the required volume—without taking account of the changes in industry conditions—potentially signals a lack of support for robust cellulosic volumes in the long term.

In addition to the problem of making far too many CWCs available, the current lack of a good-faith requirement for obligated parties fails to ensure that CWCs are a last resort, rather than a convenient substitute for cellulosic biofuel RINs. Requiring obligated parties to show that they first made a good-faith effort to purchase available cellulosic biofuel RINs before turning to CWCs would help promote robust growth of the cellulosic biofuel industry and would communicate the importance of that growth to the market.

IV. THERE IS NO BASIS TO USE THE GENERAL WAIVER TO REDUCE THE TOTAL RENEWABLE VOLUME REQUIREMENT DUE TO SEVERE HARM TO THE ECONOMY OR THE ENVIRONMENT

EPA correctly proposes not to issue a general waiver on the basis of severe economic or environmental harm, but it does invite comment on whether such a waiver is warranted. In particular, EPA entertains the suggestion that RFS "standards that would result in ethanol use beyond the blendwall would cause severe economic harm,"[86] and that the production of

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[84] *Id.*

[85] *Public Data for the Renewable Fuel Standard*, EPA, *available at* https://www.epa.gov/fuels-registration-reporting-and-compliance-help/public-data-renewable-fuel-standard.

[86] NPRM at 34,229.

feedstocks "used to produce conventional biofuels" would have "negative environmental impacts."[87] These suggestions are baseless. They fail to account for the high bar to show that implementation of the RFS program "would severely harm the economy or environment."[88] They contravene the transportation fuel industry's actual experience and EPA's findings regarding reasonably achievable levels of renewable fuel consumption. And they contravene prevailing consensus regarding the substantial environmental benefits of ethanol versus fossil-based fuels. In short, the possibility of using the general waiver ostensibly to prevent severe harm to the economy or environment should be rejected out of hand.

If EPA *were* inclined to issue such a general waiver, however, it would be required first to present an actual "comprehensive and robust analytical basis" for that decision—not the couple of passing suggestions included in the current NPRM—and provide an opportunity for public comment on *that* analysis.[89] Only then could EPA have a lawful basis for exercising that authority.

A. Under the RFS Statute and EPA's Longstanding and Sound Interpretation Thereof, the Severe Harm Provision Establishes a Very High Bar and Is Applicable in Very Narrow Circumstances

Under the RFS statute, EPA may waive an RFS volume requirement if it determines "after public notice and opportunity for comment, that implementation of the requirement *would severely harm* the economy or environment of a State, a region, or the United States."[90] EPA considered the severe harm standard at length in 2008, when it denied the State of Texas's request for such a waiver of the 2008/2009 standards. That well-reasoned decision set forth several principles that continue to control the determination of whether EPA may—and should—issue a waiver:

First, "implementation of the RFS program *itself* must be the cause of the severe harm."[91] Thus, it is not sufficient to show even that "implementation of the program would *significantly contribute* to severe harm" in combination with other factors unrelated to the RFS's implementation.[92] Thus, as EPA explained, if the market were experiencing a certain kind of severe harm (e.g., prohibitively high crop prices), and the RFS program was a significant contributor to that harm but there were other contributing factors, too (e.g., drought or insufficient farmland), that would *not* suffice to make the waiver available.[93]

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[87] *Id.*

[88] 42 U.S.C. § 7545(*o*)(7)(A)(i).

[89] *Notice of Decision Regarding the State of Texas Request for a Waiver of a Portion of the Renewable Fuel Standard*, 73 Fed. Reg. 47,168, 47,183-47,184 (Aug. 13, 2008) ("Texas Waiver Decision").

[90] 42 U.S.C. § 7545(*o*)(7)(A)(i) (emphasis added).

[91] Texas Waiver Decision at 47,171 (emphasis added).

[92] *Id.* (emphasis added).

[93] *Id.*

Second, the statute sets a "high threshold" for issuance of a waiver: "'severe' indicates a level of harm that is greater than marginal, moderate, or serious, though less than extreme."[94] In fact, "severe[] harm" is "clearly a much higher threshold than [the] 'significant adverse impacts'" standard applied by EPA in the ozone nonattainment context.[95]

Third, it is not enough that severe harm *might* result, or even that severe harm is *likely* to result. Rather, EPA must have a "high degree of confidence" that severe harm *would* result but for a waiver.[96] As EPA has explained, "in situations where there is not such a high degree of confidence, a waiver might disrupt the expected growth in use of renewable fuels but there would be no clear expectation that a waiver would provide a benefit by reducing any harm."[97]

Fourth, the statute's use of the word "economy" means that the harm must be considered in light of the economy as a whole, not any one sector of it (e.g., the oil industry, or the poultry industry). EPA has explained: "[I]t would be unreasonable to base a waiver determination solely on consideration of impacts of the RFS program to one sector of the economy, without also considering the impacts of the RFS program on other sectors of the economy or on other kinds of impact. It is possible that one sector of the economy could be severely harmed, and another greatly benefited from the RFS program; or the sector that is harmed may make up a quite small part of the overall economy."[98]

Fifth, EPA has "discretion in determining whether to grant or deny a waiver request, even in instances where EPA finds that implementation of the program would severely harm the economy or environment of a State, region or the United States."[99] Because a waiver "will always … be national in character," EPA has decided that even if the qualifying "severe harm" is limited to a certain state or region, EPA should not as a matter of policy exercise that discretion without "look[ing] broadly at all of the impacts of implementation of the program, and all of the impacts of a waiver," including "the nationwide effects" of a waiver.[100]

Sixth, although EPA recognized that it may be appropriate to *deny* a severe harm waiver summarily, it is not proper to *grant* one without a "comprehensive and robust analytical basis for any claim that the RFS itself is causing harm, and the nature and degree of that harm," and without the public having notice of and an opportunity to comment on the details of that analysis.[101]

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94 *Id.* at 47,172.

95 *Id.*

96 *Id.*

97 *Id.*

98 *Id.*

99 *Id.*

100 *Id.*

101 *Id.* at 47,183-47,1884.

Although the Texas waiver decision was specifically about severe economic harm, EPA also recognized that these principles apply equally to severe environmental harm.[102] EPA reinforced this position in its Response to Comments for the 2017 RFS rule, when it specifically invoked the first three principles above in the context of a request for a waiver on severe environmental harm.[103] Put simply, EPA should invoke the severe harm waiver, whether for harm to the economy or environment, only if it is *highly confident* that without a waiver, the RFS program would cause *severe* and *widespread* harm.

These principles taken together ensure that the severe harm standard is invoked only in very rare and limited situations. EPA's interpretation of the severe harm waiver provision is not only textually required; it is also critical to the functioning of the RFS program. The program depends on market players having the long-term certainty that EPA will adhere to the volume requirements dictated in the statute, so that they can make investments in the necessary infrastructure with an expectation that the investment will pay off.[104] Thus, EPA recognized that Congress did not intend to provide in the severe harm provision an "open-ended and wide ranging waiver."[105] Rather, EPA found that "implementing a more limited waiver provision … will better implement Congress's overall desire to promote the use of renewable fuels, reflected in enacting the expanded RFS program and mandating the increased utilization of renewable fuels over a number of years."[106] The D.C. Circuit recently reinforced these points when it pointedly rejected the notion that Congress provided a "boundless general waiver authority."[107] Such a broad waiver authority would interfere with "how the Renewable Fuel Program is supposed to work" through "increasing requirements [that] are designed to force the market to create ways to produce and use greater and greater volumes of renewable fuel each year."[108]

B. Implementation of the 2018 Total Volume Requirement Without a General Waiver Will Not Severely Harm the Economy

EPA has invited comment on whether it should use its general waiver power to avoid severely harming the economy. EPA has no basis to do so.

[102] *Id.* at 47,184.

[103] 2017 Response to Comments at 54-55.

[104] *See* 2014-2016 RFS Rule at 77,433, 77,456, 77,459-77,460; *Monroe Energy LLC v. EPA*, 750 F.3d 909, 917 (D.C. Cir. 2014).

[105] Texas Waiver Decision at 47,171.

[106] *Id.*

[107] *Americans for Clean Energy*, 864 F.3d at 711; *see also National Petrochemical & Refiners Ass'n v. EPA*, 630 F.3d 145, 149 (D.C. Cir. 2010) ("The EISA authorized the waiver of the volume requirements only in limited circumstances.").

[108] *Americans for Clean Energy*, 864 F.3d at 710.

1. EPA's "reasonably attainable" finding precludes a determination that implementation of the total volume requirement without a general waiver would cause severe harm to the economy

In both the NPRM for 2018 and the final RFS rule for 2017, EPA has found that the total required volume of renewable fuel use now proposed, as well as the implied volume of conventional renewable fuel use, could be "reasonably attained." As EPA has recognized previously, "[i]n light of [those] finding[s] …, it follows that the final requirements will not cause severe economic harm."[109]

In the final RFS rule for 2017, EPA set the total renewable fuel volume requirement to 19.28bg, and set the implied volume for conventional renewable fuels—most of which would be starch ethanol—to 15.00bg.[110] Those volume requirements reflected EPA's determination that they were "reasonably attainable,"[111] taking into account all factors potentially affecting the ability of the market to produce, dispense, and consume renewable fuel, including the potential for market disruptions and price effects as well as "factors related to the likely constraints on imports, distribution and use, and global GHG impacts of incremental growth."[112] The analysis underlying the final 2017 volume requirements, therefore, left no room to conclude that implementing those requirements would severely harm the economy, as EPA recognized: "In light of our finding that the volumes requirements and associated standards being finalized are reasonably attainable, it follows that the final requirements will not cause severe economic harm, so further reductions on that basis are not necessary."[113]

That same analysis, and EPA's corresponding analysis supporting the proposed 2018 volume requirements, similarly leave no room to conclude that implementing the proposed 2018 requirements would severely harm the economy. For 2018, EPA has proposed the same implied volume for conventional renewable fuel as it adopted for 2017 (15.00bg) and a slightly *lower* total renewable fuel volume compared to the 2017 volume (19.24bg).[114] Consistent with its finding regarding the 2017 volumes, the current NPRM again concludes that those volumes are

[109] 2017 Response to Comments at 53.

[110] 2017 RFS Rule at 89,747, 89,773, 89,780-89,781.

[111] *Id.* at 89,774, 89,780-89,782. Although under EPA's now-vacated approach to the general waiver, it assessed the "maximum achievable" volume of renewable fuel, EPA assessed the "reasonably attainable" volume of renewable fuel—a potentially lesser amount—in deciding how much of the cellulosic waiver to flow through to the advanced and total volume requirements. *See id.* at 89,774 n.103; *id.* at 89,777 n.119.

[112] *Id.* at 89,763, 89,773-89,775; 2014-2016 RFS Rule at 77,435, 77,440-77,452.

[113] 2017 Response to Comments at 53.

[114] NPRM at 34,207, 34,229.

"reasonably attainable."[115] Thus, a fortiori there is no basis to conclude that implementing the proposed 2018 volume requirements for total renewable fuel or conventional renewable fuel would severely harm the economy.

2. EPA's analysis actually understates the "reasonably attainable" volume of ethanol

Although EPA's "reasonably attainable" analysis disposes of the severe harm question, it also substantially understates the consumption of ethanol through E85 and E15 that plainly could occur without severe harm resulting.

a. EPA's flawed analysis of E85

As Growth Energy explained in its 2017 comment, and as Americans for Clean Energy, Growth Energy, and others explained in the litigation challenging the 2014-2016 RFS rule, E85 has rarely—and never consistently—been priced below E10 on an energy-parity basis.[116] That is because the RFS has never been set at levels requiring substantial use of E85,[117] and so E85 retailers have found that their profit-maximizing strategy has been to treat E85 as a premium product, targeting price-insensitive consumers such as government fleets or individuals willing to pay more for E85 in view of its environmental, economic, and security benefits.[118] This in turn means that price reductions in E85 have not historically generated substantial observed consumer response; all that happened, at most, is E85 went from "way more expensive" than E10 to merely "more expensive" than E10.[119]

Although the market thus has not had occasion to test the upper bounds of E85 potential, Growth Energy submitted, in connection with its comment on the proposed RFS rule for 2017, expert reports by Stillwater Associates and the Brattle Group, as well as rigorous prior academic research by several economics professors, demonstrating through data and economic modeling how the market can be expected to react *if and when* the standards are set high enough that substantial E85 usage is necessary for the market to reach equilibrium.[120] First, consistent with

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[115] *Id.* at 34,229. In fact, EPA initially concluded that a larger volume—19.38bg—is reasonably attainable in 2018. Proposed 2018 Standards: Briefing for Interagency Reviewers 9-10 (May 11, 2017), EPA-HQ-OAR-2017-0110. The 100mg reduction (to 19.28bg) in the NPRM resulted from EPA's decision to lower its projection of cellulosic biofuel. Even if that reduction were sound, *but see* Part II, *supra*, that would not undermine EPA's finding that 19.38bg of total renewable fuel is reasonably attainable in 2018 because the difference could easily be backfilled by non-cellulosic advanced biofuels or by starch ethanol volumes. *See, e.g.*, NPRM at 34,207.

[116] 2017 Growth Energy Comment 12 (July 11, 2016) (attached as Exhibit 6), EPA-HQ-OAR-2016-0004-3499; *Americans for Clean Energy, Inc. v. EPA*, No. 16-1005, dkt. #1661227, at 7 (D.C. Cir. Feb. 14, 2017).

[117] 2017 Growth Energy Comment at 9, 11-14, 23-25.

[118] *Id.* at 8.

[119] *Id.* at 6.

[120] *See id.* at 14-16, 22-28.

EPA's recognition that price is the most important factor for consumers when buying transportation fuel, and consistent with EPA's recognition of what economic theory would predict,[121] those reports and papers showed, through data and rigorous modeling, how the consumer demand curve would exhibit accelerating consumer response as E85 prices fell below energy parity with E10.[122] Indeed, any other demand curve would lead to implausible results as the E85 discount approaches 100%.[123] Second, the Stillwater and Brattle reports explained how, if the RFS standards are set high enough, E85 stations will find that rather than competing monopolistically with other E85 stations for the small portion of price-insensitive E85 consumers, they will be far better off discounting E85 below E10 and thus competing directly with E10 in order to capture traffic from the substantially larger, price-sensitive E10 customer base.[124]

EPA has declined to follow this commonsense logic supported by data, for no other reason than EPA's evident risk aversion. Without coherent explanation, EPA has decided that, where a linear or weakly nonlinear relationship explains the data as well as a more strongly nonlinear relationship, then the linear or weakly nonlinear model should be selected to project E85 demand.[125] But there is no reason to believe that to be the right choice when EPA's analysis lacks data from consistent pricing below parity, and particularly when that choice contravenes economic theory, rigorous research, and common sense.

EPA also insists, in the absence of data from a time when substantial E85 volume was necessary to meet the RFS mandate, on an unstated 22% cap on the E85 discount to E10, refusing to heed economic theory and expert conclusions that E85 prices will decline until the market finds an equilibrium that matches the requisite constraints. Instead, EPA treats these prices as external "constraints" that must be "achieved." As Brattle explained, basic economic theory teaches that "[n]either the E85 price discount nor the RIN price that would be necessary to

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[121] *2014 Standards for the Renewable Fuel Standard Program*, 78 Fed. Reg. 71,732, 71,760 (Nov. 29, 2013); David Korotney, *Correlating E85 consumption volumes with E85 price*, at 4 ("2016 Korotney Memorandum"), EPA-HQ-OAR-2015-0111-3666.

[122] 2017 Growth Energy Comment at 14-16.

[123] *Id.* at 6-8.

[124] *Id.* at 22-28.

[125] *See* David Korotney, *Updated correlation of E85 sales volumes with E85 price discount*, at 6-8 (Nov. 18, 2016) ("2017 Korotney Memorandum") (rejecting nonlinear forms simply because they do not appear to *add* to the explanatory power of the original dataset, while not explaining why the default linear or weakly nonlinear assumption should be treated as the default), EPA-HQ-OAR-2016-0004-3752; 2016 Korotney Memorandum at 13-16 (similarly rejecting nonlinear form simply because it purportedly did no better than the linear form, while not explaining why the linear form is thus the better choice).

In fact, EPA's use of a weakly nonlinear form in 2017 makes even less sense than the linear form EPA chose in 2016. As EPA concedes, the weakly nonlinear form "demonstrates a weaker response to price" than the original form at large E85 discounts. 2017 Korotney Memorandum at 5.

achieve a particular E85 price discount are exogenous constraints but instead are endogenous results of policy choices, namely the RVO level EPA sets and the volume of E85 sales necessary to meet that RVO level."[126]

Growth Energy maintains that this approach to E85—which EPA continues to rely upon in proposing the total volume requirement for 2018 by assuming the same ethanol concentration in 2018 as 2017—is not supportable under EPA's "reasonably attainable" standard. That view essentially creates a Catch-22 at odds with congressional intent, as EPA is declining to push the market to reach higher volumes because they have not been historically achieved. Higher volumes will be achieved only when EPA allows the RFS to actually push the market as Congress intended.

EPA's assessment of E85 infrastructure is similarly flawed. EPA claims in the NPRM that even more than price, E85 sales in 2018 will be limited by the number of stations offering E85.[127] This unexplained assertion is wrong: EPA itself has found that there were sufficient E85 stations and flex-fuel vehicles ("FFVs") with reasonable access to those stations to deliver 1.3bg gallons of E85, or 860mg of incremental ethanol in E85.[128] And EPA has never rebutted the analysis Growth Energy submitted in prior RFS rulemakings showing that there is sufficient E85 station infrastructure to deliver more than 1bg of ethanol in E85 to nearby FFVs.[129] Of course since those analyses, the number of E85 stations has increased markedly due to the BIP program, as EPA acknowledges,[130] and the number of FFVs on the road has continued to increase.[131] Insofar as EPA were to base a severe economic harm waiver on inadequate infrastructure, it would need to explain how, notwithstanding this record evidence and its prior reasoning, it has a high degree of confidence that severe harm would result.

b. EPA's flawed analysis of E15

Likewise, EPA's analysis of E15 consumption is wrong. In both its 2014-2016 and 2017 comments, Growth Energy set forth extensive analysis showing that E15 infrastructure is capable of rapid expansion once EPA sets the RFS at levels that actually require substantial E15 growth.[132] That analysis is still valid. In fact, with the addition of new opportunities for

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[126] *See* 2017 Brattle Report at 3 (attachment Exhibit B to attached Exhibit 6).

[127] NPRM at 34,231.

[128] David Korotney, *Application of one-in-four E85 access methodology to 2014* (Nov. 21, 2013), EPA-HQ-OAR-2013-0479.

[129] 2017 Growth Energy Comment at 28-33; 2014-2016 Growth Energy Comment 33-37 (July 27, 2015) (attachment Exhibit A to attached Exhibit 6), EPA-HQ-OAR-2015-0111-2604.

[130] David Korotney, *Projections of retail stations offering E15 and E85 in 2017* (Nov. 18, 2016), EPA-HQ-OAR-2016-0004-3751-0026.

[131] Air Improvement Resource, Inc., *Analysis of Ethanol-Compatible Fleet for Calendar Year 2018* (Aug. 31, 2017) (attached as Exhibit 3).

[132] 2017 Growth Energy Comment at 33-37; 2014-2016 Growth Energy Comment at 41-52.

terminal-blended E15, the potential for E15 growth is even larger today.[133] Yet EPA has consistently downplayed the potential for E15 expansion based on EPA's improper adherence to what has historically been achieved.[134] EPA has further cramped its estimates of potential E15 growth by indulging baseless concerns about retailer misfueling.[135]

3. Doubts about whether the proposed volumes are "reasonably attainable" are insufficient to meet EPA's burden for a severe harm waiver

Even if EPA were to conclude, under its method of analyzing the reasonably attainable volumes in its exercise of the cellulosic flow-through authority, that sufficient volumes of E85 and E15 were not reasonably attainable, that conclusion would not amount to a finding of severe economic harm. EPA may make such a finding only if it harbors no doubts about the harm that will result absent a waiver.

For purposes of the cellulosic flow-through, EPA's view is that reasonable doubts about achievable volumes may justify reducing volume requirements. In that context, according to EPA, its burden is to determine what volumes it has "*confidence*" the market could reasonably reach.[136] Thus, EPA has started with baseline volumes that it knows are achievable, e.g., the amounts achieved historically, and then asked what it confidently can say the market could achieve above that threshold in the next year. Thus, EPA has relied upon (misplaced) doubts such as those discussed above regarding the shape of the E85 demand curve, achievable relative pricing between E85 and E10, and E15 distribution infrastructure to justify lowering the volume requirement.

Regardless of whether that approach is sound under EPA's cellulosic flow-through authority, it would be wholly improper to use it when evaluating severe economic harm because of the different burden EPA bears in the severe harm context.[137] As discussed above, the severe harm waiver may be invoked only if EPA has a "high degree of confidence" that severe harm *would* result—even confidence that severe harm would *likely* result is insufficient.[138] Thus, in order to conclude that implementing the volume requirements would severely harm the economy, EPA must reverse its presumption in light of its different burden: whereas, for purposes of the cellulosic waiver flow-through, EPA presumes that volumes will be lower unless it can dispel its doubts that they will be higher, for purposes of the severe harm waiver EPA must

[133] *See* NPRM at 34,236.

[134] *Id.*

[135] NPRM at 34,232.

[136] NPRM at 34,235; 2017 RFS Rule at 89,791; 2014-2016 RFS Rule at 77,481; *see also* 2014-2016 RFS Rule at 77,472 (limiting expected biodiesel volumes based on what EPA thinks it would be "prudent" to assume).

[137] To be clear, Growth Energy does not believe that EPA would even need to consider potential growth of E85 to *reject* outright use of a severe economic harm waiver. But certainly EPA could not decide to *apply* this waiver without fundamentally changing its analysis as described here.

[138] Texas Waiver Decision at 47,171.

presume that volumes will be higher unless it can dispel its doubts that they will be lower. Mere doubt or inadequate data about whether there would be severe harm militates *against* waiving the volumes.[139]

4. Even if EPA's "reasonably attainable" finding did not foreclose a finding of severe harm to the economy, EPA could not make such a finding for 2018

Even setting aside EPA's sound determination that at least 19.24bg of total renewable fuel, and 15.00bg of conventional renewable fuel, are "reasonably attainable" volumes in 2018, it would be inappropriate to invoke the general waiver because adherence to those levels would not cause severe harm to the economy. Because the 2018 total standard is *lower* than the 2017 standard—and only modestly above what the market actually achieved in 2016 (18.6 billion net RINs)[140]—such a claim would mean that we are experiencing severe economic harm *right now*. That is manifestly false.

Growth Energy expects some obligated parties to argue that the RIN prices they must pay constitute a severe harm to them. EPA, however, has repeatedly and thoroughly debunked the notion that independent refineries are experiencing harm by virtue of being required to submit RINs for compliance while not themselves owning blending operations. EPA explained in its screening analysis on the costs to small entities as part of this proposal:

> EPA continues to believe that because there is a cost to all obligated parties to acquire RINs, obligated parties are recovering the cost of these RINs through higher prices they receive for the petroleum based gasoline and diesel fuel they produce. EPA has examined available market data and concluded that current gasoline and diesel prices generally enable obligated parties to recover the cost of the RINs. When viewed in light of this data, *there is no net cost of compliance with the RFS standards to obligated [parties]* (cost of compliance with the RFS standards minus the increased revenue due to higher gasoline and diesel prices that result from implementing the RFS program).[141]

That conclusion follows a succession of similar findings in prior years. In 2016, EPA not only concluded that obligated parties were recovering these costs, but more broadly recognized that "The Current Program Structure Appears to be Working to Achieve the Goals of the RFS

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[139] Beyond these ethanol pathways, the severe economic harm waiver also alters how EPA must consider biodiesel. For instance, in the current NPRM EPA reduces the amount of BBD it deems reasonably achievable based on concerns about feedstock diversion and not taking away from exports. NPRM at 34,221. Under the severe economic harm waiver, EPA may not limit the amounts of biofuels that it determines can be achieved based on such policy goals – the sole question is whether requiring a certain level of consumption would cause severe economic harm.

[140] 2016 Supply (Mar. 7, 2017), EPA-HQ-OAR-2017-0091-0061.

[141] Dallas Burkholder, et al., *Screening Analysis for the Renewable Fuel Standard Program Renewable Volume Obligations for 2018* (June 28, 2017), EPA-HQ-OAR-2017-0091-0097.

Program," and that current RIN prices were not indicative of a dysfunctional RIN market.[142] In 2015, EPA issued a docket memorandum that made similar findings.[143]

These findings alone would defeat a claim of severe economic harm by the obligated parties. But even if obligated parties were incurring costs that were not being recovered, there would be no basis to conclude that any harm they are experiencing is severe. Any government policy generally provides benefits to certain parts of the economy while working adversely to the interests of another. RIN price costs on refiners—particularly those who have no blending operations and thus are not themselves directly acting to further the policy goals Congress set forth in the RFS statute—are precisely the "lesser degrees of economic harm" that the D.C. Circuit recognized that Congress expected to impose by establishing the RFS program in the first place, and that would not qualify as "severe" harm for purposes of the general waiver.[144] Indeed, far from being a basis for waiver, those higher RIN prices are the very engine for the growth that Congress intended the RFS program to achieve, as "higher RIN prices" should "incentivize precisely the sorts of technology and infrastructure investments and fuel supply diversification that the RFS program was intended to promote."[145] EPA must reserve the severe harm waiver for truly catastrophic economic events, not the economic transfers that Congress specifically intended as part of its market-forcing scheme.

Nor are other industry players being severely harmed. EPA has already found that, although refiners are able to pass the RIN price through via higher blendstock pricing, that does *not* result in higher costs of E10 to the end-consumer.[146] Rather, the higher blendstock price is offset by the lower cost of ethanol.[147] EPA recently reaffirmed these findings when it proposed denying the petition to move the point of obligation.[148] In fact, as Growth Energy documented in its comments to the 2014-2016 rule, and as updated in a recent report by Marc Chupka and J. Michael Hagerty of the Brattle Group and Philip K. Verleger of PKVerleger LLC (discussed further in Part V.B, *infra*), numerous studies show how implementation of the RFS program and increased ethanol consumption have meaningfully *reduced* the prices of fossil fuels, by

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[142] EPA, *Proposed Denial of Petitions for Rulemaking to Change the RFS Point of Obligation*, at 12-21 (Nov. 2016) ("Proposed Denial"), *available at* https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100PUF0.pdf.

[143] Dallas Burkholder, *A Preliminary Assessment of RIN Market Dynamics, RIN Prices, and Their Effects*, at 2 (May 14, 2015) ("2015 Burkholder Memorandum"), EPA-HQ-OAR-2015-0111-0062.

[144] *Americans for Clean Energy*, 864 F.3d at 712.

[145] *Monroe Energy*, 750 F.3d at 919.

[146] *See* 2015 Burkholder Memorandum at 1, 31; *see also* 80 Fed. Reg. 33100, 33,119 n.49 (June 10, 2015).

[147] *Id.* Of course, even if EPA were to find some effect on overall transportation fuel prices, that would still not itself constitute severe harm; among other things, that increase in fuel prices would have to be considered in light of the benefits that the RFS program provides.

[148] Proposed Denial at 16.

"stretch[ing]" existing available fossil fuel supply.[149] Those comments also marshaled numerous studies showing how implementation of the RFS program has minimal effect on feed and retail food prices: corn ethanol uses only the starch of the corn and thus has co-products that *add* to the feed supply, and retail food prices are driven more by crude oil prices than the price of individual crops like corn.[150]

Indeed, as EPA recognized in resolving the Texas waiver request, EPA cannot judge the degree of harm for purposes of the waiver simply by focusing on one industry in isolation. Rather, EPA must look at the economy as a whole, and thus consider the benefits that the RFS program has for the economy as a whole. Those benefits here are substantial, as discussed in greater detail in Part V.B, *infra*, and outweigh any purported harms being borne by obligated parties or other players in the industry due to existing RIN prices or compliance obligations.

5. EPA must consider carryover RINs and carryover deficits when assessing whether there would be severe harm to the economy

Yet another reason that implementation of the proposed total volume requirement without a general waiver would not cause severe harm to the economy is the important compliance flexibilities available to obligated parties to mitigate such harm, including a large bank of carryover RINs and the ability to carry over RIN deficits. Carryover RINs and carryover deficits are flexibilities that are part and parcel of the RFS program as implemented by EPA, and are specifically designed to mitigate harms that might otherwise result from the program while still ensuring that the overall requirements are met.[151] Although the D.C. Circuit recently affirmed EPA's position that it is not required to count carryover RINs when assessing whether the "supply" of renewable fuel is "inadequate" to meet the applicable statutory volume requirement,[152] and although EPA takes the view that it may exclude carryover RINs from its "reasonably attainable" analysis under its cellulosic waiver flow-through authority, EPA must still account for carryover RINs (and the ability to carry over deficits) when deciding whether implementation of the RFS program would, in fact, cause severe harm without a waiver.[153]

Thus, to apply the severe economic harm waiver, EPA would have to take into account both the market's ability to use existing carryover RINs and its opportunity to use carryover deficits, and *still* conclude that, nonetheless, implementation of the statutory requirements would

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[149] The Marc Chupka and J. Michael Hagerty, the Brattle Group, and Philip K. Verleger, PKVerleger LLC, *Blending In: The Role of Renewable Fuel in Achieving Energy Policy Goals* 22 (Aug. 31, 2017) (attached as Exhibit 2) ("Chupka, Hagerty & Verleger Report"); *see* 2014-2016 Growth Energy Comment at 75-77.

[150] 2014-2016 Growth Energy Comment at 77-78.

[151] *See* 2014-2016 RFS Rule at 77,483-77,484; *Americans for Clean* Energy, 864 F.3d at 715 (discussing EPA's view that carryover RINs are important for "unexpected shortfalls or increased demand").

[152] *Americans for Clean* Energy, 864 F.3d at 713-716.

[153] *Cf. id.* at 714 (noting that the text "inadequate domestic supply" was controlling in its analysis of carryover RINs).

cause severe harm to the economy. No such conclusion is possible in the present circumstances. According to EPA, the market generated 18.6 billion net RINs in 2016,[154] and EPA estimates that there are currently approximately 2 billion carryover RINs. Thus, even if the market simply maintained its 2016 level of net RIN generation—a level that plainly did not cause severe economic harm—the market could achieve the proposed volume of 19.24 billion RINs in 2018 and still have more than 1.36 billion RINs in the carryover bank.

Nor can there be any argument that reducing the bank—by that amount or more—somehow "would" cause severe harm. EPA has said that the purpose of the bank is to create a buffer to address unforeseen circumstances such as natural disaster.[155] EPA's concern is that such circumstances *might* occur, which in turn *might* result in a RIN shortfall that (EPA erroneously claims) *might not* be adequately addressed through carryover deficits.[156] The layers and layers of speculation required before the reduction or elimination of the bank could lead to tangible severe economic harm is well below even the threshold of showing *likely* harm, let alone reaching the required "high degree of confidence" that severe harm "would" result.[157]

C. Implementation of the 2018 Total Volume Requirement Without a General Waiver Will Not Severely Harm the Environment

EPA has also invited comment on whether it should use its general waiver power to avoid severely harming the environment. EPA should not and indeed could not do so. Notably, neither actual experience in 2016 nor the 2017 RFS rulemaking process—which, again, resulted in the same implied volume for conventional renewable fuel of 15bg as now proposed for 2018—prompted EPA to express any concern about resultant environmental harm. In fact, EPA recently rejected that very proposition.

There is no warrant for changing course. The statute reflects Congress's judgment that biofuels, including conventional biofuels such as corn starch ethanol, would benefit the environment by reducing greenhouse gas ("GHG") emissions. The newest data confirm that judgment. And there is no basis to conclude that any environmental factors not already accounted for by lifecycle GHG analysis would support a finding of "severe[]" harm to the environment.

On the contrary, what would harm the environment is *waiving* the implied volume of 15bg for conventional renewable fuel. The gap between lifecycle GHG emissions associated with conventional biofuels and those of fossil fuels is *growing wider*, which translates into increased environmental *benefits* from starch ethanol. Moreover, maintaining a commitment to starch ethanol also benefits the environment by supporting the companies that are leading investment in the next wave of environmentally beneficial renewable fuel technologies.

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[154] 2016 Supply (Mar. 7, 2017), EPA-HQ-OAR-2017-0091-0061.

[155] 2014-2016 RFS Rule at 77,483.

[156] *Id.* at 77,483-77,484.

[157] Texas Waiver Decision at 47,172.

1. Starch ethanol benefits the environment relative to fossil fuels by reducing GHG and other pollutant emissions substantially

EPA will not be able to identify severe harm to the environment because, with respect to the single most important available metric of environmental impact—GHG emissions—the use of starch ethanol instead of fossil fuel indisputably benefits the environment. Reducing the total volume requirement through a general waiver would replace starch ethanol with fossil fuel and thus would deprive the nation of the very environmental benefits Congress sought to achieve through the RFS program.

"[R]educing greenhouse gas emissions" is the "objective" of the RFS program.[158] EPA itself has observed that one of the "central policy goals underlying the RFS program" is "reductions in greenhouse gas emissions."[159] Congress's judgment that reducing greenhouse gas emissions is a critical environmental goal—indeed, *the* critical environmental goal of the RFS program—is highlighted by the structure of the program itself, which provides detailed definitions of lifecycle GHG emissions, and which includes renewable fuels like ethanol in the RFS program based in some instances on whether they achieve significant (*i.e.*. 20% or greater) reductions in lifecycle GHG emissions over gasoline.[160]

The most salient question with respect to whether a general waiver of the total volume requirement could be justified based on environmental harm is therefore how the invocation of a waiver—and the resulting decrease in the amount of conventional biofuels consumed in place of fossil fuels—would affect GHG emissions. And the answer is clear: Invoking the general waiver would by definition result in less ethanol, which would lead to higher overall GHG emissions. A general waiver would thus *elevate* the risk of environmental harm, rather than prevent it.

The data on lifecycle GHG emissions for ethanol versus gasoline is robust. In previous years, Growth Energy has pointed to analyses from the Department of Energy's Alternative Fuels Data Center and its Argonne National Laboratory showing corn starch-based ethanol accounts for significant (*i.e.*, approximately 40%) reductions in lifecycle GHG emissions relative

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[158] *API*, 706 F.3d at 476.

[159] 78 Fed Reg. at 71,778; *see also* 80 Fed. Reg. at 33,110 (concluding that "we do not believe that it would be consistent with the … greenhouse gas reduction goals of the statute to reduce the applicable volumes of renewable fuel set forth in the statute absent a substantial justification for doing so.").

[160] *See* 42 U.S.C. § 7545(*o*)(1)(B)-(H); *id.* § 7545(*o*)(2)(A)(i). This 20 percent threshold applies only to ethanol produced in factories built after December 19, 2007; ethanol from older factories need not meet the 20 percent threshold to be included, although (as this comment indicates) such ethanol likely does so.

to gasoline.[161] Already, those numbers are well above EPA's previous 2010 assessment that ethanol's lifecycle GHG emissions are 21% lower than gasoline's[162]—demonstrating in part that the ethanol industry has greatly improved its efficiency, minimized the local environmental impact of its operations, and adopted new technologies at ethanol facilities at a faster rate than anticipated by EPA.

Newer studies confirm and build on these older analyses, showing potentially even sharper GHG emissions reductions from ethanol. In January 2017, USDA released the most comprehensive lifecycle GHG emissions analysis for ethanol yet.[163] Building on EPA's 2010 Regulatory Impact Analysis ("RIA"), the USDA's 2017 Report updates the RIA model based on "a large body of new information [that] has become available since 2010—including new data, scientific studies, industry trends, technical reports, and updated emissions coefficients."[164] The USDA Report considers the carbon costs of feedstock production, fertilizer usage and production, and land usage. And it concludes that ethanol's lifecycle GHG emissions are significantly less than were estimated at the time of the RIA. Specifically, it estimates lifecycle GHG emissions at 55 kg CO_2/MMBTU under 2014 conditions, and 50 kg in its 2022 "business as usual" scenario (*i.e.*, based on existing trends in land usage and other factors),[165] down from the RIA estimate of 79 kg CO_2/MMBTU. By comparison, the lifecycle GHG emissions of gasoline in 2005, the baseline prescribed by the RFS statute, is 98 kg CO_2/MMBTU. The USDA

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[161] U.S. Dept. of Energy, Alternative Fuels Data Center ("On a lifecycle analysis basis, GHG emissions are reduced on average by 40% with corn-based ethanol produced from dry mills, and up to 108% if cellulosic feedstocks are used, compared with gasoline and diesel production and use."), *available at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html; *see also* Michael Wang et al., Argonne National Labs, *Well-to-Wheels Energy Use and Greenhouse Gas Emissions of Ethanol from Corn, Sugarcane, and Cellulosic Biomass for U.S. Use*, at 9 table 7 (Dec. 13, 2012) (showing 19-48% reduction versus gasoline, taking account of the full lifecycle of emissions, including emissions associated with ethanol plants, fertilizer production, and corn farming), *available at* http://iopscience.iop.org/1748-9326/7/4/045905/pdf/1748-9326_7_4_045905.pdf.

[162] *See* U.S. Dep't of Agriculture, *A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol* 4 (January 12, 2017) ("USDA 2017 Report").

[163] *See id.*

[164] *Id.* at 4-5.

[165] *Id.* at 167 Fig. 4-4.

report thus concludes that lifecycle GHG emissions reductions compared to gasoline are more than *double* what the EPA concluded in 2010.[166]

A report prepared for Growth Energy using the data from the 2017 USDA Report, as well as data from the Argonne National Laboratory's "GREET2016" Model, breaks down the bottom line conclusion: In contrast to the 21% reduction found by EPA in the 2010 RIA, the USDA Report finds a *43-48% reduction in lifecycle GHG emissions from ethanol over gasoline*, and GREET2016 meanwhile shows a 40% reduction.[167] Another report prepared for Growth Energy explains in concrete terms what these numbers mean for the use of a general waiver: For every 100 million gallons of reduced starch ethanol below the proposed level of 15bg, annual GHG emissions in the U.S. would *increase by 322,876 metric tons*.[168]

Studies have also established other environmental benefits from ethanol. For example, a recent natural experiment on emissions and air quality in Sao Paulo, where scientists were able to measure harmful ultrafine particulate matter in the air before and after pricing and usage shifts between E100 ethanol and E20 gasoline, yielded a striking and clear conclusion: "Ultrafines

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[166] While part of this difference may simply be a more accurate picture based on additional data collection, it is also the case that corn farming and land usage are becoming more efficient, which reduces the carbon costs of one of the most intensive inputs for ethanol. *E.g.*, 2017 USDA Report 1-2. This trend was already in full swing by 2012, by which point per bushel land use had been reduced by 30 percent, erosion by 67 percent, irrigation by 53 percent, and energy use by 43 percent. *See* Field to Market (The Keystone Alliance for Sustainable Agriculture), *Environmental and Socioeconomic Indicators for Measuring Outcomes of On-Farm Agricultural Production in the United States* 10 (Dec. 2012), *available at* https://www.fieldtomarket.org/report/national-2/PNT_SummaryReport_A17.pdf.

[167] Air Improvement Resource, Inc., *Emissions Reductions from Current Natural Gas Corn Ethanol Plants* (Aug. 31, 2017) (attached as Exhibit 4).

[168] Air Improvement Resource, Inc., *EPA Proposed Renewable Fuel Standards for 2018: Estimated Increase in National GHG Emissions if EPA Reduces the Conventional Fuel Volume* (Aug. 31, 2017) (attached as Exhibit 5).

rose with shift to gasoline and fell upon return."[169] This clear link between increased ethanol use and enhanced air quality had previously been shown in numerous other studies.[170]

Although the fossil-fuel industry might attempt to argue that the lifecycle GHG emissions for gasoline are now lower than the 2005-based figure of 98 kg CO_2/MMBTU used in the ICF study (and indeed, in the RFS statute[171]), that argument could not change the bottom line, for several reasons. First, more recent data does not appear to show an appreciable change in the lifecycle GHG emissions of gasoline.[172] Second, there is no indication that any supposed decline in the lifecycle GHGs of fossil fuels exceed the significant decline for ethanol, let alone by enough to erase ethanol's sizeable head start from 2010. Third, now more than ever, the marginal gallons of gasoline that are the first to be supplanted by ethanol come from the dirtiest, most carbon-intensive sources, like tar sands extraction.[173] If anything, then, using the statutorily defined average lifecycle GHG emissions of gasoline *understates* the GHG reduction from substituting ethanol for fossil fuels.

It is thus beyond any doubt that on an all-in basis, ethanol has substantial environmental benefits relative to fossil fuel as measured by lifecycle GHG emissions.

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[169] Salvo, et al, *Reduced Ultrafine Particle Levels in São Paulo's Atmosphere During Shifts From Gasoline To Ethanol Use*, Nature Communications, *available at* https://www.nature.com/articles/s41467-017-00041-5.epdf

[170] *See* 2012 Growth Energy Comment, Attachment 3, at 5-8 (Feb. 13, 2012) (collecting studies showing link between ethanol use and decreased particulate matter emissions, including Storey, et al., *Ethanol Blend Effects On Direct Injection Spark-Ignition Gasoline Vehicle Particulate Matter Emissions*, SAE publication 2010-01-2129 (finding that "[e]thanol blends reduced the PM mass and number concentration emissions for both transient and steady-state cycles")), EPA-HQ-OAR-2010-0799-9540; Maricq, et al., *The Impact of Ethanol Fuel Blends on PM Emissions from a Light-Duty GDI Vehicle*, Aerosol Science and Technology 46:5, 576-583 (2012) (finding "statistically significant … reduction in PM mass and number emissions" at particular ethanol levels); Zhang et al, *A Comparison of Total mass, Particle Size Distribution and Particle Number Emissions of Light Duty Vehicles tested at Haagen-Smit Laboratory from 2009 to 2010*, Proceedings of 21st CRC Real World Emissions Workshop, San Diego, CA, USA (Mar. 2011) (finding a large reduction in particulate matter emissions when using ethanol-based flex fuel)).

[171] *See* 42 U.S.C. § 7545(*o*)(1)(c) (defining baseline GHG emissions as lifecycle GHG emissions for gasoline in 2005).

[172] *See* Tong, et al., *Comparison of Lifecycle Greenhouse Gases from Natural Gas Pathways for Light-Duty Vehicles*, Energy Fuels 2015, 29, 6008−6018 tbl. 4 ("Comparison of Greenhouse Gases"), *available at* http://pubs.acs.org/doi/pdf/10.1021/acs.energyfuels.5b01063.

[173] Advanced Biofuels Business Council 2014-2016 Comment at 28 (July 27, 2015), EPA-HW-OAR-2015-0111-3528; *see also* Comparison of Greenhouse Gases at tbl. 4 (noting lifecycle GHG emissions for tar sands-based gasoline approximately 20% higher than gasoline from traditionally extracted crude).

2. Starch ethanol benefits the environment relative to fossil fuels by supporting investment in next-generation environmental technologies

The direct effect on lifecycle GHG emissions alone would be enough to preclude the invocation of any environmental harm waiver of the total volume requirement. But adhering to the proposed total volume requirement would also *benefit* the environment by promoting the transition to next generation biofuels like cellulosic ethanol.

Cellulosic biofuel "is the 'greenest' form of renewable fuel mandated by the Renewable Fuel Program."[174] By definition, it must have "lifecycle greenhouse gas emissions … at least 60 percent less than" 2005 gasoline.[175] The Department of Energy has determined that cellulosic ethanol use could reduce GHGs by as much as 108%.[176] Increasing usage of cellulosic ethanol, however, requires development of both production facilities and delivery and consumption infrastructure. A commitment by EPA to high demand for starch ethanol helps on all such fronts.

EPA itself has acknowledged that higher overall volume requirements are "necessary to provide the certainty of a guaranteed future market that is needed by investors, and by those companies who are working directly to bring cellulosic technologies to profitability and to build new production, distribution, and consumption capacity."[177] By contrast, the use of general waiver authority is a threat to stable biofuel markets, and to future investment in both conventional renewable fuel and especially next-generation biofuels like cellulosic ethanol.[178]

That is so because producers of starch ethanol, including members of Growth Energy, are leading investors in cellulosic biofuels, which may be derived from corn.[179] Major corn ethanol producers (e.g., POET-DSM and Quad City Corn Producers) have already spent considerable sums building facilities and harvesting cellulosic feedstocks based on Congress's direction that

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[174] *Americans for Clean Energy*, 864 F.3d at 723.

[175] 42 U.S.C. § 7545(*o*)(1)(C) & (E).

[176] U.S. Dept. of Energy, Alternative Fuels Data Center, *available at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html.

[177] 80 Fed. Reg. at 33,118.

[178] *Cf.* Congressional Research Service, *The Renewable Fuel Standard (RFS): Cellulosic Biofuels* 13 (Jan. 14, 2015) ("One source of uncertainty, particularly for investors in cellulosic biofuels ventures, concerns EPA's waiver authority. Investors may fear that the full cellulosic biofuels mandate will continually be waived to lower amounts by EPA, thus depriving them of the government-mandated market on which they had originally based their investment."), *available at* http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R41106.pdf.

[179] *See* Ryan Fitzpatrick, *Cellulosic Ethanol is Getting a Big Boost from Corn, for Now* (Apr. 2, 2015) (explaining "established companies with a sizable presence in the corn ethanol industry" are necessary to overcome the technological and economic challenges to scaling up cellulosic production), *available at* http://thirdway.org/report/cellulosic-ethanol-is-getting-a-big-boost-from-corn-for-now.

volume requirements continuously increase over fifteen years—*i.e.*, based on adherence to the RFS program. Indeed, they are uniquely able to invest in both conventional and cellulosic paths simultaneously by co-locating facilities with the capacity to produce both types of ethanol.[180] Additionally, new technologies have emerged, such as technology developed by POET and Edeniq, that enable producers of starch ethanol to inexpensively convert the waste from their production (the crop residue and corn kernel fiber) into cellulosic biofuel.[181]

But although cellulosic production capacity has been increasing,[182] the market is sensitive to demand levels set by EPA. For example, after EPA previously suggested lowering the volume requirement in 2014, DuPoint froze existing plans for cellulosic investment in the U.S. and began looking for opportunities abroad, declaring, "Make no mistake, investments in additional cellulosic ethanol capacity and plants in the United States are absolutely dependent on the EPA fulfilling its obligations to the existing biofuels industry," and that "RFS policy certainty is a prerequisite for the existing industry to expand and invest in cellulosic ethanol capacity and new plants."[183] The invocation of a general waiver could therefore cause severe harm to the continued development of the cellulosic biofuel industry, and thus to the environment, by undercutting the starch ethanol producers that are leading that development.[184]

For much the same reasons, maintaining the total volume requirement is also critical to continuing efforts to expand the delivery pathways for consuming cellulosic ethanol. Cellulosic ethanol, like starch ethanol, is blended into gasoline. Expanding the market's ability to consume

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[180] 2014-2016 POET Comment at 7 (July 27, 2015), EPA-HQ-OAR-2015-0111-2481.

[181] *See* Part II.C.1, *supra*; EPA, *Regulation of Fuels and Fuel Additives: RFS Pathways II, and Technical Amendments to the RFS Standards and E15 Misfueling Mitigation Requirements; Final Rule*, 79 Fed. Reg. 42,128 (July 18, 2014).

[182] *See, e.g.*, p.3, *supra*; *see also, e.g.*, Congressional Research Service, *The Renewable Fuel Standard (RFS): Cellulosic Biofuels* (noting in Summary section the opening of new plans with combined capacity of 52 million gallons per year).

[183] See *DuPont Industrial Biosciences Statement on Environmental Protection Agency Renewable Fuel Standards Rulemaking* (June 25, 2015), *available at* http://www.dupont.com/products-and-services/industrial-biotechnology/press-releases/dupont-statement-on-epa-rfs-rulemaking.html (cited in POET July 27 2015 Comment at 7-8).

[184] *See* Nathan Miller et al., International Council on Clean Transportation, *Measuring and Addressing Investment Risk in the Second-Generation Biofuels Industry*, at 25 (Dec. 2013) (noting that a waiver of the RFS would "have the indirect effect of eroding market confidence for all fuels that fall under the standard," especially for "companies that invest in second-generation fuels (cellulosic and other advanced fuels)," because "[t]hese second-generation plants rely heavily on market confidence to access and reduce the price of debt financing for plant expansions as they move to commercialize their technologies."), *available at* http://www.theicct.org/sites/default/files/publications/ICCT_AdvancedBiofuelsInvestmentRisk_Dec2013.pdf; *see also Advanced Biofuel Companies Tell White House: Changes to RFS Program Will Undercut Investment* (Oct. 29, 2013), *available at* http://www.businesswire.com/news/home/20131029006398/en/Advanced-Biofuel-Companies-White-House-RFS-Program.

higher-ethanol blend transportation fuels, such as E85 and E15, promotes consumption of ethanol beyond the so-called E10 blendwall equally for its conventional and cellulosic forms.

In sum, as a leading analyst has said, a general waiver of the total volume requirement

> would send a strong signal to car companies to reduce their production of flex vehicles, and to investors to not invest in high-ethanol-blend fueling stations or in next-generation plants that convert cellulosic material to ethanol. It likely also sends a negative signal to investors in biofuel plants that can convert cellulosic material to nonethanol biofuels, such as synthetic diesel or gasoline. … [T]he cost of constructing plants that can produce drop in fuels is high. High investment costs imply high risk. A reduction in public policy support for ethanol would only increase the perceived risk that in the future EPA would also reduce its support for other biofuels.[185]

Using the general waiver in the name of *preventing* environmental harm would therefore be nonsensical.

3. There are no other potential severe environmental harms that could justify a general waiver of the total volume requirement

In light of the compelling, comprehensive lifecycle analyses demonstrating that starch ethanol substantially reduces GHG emissions (and other harmful pollutants) as compared to fossil fuels, it is not at all clear how the production and use of starch ethanol itself (as opposed to some external event) could justify the invocation of an environmental harm-based waiver. Nonetheless, in the past a few groups have sought to argue that ancillary aspects of the production process for starch ethanol cause environmental harms that could justify the use of the general waiver authority. For example, the National Wildlife Federation's ("NWF") comments on EPA's 2017 NPRM argued that a waiver was justified primarily by the negative environmental effects from changes in land use resulting from increased demand for corn, specifically a reduction in the amount of native grassland and in biodiversity, and also from increased water usage and the supposed harmful effects on lakes and streams from the use of farm-based fertilizers.[186]

EPA correctly rejected those arguments.[187] EPA explained that it does "not believe that the information provided by [those] commenters sufficiently establishes, for purposes of [the 'sever harm' waiver provision], that implementation of the volumes established by this rule will

[185] Bruce Babcock & Wei Zhou, Impact on Corn Prices from Reduced Biofuel Mandates, Iowa State University CARD Working Paper 13-WP 543, at 10 (Nov. 2013), *available at* http://www.card.iastate.edu/products/publications/pdf/13wp543.pdf.

[186] *See* NWF 2017 Comment at 2-5 (July 11, 2016) ("NWF 2017 Comment"), EPA-HQ-OAR-2016-0004-1700.

[187] *See* 2017 Response to Comments.

cause severe environmental harm."[188] To the extent that it considers these or similar arguments anew, EPA should again reject them as insufficient to justify a severe harm waiver.

First, the lifecycle analyses discussed above *already include* the carbon cost of land use and corn production, and still demonstrate substantial GHG reductions over fossil fuels. Growth Energy does not believe that scientific evidence establishes a direct causal link between land use change and ethanol production. Indeed, the greater GHG emissions reductions shown by the latest studies stem in part from the fact that land use associated with ethanol production has actually *decreased* significantly over the last decade.[189] Thus, the entirety of the posited "severe" harm would need to be based on costs other than GHG emissions, such as the independent value of biodiversity. And it would need to (seriously) outweigh the environmental gains from reducing GHG emissions through the use of larger volumes of conventional and cellulosic ethanol in place of fossil fuels.

Second, under EPA's established standard for assessing severe harm, the harms alluded to in earlier comments like NWF's are not cognizable because they are not sufficiently traceable to the RFS program, as EPA recognized in its response to the 2017 comments.[190] That reasoning continues to apply with respect to the supposed harms stemming from fertilizer usage from corn cultivation for ethanol, and it applies to biodiversity and habitat-reduction concerns as well.

Third, and as noted above, ethanol is most likely to replace not the average barrel of fossil fuels, but the marginal barrel—the one that was most difficult to extract. The extraction of fossil fuels through methods like hydrofracking are particularly water-intensive—and particularly dangerous to our water systems.[191] Ethanol uses almost 50% less water than fracked oil.[192] It would therefore be particularly improper to invoke the severe environmental harm waiver based on any risk to water systems.

D. EPA Cannot Grant a Severe Harm Waiver Without Proposing an Analysis of the Basis for Such a Waiver and Affording the Public an Opportunity to Comment on That Analysis

Because the NPRM does not present any "comprehensive and robust analytical basis for a[] claim that the RFS itself is causing harm, and the nature and degree of that harm," EPA has not provided Growth Energy and others an adequate opportunity to comment as required by EPA

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188 *Id.* at 54-55.

189 *See* USDA 2017 Report at 167 Fig. 4-4 (showing large drop in emissions costs associated with "International Land Use" from EPA's 2010 RIA); Renewable Fuels Association, *2017 Ethanol Industry Outlook* 29, *available at* http://www.ethanolrfa.org/wpcontent/uploads/2017/02/Ethanol-Industry-Outlook-2017.pdf (showing decrease in domestic land usage).

190 2017 Response to Comments at 55.

191 Growth Energy, *Oil and Water Don't Mix*, *available at* http://www.growthenergy.org/news-media/blog/oil-and-water-dont-mix/.

192 *Id.*

precedent.[193] Judicial precedent also requires such an opportunity. As the D.C. Circuit has explained, "integral" to the notice-and-comment requirement "is the agency's duty to identify and make available technical studies and data that it has employed in reaching the decisions to propose particular rules. An agency commits serious procedural error when it fails to reveal portions of the technical basis for a proposed rule in time to allow for meaningful commentary."[194] Thus, in *Owner-Operator Ind. Drivers Ass'n v. Fed. Motor Carrier Safety Admin.*, the D.C. Circuit found that the agency had committed reversible procedural error because it had failed to disclose particular elements of its methodology, such that the public "had no way of knowing that the agency would calculate the impact of that [element] in the way that it did."[195]

Accordingly, although EPA may decline now to issue a severe harm waiver for reasons stated above, EPA may not *issue* such a waiver unless and until it presents an analysis to justify the waiver and affords the public an opportunity to comment on that analysis.

V. PROMOTING U.S. ENERGY INDEPENDENCE AND SECURITY CANNOT AND SHOULD NOT JUSTIFY A WAIVER OF THE TOTAL VOLUME REQUIREMENT

In the NPRM, EPA "request[s] comment on whether and to what degree" considerations of "energy independence and security" "could support the use of the general waiver authority, inherent authority or other basis consistent with general construction of authority in the statute to reduce the required volume of advanced biofuel (with a corresponding reduction to the total renewable fuel requirement) below the level proposed for 2018."[196] More broadly, EPA states that it "is interested in stakeholder views … on what steps EPA might take to ensure energy independence and security."[197] In particular, EPA expresses concern that "imported renewable fuels," volumes of which, EPA asserts, have been "increasing," "may not have the same impact on energy independence as those produced domestically.[198]

These concerns are wholly misplaced. First and foremost, EPA has no authority to waive applicable volume requirements in order to further U.S. energy independence and security or any other policy objective; EPA may waive only for the reasons and in the circumstances specified by Congress in the RFS statute.

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[193] Texas Waiver Decision at 47,183-47,1884.

[194] *Owner-Operator Indep. Drivers Ass'n v. Federal Motor Carrier Safety Admin.*, 494 F.3d 188, 199 (D.C. Cir. 2007) (quoting *Solite v. EPA*, 952 F.2d 473, 484 (D.C. Cir. 1991)); *see id.* ("The most critical factual material that is used to support the agency's position on review must have been made public *in the proceeding* and exposed to refutation.") (quoting *Air. Transp. Ass'n of Am. v. FAA*, 169 F.3d 1, 7 (D.C. Cir. 1999)).

[195] *Id.* at 202.

[196] NPRM at 34,212.

[197] *Id.*

[198] *Id.*

Second, a commitment to at least maintain current volumes of starch ethanol *furthers* the policy objectives of U.S. energy independence and security, as well as what the President has termed "American energy dominance."[199] The expansion of the ethanol industry has not come at the expense of the petroleum industry, but rather has complemented a concurrent petroleum expansion. In other words, the nation's experience with increased ethanol production suggests that it is not in a zero-sum game with the petroleum industry. And that redounds to the nation's benefit: Diversifying the U.S. energy supply through a robust domestic ethanol industry has supported the rebalancing of global energy trade, as U.S. energy production and exports have increased and imports have declined. That diversification also cushions the U.S. economy from petroleum shortages and price spikes. And the ethanol industry has generated significant economic growth, particularly in rural Midwestern areas. Using the general waiver to reduce the implied volume for conventional renewable fuels would therefore be detrimental to the achievement of those policy objectives.

A. Promoting Energy Independence and Security Is Not a Cognizable Basis for a Waiver of RFS Volume Requirements

EPA has no authority to waive volume requirements in order to promote energy independence and security, or any other policy objective other than those stated in the statutory waiver provisions.

EPA cannot use the general waiver power for this purpose. The statute explicitly specifies the bases for issuing a general waiver, and concerns about energy independence and security are not among them. Rather, Congress has provided that EPA may use the general waiver power to reduce a volume requirement only if "implementation of the requirement would severely harm the economy or environment of a State, a region, or the United States" or "there is an inadequate domestic supply" of renewable fuel."[200]

Nor may EPA infer some new waiver power for this situation, whether under the guise of "inherent authority" or the (non-existent) notion of "general construction of authority in the statute." The D.C. Circuit's recent decision in *Americans for Clean Energy* and the plain text of the statute close the door on such a view. The D.C. Circuit held that EPA's waiver power extends no further than what Congress provided for statutorily, regardless of any policy considerations that might militate in favor of additional or broader waiver power. As the court there said in rejecting EPA's consideration of demand factors for purposes of a general waiver, "the fact that EPA thinks a statute would work better if tweaked does not give EPA the right to amend the statute."[201] Rather, as the Supreme Court and the D.C. Circuit have said, "Agencies

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[199] Remarks by President Trump at the Unleashing American Energy Event (June 29, 2017) ("Unleashing American Energy"), *available at* https://www.whitehouse.gov/the-press-office/2017/06/29/remarks-president-trump-unleashing-american-energy-event.

[200] 42 U.S.C. § 7545(*o*)(7)(A)(i)-(ii); *Americans for Clean Energy,* 864 F.3d at 696, 707.

[201] *Americans for Clean Energy,* 864 F.3d at 712.

exercise discretion only in the interstices created by statutory silence or ambiguity; they must always give effect to the unambiguously expressed intent of Congress."[202]

Here, the statute is perfectly clear that concerns about energy independence and security are not a valid basis for waiving a volume requirement. The statute contains an entire section entitled "Waivers," in which Congress provided EPA with a panoply of waiver authorities for various specified circumstances. None of those circumstances recognizes concerns about energy independence and security. Specifically, Congress explicitly permitted EPA to waive:

- A volume requirement if "implementation of the requirement would severely harm the economy or environment of a State, a region, or the United States";[203]

- A volume requirement if "there is an inadequate domestic supply" of renewable fuel;[204]

- The cellulosic biofuel requirement if "the projected volume available" is less than the requirement, and then to waive the advanced and total volume requirements "by the same or a lesser volume";[205]

- The biomass-based diesel ("BBD") requirement if "there is a significant renewable feedstock disruption or other market circumstances that would make the price of biomass-based diesel fuel increase significantly," and then to waive the advanced and total requirements "by the same or a lesser volume";[206]

- The total volume requirement for 2006 if that requirement "will likely result in significant adverse impacts on consumers in 2006, on a national, regional, or State basis."[207]

That's it; Congress provided no other bases for waiving volume requirements.[208] On the other hand, Congress *did* expressly direct EPA to consider "the impact of renewable fuels on the energy security of the United States"—not in the context of a waiver, but rather after the

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[202] *Utility Air Regulatory Grp. v. EPA*, 134 S. Ct. 2427, 2445 (2014), *quoted in Americans for Clean Energy,* 864 F.3d at 712; *see also, e.g.*, *Friends of Earth, Inc. v. EPA*, 446 F.3d 140, 145 (D.C. Cir. 2006) ("EPA may not avoid the Congressional intent clearly expressed in the text simply by asserting that its preferred approach would be better policy.").

[203] 42 U.S.C. § 7545(*o*)(7)(A)(i).

[204] 47 U.S.C. § 7545(*o*)(7)(A)(ii); *Americans for Clean Energy,* 864 F.3d at 696, 707.

[205] *Id.* § 7545(*o*)(7)(D)(i).

[206] *Id.* § 7545(*o*)(7)(E)(ii).

[207] *Id.* § 7545(*o*)(8)(A), (D)(i).

[208] *Cf. id.* § 7545(*o*)(9)(A) (exempting small refineries from volume requirements under certain circumstances).

calendar years specified in the volume table were completed or in the event that the so-called reset was triggered.[209]

Given the explicit statutory powers to waive based on considerations *other than* energy independence and security, and the explicit statutory directive to consider such factors in specific circumstances for *non*-waiver purposes, the absence of any provision authorizing a waiver based on concerns about energy independence and security (or any other policy objective EPA might identify) makes unmistakably clear that Congress did not intend to include such a waiver power and that the statute cannot be interpreted otherwise. As the Supreme Court has declared: "When a statute limits a thing to be done in a particular mode, it includes the negative of any other mode."[210]

B. The Administration's Energy Policy Objectives Are Promoted by at Least Maintaining the Current Volume of Conventional Renewable Fuel, Not by Reducing It

EPA posits that volume requirements may be too high, drawing in imports of renewable fuel and thereby jeopardizing U.S. energy independence and security. EPA's proposed theory is unfounded. On the contrary, current levels of conventional renewable fuel use *promote* U.S. energy independence and security, as well as "American energy dominance." Here, we explain why that is so with respect to ethanol and the total volume requirement, but similar analysis could apply with respect to advanced renewable fuels and the advanced volume requirement.

1. The Administration Seeks to Achieve U.S. Energy Independence, Security, and Dominance

As explained in a report prepared by Chupka, Hagerty and Verleger, U.S. energy independence and security are not realistically achieved by cutting off energy imports or otherwise isolating U.S. energy production and consumption from the rest of the world.[211] The United States unavoidably participates in global energy markets. Domestic prices for crude oil and petroleum products, for example, "will rise or fall as global market conditions dictate, including shifts in U.S. commodity futures markets that translate directly to movements in the price of crude, gasoline, and diesel."[212] Similarly, because "retail prices closely follow futures

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[209] 42 U.S.C. § 7545(*o*)(2)(B)(ii), (7)(F).

[210] *National R. R. Passenger Corp. v. National Ass'n of R. R. Passengers*, 414 U.S. 453, 458 (1974); *see, e.g.*, *Ivy Sports Med., LLC v. Burwell*, 767 F.3d 81, 89 (D.C. Cir. 2014) ("Because Congress created a procedure for FDA to reclassify medical devices, FDA may not short-circuit that process through what it calls its inherent authority to reverse its substantial equivalence determinations for those devices."); *American Methyl Corp. v. EPA*, 749 F.2d 826, 835 (D.C. Cir. 1984) (rejecting EPA's assertion of "inherent power" to reconsider a decision because "Congress has provided a mechanism capable of rectifying mistaken actions").

[211] Chupka, Hagerty & Verleger Report 21.

[212] *Id.*

prices, disruptions in supply any place in the world will directly affect prices paid by U.S. consumers."[213]

In this environment, energy independence and security are primarily characterized by other circumstances. Among those are a decreased reliance on energy imports, robust energy exports, and greater balance between domestic energy production and domestic energy consumption.[214] U.S. energy markets should also exhibit a "resilience" against "the adverse economic effects of oil price shocks that will continue to occur periodically."[215] And domestic production of raw energy and "value-added products," i.e., refined and manufactured goods, should support domestic economic growth.[216]

Perhaps recognizing the United States' essential participation in global energy markets, the President has recently prioritized achieving not only energy independence and security, but also a broader policy of "American energy dominance."[217] He explained: "[M]y administration will seek not only American energy independence that we've been looking for so long, but American energy dominance. … We will export American energy all over the world, all around the globe. These energy exports will create countless jobs for our people, and provide true energy security to our friends, partners, and allies all across the globe."[218] To achieve energy dominance, Mr. Trump proposed several actions, including "expand[ing]" sources of "renewable" energy (referring specifically to nuclear energy), "boost[ing] American energy exports," and "bring[ing] new opportunity to the heartland."[219]

2. Reducing the Implied Volume for Conventional Renewable Fuel Would Impede the Achievement of These Policy Objectives

a. Ethanol has helped rebalance energy trade in the United States' favor

Since the year 2000, domestic fuel ethanol production has increased dramatically and steadily (except for the bad-harvest year of 2012), from barely 100,000 barrels per day to about 1,000,000 barrels per day.[220] This expansion altered the energy trade balance in important ways.

More ethanol was consumed domestically, yet more ethanol was exported. The increase in ethanol production thus both "expanded the overall domestic supply of fuel" and helped the U.S. become a net exporter of ethanol.[221]

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[213] *Id.*

[214] *Id.*

[215] *Id.* at 22.

[216] *Id.* at 23.

[217] Unleashing American Energy.

[218] *Id.*

[219] *Id.*

[220] Chupka, Hagerty & Verleger Report at 3-4.

Rather than "crowd[ing] out some other sources of petroleum supply," this expansion also strengthened the country's position with respect to petroleum markets by supporting the reduction of imports and the increase of exports of petroleum products and crude oil.[222] For example, oil refinery capacity has increased by about 1 million barrels per day since 2007, while oil refinery utilization today is near its post-2000 peak (90% vs. 93% in 2004), corresponding to increased oil refinery production.[223] With U.S. consumption of transportation fuel holding relatively constant, the "overall trend in gasoline trade volumes … is a pronounced reduction in imports and a significant increase in exports"—whereas in 2007 gasoline imports were about six times as large as exports, in 2016 the United States "became a net exporter for the first time since 1961."[224] During the same period, the United States also became a net exporter of other petroleum products, by an even wider margin.[225] These developments have coincided with a period in which U.S. crude oil production has increased markedly, exports of crude oil have increased, and imports of crude oil have decreased.[226] Although these markets are complex and the causes of these changes are varied, it is significant that they occurred during this period of such substantial increase in U.S. ethanol production.

The availability of increased ethanol can also soften the economic blow to the United States of oil price spikes. For example, when global crude oil and petroleum product markets were tight a few years ago, the increased availability of ethanol "moderat[ed] the world crude oil price."[227] Even when the global petroleum supply is not as tight, high availability of ethanol can mitigate the effect of occasional oil price shocks: when consumers have greater access to higher-ethanol blends, they can "take advantage of relative prices between E10 and E15 or E85 … by purchasing more E15 or E85."[228]

Contrary to EPA's suggestion, renewable fuel imports have a negligible adverse effect on U.S. energy independence, security, and dominance, and in any event higher RFS volume requirements are not responsible for the bulk of those imports, as the Chupka, Hagerty & Verleger Report explains.

Ethanol "imports represent 0.3 percent of U.S. production," and "imported biodiesel and renewable diesel fuel accounts for 0.5 percent of the overall projected U.S. diesel consumption."[229] Those percentages are far too low for imports to materially threaten U.S.

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[221] *Id.* at 4-5, 7-8.

[222] *Id.* at 4-5, 7.

[223] *Id.* at 5-6.

[224] *Id.* at 6-9. Imports went from 0.189 to 1.091 million barrels per day.

[225] *Id.* at 8-9.

[226] *Id.* at 9-11.

[227] *Id.* at 21-22.

[228] *Id.* at 22.

[229] Chupka, Hagerty & Verleger Report at 12.

energy independence, security, and dominance.[230] In fact, as the Chupka, Hagerty & Verleger Report notes, some have claimed that BBD imports are facilitated by illegal dumping and other illegal trade activity by foreign producers, and that domestic producers could well meet all domestic demand "if not for the unfair competition from foreign sources."[231]

Moreover, "[m]uch of the ethanol and renewable diesel imports are explained by a policy completely unrelated to the RFS program, namely, California's state-level Low Carbon Fuel Standard Program (LCFS)."[232] That standard establishes required levels of carbon intensity ("CI") for gasoline and diesel fuel producers and importers. The largest sources of ethanol with low CI levels (as determined by the California Air Resources Board[233]), however, are Brazil and other Latin American countries,[234] and as EPA notes, the "predominant available source of advanced biofuel other than cellulosic biofuel and BBD is imported sugarcane ethanol," which primarily comes from Brazil.[235] California's LCFS requirement creates a strong incentive to import Brazilian ethanol regardless of RFS requirements. Further, PADD V, whose energy consumption is dominated by California, "accounted for almost all of the fuel ethanol imports" nationwide in 2016.[236] EPA concludes that the LCFS "has not resulted in the large volumes of advanced ethanol imports that some stakeholders believed would occur."[237] That conclusion may be correct, but it is also evident that California's regulatory structure, not the RFS, is driving the bulk of extant importation of ethanol. Accordingly, using the general waiver to reduce RFS volume requirements is unlikely to reduce ethanol imports. (Similar analysis applies to renewable biodiesel.[238])

b. Ethanol has stimulated substantial economic development in rural Midwestern areas and provided various other economic benefits

In addition to supporting the rebalancing of energy trade balance in the United States' favor, increased ethanol has spurred significant growth in domestic agriculture, which has facilitated broader economic growth especially in rural Midwestern areas.

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[230] *Id.*

[231] *See id.*

[232] *Id.* at 13.

[233] Growth Energy disputes the carbon intensity values assessed by the California Air Resources Board and believes that net carbon reductions from corn ethanol are equal to or lower than foreign ethanol sources.

[234] Chupka, Hagerty & Verleger Report at 14.

[235] NPRM at 34,222.

[236] Chupka, Hagerty & Verleger Report at 14.

[237] NPRM at 34,222.

[238] Chupka, Hagerty & Verleger Report at 14.

Most directly, "increased demand for corn-based ethanol has significantly increased production of grain corn and increased energy-related jobs in the U.S."[239] Ninety-five percent of the increase in corn production since 2000 is the result of increased domestic ethanol demand.[240] Corn grown for ethanol production in 2016 accounted for $18 billion in income for corn growers.[241] The increased agricultural income resulting from increased corn production has provided a buffer against some recent declines in corn prices.[242]

The process of producing ethanol from that corn enlarges the economic benefits of ethanol. More than 90% of ethanol production occurs in the Midwest.[243] According to the U.S. Department of Energy, the biofuels industry employs more than 105,000 people, about 29,000 of whom work in the corn ethanol fuels sector, meaning that the ethanol industry supports slightly more jobs than the petroleum industry on a per-gallon-produced basis.[244] A study by the U.S. Department of Agriculture found that increasing an ethanol plant's annual production by 100 million gallons would generate $203 million in sales and add 39 full-time jobs.[245] Ethanol production also supports economic growth indirectly: according to the U.S. Department of Agriculture, each ethanol job creates 2.6 to 3.2 indirect jobs.[246] So significant is the impact of higher ethanol production that, according to another study by the U.S. Department of Agriculture, ethanol demand accounts for 32% of the total change in employment in areas where new ethanol facilities are established.[247]

VI. THERE IS NO BASIS TO USE THE GENERAL WAIVER TO REDUCE THE TOTAL RENEWABLE VOLUME REQUIREMENT DUE TO INADEQUATE DOMESTIC SUPPLY OF RENEWABLE FUEL

EPA has no authority to use the general waiver to reduce the total volume requirement due to "inadequate domestic supply."[248] In *Americans for Clean Energy, Inc. v. EPA*, the D.C. Circuit rejected EPA's prior interpretation of "inadequate domestic supply" and concluded that this term "refers to the supply of renewable fuel available to refiners, blenders, and importers to meet the statutory volume requirements."[249] Although EPA may thus consider "the availability of feedstocks used to make renewable fuel, the production capacity of renewable fuel producers,

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239 *Id.* at 15.

240 *Id.* at 15-16.

241 *Id.* at 17.

242 *Id.*

243 *Id.* at 18.

244 *Id.* at 18-19.

245 *Id.* at 19.

246 *Id.* at 20.

247 *Id.*

248 42 U.S.C. § 7545(*o*)(7)(A)(ii).

249 *Americans for Clean Energy*, 864 F.3d at 709.

the amount of renewable fuel available for import from foreign producers, or the infrastructure capacity needed to get renewable fuel from producers to refiners, importers, and blenders," EPA may *not* consider "those factors affecting availability of renewable fuel to market actors downstream from refiners, importers, and blenders, such as fuel retailers or consumers."[250]

Under this controlling interpretation of the general waiver provision, there is no shortage of "supply" to meet the implied conventional volume of 15.00bg, or the proposed total requirement. As EPA recognizes in the NPRM, "[e]thanol supply is not currently limited by production and import capacity, which is in excess of 15 billion gallons."[251] In fact, the latest RFA industry outlook recognizes that domestic ethanol production capacity is 16bg. Further, there is no basis in the record (nor has EPA ever suggested any basis) to conclude that there would be any bottlenecks in getting this ethanol supply to refiners, blenders or importers.[252] When that supply of ethanol is added to the 4.496 billion RINs (or 2.9bg) of BBD production and consumption that EPA determined is reasonably attainable,[253] there is no question that the total supply of renewable fuel easily exceeds the proposed total requirement of 19.24bg.

VII. EPA SHOULD STRIVE TO INCREASE TRANSPARENCY AND PREVENT MANIPULATION IN THE RIN MARKET

We also urge EPA to develop better methods for gathering accurate, complete, and timely data regarding RIN transactions. Similarly, we urge EPA to increase transparency into the current state of the RIN market to mitigate the risk of market manipulation. Additional rulemaking may be appropriate to accomplish these goals.

VIII. CONCLUSION

For the reasons set forth above, EPA should: (1) modify its methodologies for projecting cellulosic biofuel production to ensure neutrality and accuracy; (2) revise the cellulosic waiver

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250 *Id.*; *see also id.* at 696 ("We hold that the 'inadequate domestic supply' provision authorizes EPA to consider *supply-side* factors affecting the volume of renewable fuel that is available to *refiners, blenders, and importers* to meet the statutory volume requirements. It does not allow EPA to consider the volume of renewable fuel that is available to ultimate *consumers* or the *demand-side* constraints that affect the consumption of renewable fuel by consumers.").

251 NPRM at 34,230 (citing "RFA 2016 Annual Industry Outlook," EPA-HQ-OAR-2016-0004).

252 In fact, the record is to the contrary. *See* 2017 Growth Energy Comment, Exhibit D at 7 (report by Stillwater Associates explaining that "[b]ecause the ethanol distribution system is already handling substantial ethanol volumes through E10, significant increases in ethanol consumption are possible without much impact on … ethanol distribution"). Additionally, EPA has never suggested, nor could it find, that there are material feedstock constraints on achieving this level of ethanol production. In fact, as the Chupka, Hagerty & Verleger Report notes, domestic corn production has been able to grow to keep pace with the increase in ethanol production that has occurred since the early 2000s. Chupka, Hagerty & Verleger Report at 20-21.

253 NPRM at 34,234.

credit program to ensure the efficacy of the volume requirement; (3) decline to issue a general waiver of the total volume requirement based on severe harm to the economy or the environment; (4) decline to issue a waiver of the total volume requirement based on energy independence and security; (5) decline to issue a general waiver of the total volume requirement based on inadequate domestic supply of renewable fuel; (6) take actions to mitigate the risk of manipulation in the RIN market.

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 13

Growth Energy Comments on EPA's Proposed Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017

Docket # EPA-HQ-OAR-2015-0111

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I. INTRODUCTION AND EXECUTIVE SUMMARY

Growth Energy respectfully submits these comments on the Environmental Protection Agency's proposed rule entitled "Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017."[1] Growth Energy is the leading association of ethanol producers in the country, with 86 members and 66 affiliated companies who serve the Nation's need for renewable fuel. Growth Energy has participated in each of EPA's major rulemakings implementing the Renewable Fuel Standard ("RFS") program, including EPA's first attempt to set volume obligations for 2014. Growth Energy has been a strong supporter of national strategies to promote the use of renewable fuel and to improve the efficiency of domestic biorefineries. For the reasons set forth below, Growth Energy urges EPA to change course and to refrain from issuing a general waiver that is unauthorized, unnecessary, and counterproductive. EPA should not decrease the 2014, 2015, or 2016 statutory requirements for renewable fuel, other than through its cellulosic waiver authority.

Through the Energy Independence and Security Act of 2007 ("EISA"), Congress expanded and strengthened the RFS program in order "[t]o move the United States toward greater energy independence and security" and "to increase the production of clean renewable fuels."[2] Since then, the RFS program has been an overwhelming success. It has created American jobs, revitalized rural America, injected much-needed competition into a monopolized vehicle-fuels market, lowered the price at the pump, reduced greenhouse gas emissions, and made our nation more energy independent and secure by reducing our dependence on foreign oil.

"Congress expected the RFS program to compel the industry to make dramatic changes in a relatively short period of time."[3] Accordingly, EPA recognizes here that "the proposed volume requirements are … intended to drive significant growth in renewable fuel use beyond what would occur in the absence of such requirements."[4] But by that measure, this proposal is a total failure. If EPA persists with its proposal, this rule would halt meaningful growth in renewable fuels and eviscerate the RFS program. The resulting stagnation in renewable fuels would contravene Congress's intent and disserve the public interest.

EPA has proposed to exercise its cellulosic waiver authority under 42 U.S.C. § 7545(*o*)(7)(D)(i) to reduce the 2014, 2015, and 2016 volume requirements for cellulosic biofuel and to flow those reductions through to the volume requirements for advanced biofuel and renewable fuel. EPA also proposes to invoke the general waiver authority under 42 U.S.C. § 7545(*o*)(7)(A)(ii) to further reduce the 2014, 2015, and 2016 volume requirements for renewable fuel based on a purported "inadequate domestic supply" in those years.

Despite appearances, EPA's proposal will not spur growth in renewable fuel in 2015, 2016, or beyond. Because of the large bank of carryover Renewable Identification Numbers

[1] 80 Fed. Reg. 33,100 (June 10, 2015).

[2] Pub. L. No. 110-140, 121 Stat. 1492 (Dec. 19, 2007).

[3] 80 Fed. Reg. at 33,118.

[4] *Id*. at 33,109.

("RINs"), obligated parties will be able to fully comply with their proposed renewable volume obligations merely by maintaining their 2014 levels and drawing down the RIN bank. Obligated parties will have a strong incentive to do just that, especially because EPA's proposal will trigger its authority to "reset" all the volume requirements for renewable fuel going forward—and EPA's current proposal and prior 2014 proposal leave little doubt that it will use that authority to establish new volume obligations that will not push the industry to expand and that will thus diminish the value of banked RINs. In fact, there is a strong basis to conclude that EPA specifically and improperly set the proposed 2015 and 2016 renewable fuel volume requirements in order to trigger its reset authority. Not only are those volumes remarkably close to the trigger threshold, but also EPA's Acting Administrator for Air and Radiation, testifying before Congress shortly after the proposal was issued, explained that "[w]e actually think it makes a lot of sense to focus a reset on all volumes at one time."[5]

The proposed volume requirements fall far short of the Nation's current supply of renewable fuel, even though they exceed historical production. Even under conservative estimates, the available supply of ethanol and biomass-based diesel alone will exceed the statutory volume requirement for renewable fuel by at least one billion ethanol-equivalent gallons, after the proposed flow-through of the cellulosic waiver, in each of the three covered years. Indeed, the proposal effectively concedes this: "[A]lthough at least for 2014 and possibly 2015 and 2016, there is no shortage of ethanol and other types of renewable fuel that could be used to satisfy the statutory applicable volume of total renewable fuel, there are practical and legal constraints on the ability of ethanol to be delivered to and used as transportation fuel by vehicles."[6]

The fundamental problem with EPA's approach is that constraints on the *distribution and use of transportation fuel* do not matter in determining whether EPA may exercise its general waiver authority. The phrase "inadequate domestic supply" in the general waiver provision refers to the amount of renewable fuel available for obligated parties to comply with their volume obligations, which is properly measured by production capacity. By expanding "supply" of "renewable fuel" to include downstream constraints on the supply and consumption of a different product that contains renewable fuel (that is, blended transportation fuel), EPA in effect interprets "supply" of "renewable fuel" to include "demand for renewable fuel." That stretches "supply" far beyond what reasonable interpretation permits.

In any event, there is adequate "supply" in 2014, 2015, and 2016, even under EPA's flawed interpretation, to foreclose EPA's exercise of the general waiver authority. As this comment explains in detail, there are various feasible, relatively inexpensive, and fast pathways to expand distribution and consumption of ethanol-based renewable fuels and biomass-based diesel. Even the most conservative of these pathways could boost distribution and consumption of renewable fuel by hundreds of millions of gallons—more than needed to support compliance

[5] Testimony of Janet McCabe, EPA Acting Administrator for Air and Radiation, before Committee of the U.S. Senate on Homeland Security and Government Affairs, Subcommittee on Regulatory Affairs and Federal Management, at 23 (June 18, 2015), *at* http://www.cq.com/doc/financialtranscripts-4711934?6&search=1E4v24rR.

[6] 80 Fed. Reg. at 33,113.

with the statutory volume requirements for renewable fuel in 2014-2016, after the proposed cellulosic waiver flow-through.

At its core, EPA's proposal rests on a fundamental misunderstanding of the RFS program as Congress designed it. The RFS program forces innovation and investment by intentionally requiring future levels of renewable fuel use far higher than what can be achieved with present production capacity, distribution capacity, and technology. The proposal, by contrast, ignores this mandate and instead only looks backward, setting volumes based on *existing* capacity to produce, distribute, and use renewable fuel. Under EPA's approach, distribution constraints and weak demand become a self-fulfilling prophecy.

That would be lamentable for the United States. Renewable fuel is an American industry that promotes energy independence, improves our nation's environment, supports hundreds of thousands of jobs (especially in rural areas), and reduces prices at the pump, all without appreciably raising the price of food or feed. Yet EPA would stunt this industry by capping demand for its product and forcing the industry to idle production and identify export markets for excess capacity. That is particularly strange given that EPA's proposed advanced volume requirement would encourage significant importation of sugarcane ethanol from Brazil.

Therefore, the final rule should adhere to the statutory volume requirements for renewable fuel, reduced by no more than the proposed cellulosic waiver flow-through, as follows:

- 2014—17.08 bil gal;
- 2015—17.90 bil gal;
- 2016—18.40 bil gal.

These volumes would properly reflect supply regardless of whether EPA correctly interprets the general waiver provision to refer to the amount of renewable fuel available for obligated parties to comply with their volume obligations, or incorrectly interprets it to refer to the amount of blended transportation fuel that can be delivered to vehicles that can use it.

At a minimum, however, EPA should raise its proposed renewable fuel volume requirements to account for three factors:

- The Department of Energy's latest projections for nationwide gasoline consumption imply a higher E10 blendwall in 2015 and 2016 than EPA's proposal assumes.
- When computing 2014 net D6 RIN generation, EPA erroneously assumed that a D6 RIN was generated on all 846 mil gal of exported ethanol and that all of those RINs would be retired and unavailable for compliance, when in fact much of that volume did not generate a RIN, including hundreds of millions of gallons of un-denatured ethanol. Thus, EPA not only got 2014 wrong, but also understated the market's already-proven generation capacity by hundreds of millions of RINs per year, an error that affects its proposal for 2015 and 2016 as well.

- EPA is required to treat banked RINs as supply when determining the level at which "supply" would be "inadequate" for purposes of the general waiver provision. In other words, EPA must set the renewable fuel volume requirements high enough to ensure that the RIN bank is consumed.

Unless EPA takes these actions, the oil industry will have little incentive to make the investments needed to expand the production and use of renewable fuel that Congress intended the RFS program to achieve.

II. BACKGROUND

A. The Renewable Fuel Standard Program

Congress revised the Renewable Fuel Standard ("RFS") program in 2007 "[t]o move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government."[7] To achieve these goals, Congress required that "gasoline sold or introduced into commerce in the United States … contain[] the applicable volume of renewable fuel," and charged obligated parties—such as gasoline refiners—with meeting those volume requirements.[8]

By mandating the amount of renewable fuel that is blended into transportation fuel, Congress sought to stimulate greater production of renewable fuels. These mandates ensure renewable-fuel suppliers a market for their products, which encourages suppliers to make costly investments in production facilities. The RFS also indirectly stimulates greater *consumption* of transportation fuels that contain renewable fuel. Obligated parties, having acquired and blended renewable fuel, have a strong economic incentive to find an outlet for the resulting blended transportation fuels and, consequently, to invest in renewable-fuel infrastructure to reduce their compliance costs.[9]

The statute uses market signals to translate its quantitative mandates into action. Specifically, Congress directed EPA to create a "credit program" to enable obligated parties to comply as efficiently as possible, either by blending renewable fuel themselves or by buying credits, called RINs, from others who do.[10] As volume obligations become more difficult to achieve, RIN prices rise accordingly, creating an incentive to invest in infrastructure so that obligated parties can comply with their obligations by generating RINs rather than buying them. High RIN prices also permit blended fuels to be sold at a lower effective price to the consumer—

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[7] EISA, 121 Stat. 1492; *see Monroe Energy, LLC v. EPA*, 750 F.3d 909, 911-912 (2014).

[8] 42 U.S.C. § 7545(*o*)(2)(A)(i) & (iii); *see* 40 C.F.R. § 80.1406(a)(1).

[9] *See Monroe Energy*, 750 F.3d at 919.

[10] 42 U.S.C. § 7545(*o*)(5).

the blender is able to discount the blended fuel by the amount earned from the sale of the accompanying RIN.[11]

Both aspects of the RFS program—increasing production of renewable fuels and their consumption via transportation fuel—therefore depend on properly calibrated economic incentives. And those incentives derive from properly ambitious volume obligations, as Congress envisioned when it chose the statutory volumes.

In three principal ways, Congress charged EPA with playing an important role in establishing applicable volumes and thus the incentives needed to achieve Congress's goals. First, EPA annually converts the volume requirements into a percentage of gasoline that is projected to be sold or introduced into commerce in the United States, called renewable volume obligations ("RVOs").[12]

Second, EPA must set volume requirements after the statutory schedule expires. The applicable volumes define minimum amounts of four nested categories of renewable fuel: cellulosic biofuel; biomass-based diesel ("BBD"); advanced biofuel, which contains cellulosic biofuel, BBD, and other advanced biofuels; and renewable fuel, which contains advanced and conventional renewable fuels.[13] For cellulosic biofuel, advanced biofuel, and renewable fuel, "[t]he volumes increase progressively through 2022; thereafter, EPA, rather than Congress, will set the applicable volumes"[14]; for BBD, the volumes increased progressively through 2012.[15] Thereafter, the annual applicable volumes are to be determined by the EPA, "in coordination with the Secretary of Energy and the Secretary of Agriculture, based on a review of the implementation of the program during calendar years specified in the tables, and an analysis of" six factors.[16]

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[11] *See generally* Edgeworth Economics, *Impact of the RFS Mandate on Motor Fuel Volumes and Prices, 2014-2016* (*"Impact on Motor Fuel Prices"*) (July 27, 2015) (attached as Exhibit 1); Bruce Babcock & Sebastien Pouliot, *Price It and They Will Buy: How E85 Can Break the Blend Wall*, Iowa State University CARD Policy Brief 13-PB 11 (Aug. 2013), *at* http://www.card.iastate.edu/publications/dbs/pdffiles/13pb11.pdf.

[12] 42 U.S.C. § 7545(*o*)(3)(B) (EPA must publish annual RFS obligations before November 30 of the preceding year).

[13] *Id.* § 7545(*o*)(2)(B)(i).

[14] *Monroe Energy*, 750 F.3d at 912.

[15] 42 U.S.C. § 7545(*o*)(2)(B)(i).

[16] *Id.* § 7545(*o*)(2)(B)(ii). The factors are: (1) the impact of the production and use of renewable fuels on the environment; (2) the impact of renewable fuels on the energy security of the United States; (3) the expected annual rate of future commercial production of renewable fuels; (4) the impact of renewable fuels on the infrastructure of the United States; (5) the impact of the use of renewable fuels on the cost to consumers of transportation fuel and on the cost to transport goods; and (6) the impact of the use of renewable fuels on other factors, including job creation, the price and supply of agricultural commodities, rural economic development, and food prices. *Id.*

And third, EPA may waive an applicable statutorily prescribed volume requirement under certain limited circumstances. First, for any year "for which the projected volume of cellulosic biofuel production is less than the minimum applicable [statutory] volume …, as determined by the Administrator …, the Administrator shall reduce the applicable [statutory] volume of cellulosic biofuel … to the projected volume available during that calendar year."[17] For any year in which EPA exercises its cellulosic waiver authority, it "may also" flow the waiver through to the enclosing volume requirements, i.e., "reduce the applicable volume of renewable fuel and advanced biofuels requirement … by the same or a lesser volume."[18] Second, "in consultation with the Secretary of Agriculture and the Secretary of Energy," EPA "may waive the [statutory] requirements … in whole or in part … by reducing the national quantity of renewable fuel required" based on a determination that (i) "implementation of the requirement would severely harm the economy or environment of a State, a region, or the United States" or (ii) "there is an inadequate domestic supply."[19] EPA may exercise this general waiver authority "on petition by one or more States, by any person subject to the requirements of this subsection, or by the Administrator on his own motion."[20]

Under certain circumstances, exercise of waiver authority will empower EPA to also "reset" the statutory volume requirements going forward before the statutory schedule expires. If EPA waives at least 20 percent of a particular volume requirement in two consecutive years *or* at least 50 percent of a particular volume requirement in a single year, EPA "shall promulgate a rule … that modifies the applicable volumes [for that category of renewable fuel] … for all years following the final year to which the waiver applies."[21] EPA must promulgate such a rule within one year after issuing the waiver that triggers the reset.[22] When resetting volume requirements under this authority, EPA must adhere to the same process that governs the setting of volume requirements after 2022, including determining the new levels in coordination with the Secretaries of Energy and Agriculture, and based on a review of the implementation of the RFS program to date and on an analysis of six statutory factors.[23]

B. EPA's Prior Proposal For 2014

On November 15, 2013, EPA proposed RVOs for 2014.[24] The proposed RVOs were derived from volume requirements that were, for the most part, substantially below the statutorily prescribed levels. EPA explained that it was proposing to exercise its waiver authority to reduce the volume requirements.

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[17] *Id.* § 7545(*o*)(7)(D)(i).

[18] *Id.*

[19] *Id.* § 7545(*o*)(7)(A).

[20] *Id.*

[21] *Id.* § 7545(*o*)(7)(F)(ii).

[22] *Id.* § 7545(*o*)(7)(F).

[23] *Id.*; *see id.* § 7545(*o*)(2)(B)(ii).

[24] 78 Fed. Reg. 71,732 (Nov. 29, 2013).

In particular, EPA proposed to exercise its cellulosic waiver authority to reduce the volume requirement for cellulosic biofuel from the statutory level of 1.75 bil gal to 17 mil gal to reflect its projection of the volume of cellulosic biofuel production.[25] Although EPA recognized that "total biodiesel production by the end of 2013 could be as high as 1.7 bill gal," and that biodiesel plants had "total operating capacity of 2.1 bill gal per year,"[26] EPA proposed to set the applicable 2014 volume for biodiesel at 1.28 bil gal, slightly above the statutory level of 1.0 bil gal.[27] EPA next proposed to flow the cellulosic waiver through to reduce the advanced volume requirement from 3.75 bil gal to 2.2 bil gal.[28] Finally, EPA proposed to exercise its general waiver authority to reduce the renewable fuel volume requirement from 18.15 bil gal to 15.21 bil gal.[29]

EPA's proposed exercise of its general waiver authority was based on its determination that there was "inadequate domestic supply." EPA interpreted that prong of the general waiver provision to permit consideration of not just the supply of renewable fuels produced but also "factors affecting the ability to distribute, blend, dispense, and consume those renewable fuels," including the so-called E10 blendwall.[30] The E10 blendwall refers to "the volume of ethanol that could be used if all gasoline contained 10% ethanol and there were no higher level ethanol blends."[31] In EPA's view, sufficient ethanol could not be distributed and consumed in 2014 to achieve the statutorily prescribed level.[32]

During the comment period, Growth Energy submitted a comment on EPA's 2014 proposal. Growth Energy identified numerous fundamental flaws in EPA's proposed exercise of its general waiver authority and the proposed renewable fuel requirement, including:

- EPA's proposal would undermine Congress's goal of using RFS volume requirements to spur rapid growth in the production and use of renewable fuels.[33]

- EPA could not exercise its general waiver authority because the supply of ethanol, as measured by production capacity, was sufficient to meet the statutory renewable fuel requirement.[34]

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[25] *Id.* at 71,738-71,751.

[26] *Id.* at 71,752.

[27] *Id.* at 71,752-71,754.

[28] *Id.* at 71,754.

[29] *Id.*

[30] *Id.* at 71,755.

[31] 80 Fed. Reg. 33,100, 33,126.

[32] *Id*. at 33,104.

[33] Growth Energy, Comments on EPA's Proposed 2014 Standards for the Renewable Fuel Standard Program, Dkt. # EPA-HQ-OAR-2013-0479 ("Growth Energy Prior Comments on 2014 RFS"), at 16-18 (Jan. 28, 2014).

[34] *Id.* at 10-11.

- EPA incorrectly interpreted the general waiver provision to mean that in determining whether there is inadequate domestic supply, EPA could consider not just the capacity for producing renewable fuels, but also the capacity for distributing and consuming them.[35]

- Even under EPA's erroneous interpretation of the general waiver provision, it could not exercise that authority because supply was still adequate.[36]

- EPA substantially understated the volume of E85 that could be distributed and consumed in 2014.[37]

- EPA should not have disregarded the potential for distributing and consuming E15 in 2014.[38]

- EPA understated the amount of biodiesel that could be produced and consumed in 2014.[39]

- EPA erred in failing to account for the sizeable RIN bank when determining whether supply was adequate, instead setting the renewable fuel volume requirement low enough to preserve a RIN "buffer."[40]

- Even if EPA could preserve a RIN buffer, EPA had failed to articulate any basis for setting the buffer at the chosen level.[41]

- EPA's proposal would have numerous adverse consequences, including harming corn farmers and the ethanol industry, setting back the development of second-generation renewable fuels, increasing energy dependence, raising retail gasoline prices, and harming the environment.[42]

In December 2014, EPA announced that it would not be finalizing the 2014 RFS rule in 2014, effectively withdrawing the proposal.[43] EPA subsequently explained that it had "concluded that the approach in the November 2013 proposal, projecting volume growth into the

[35] *Id.* at 11-19.

[36] *Id.* at 19-44.

[37] *Id.* at 22-30.

[38] *Id.* at 35-43.

[39] *Id.* at 43-44.

[40] *Id.* at 30-35.

[41] *Id.* at 35.

[42] *Id.* at 45-50.

[43] 79 Fed. Reg. 73,007 (Dec. 9, 2014).

the-then future, was not an appropriate way to set standards in late 2014, for a year that was largely over."[44]

C. EPA's Current Proposal For 2014-2016

On May 29, 2015, EPA officially withdrew the November 2013 proposal and released a new proposal for 2014, 2015, and 2016, which it formally issued for comment on June 10.[45] Table 1 summarizes EPA's proposed volume requirements.

Table 1: EPA Proposed Volume Requirements[46]			
	2014	**2015**	**2016**
Cellulosic biofuel	0.033	0.106	0.206
Biomass-based diesel	1.63	1.70	1.80
Advanced biofuel	2.68	2.90	3.40
Renewable fuel	15.93	16.30	17.40

All numbers in billions of gallons (volumetric)

EPA said its task was "to determine the maximum volumes of renewable fuel that can be expected to be achieved in light of supply constraints."[47] "Because 2014 has passed," EPA proposed 2014 volume requirements that "reflect the actual supply in 2014."[48] "For 2015 [EPA] similarly propos[ed] to take into account actual renewable fuel use during the time that has already passed."[49]

With respect to cellulosic biofuels, EPA explained that it was exercising its cellulosic waiver authority to reduce the applicable volume requirements for 2014-2016. According to EPA, net 0.033 bil RINs for cellulosic biofuel were generated in 2014, and so it proposed to set the volume requirement at that level for that year.[50] EPA then proposed slightly increasing volumes for 2015 and 2016 based on its assessment of current and projected production capacities.[51]

With respect to BBD, EPA proposed to set the 2014 volume requirement equal to the 2014 net RIN generation, and then to increase that amount by about 100 mil gal (volumetric) per

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[44] 80 Fed. Reg. at 33,104.

[45] *Id*. at 33,100, 33,104.

[46] *Id*. at 33,105, Table I.A-3.

[47] *Id*. at 33,105.

[48] *Id*.

[49] *Id*. at 33,108.

[50] *Id*. at 33,107.

[51] *Id*.; *see also id.* 33,138-33,146.

year through 2017.[52] EPA acknowledged that there could be substantial volume of BBD above these levels, but reasoned that "establishing the volumes at these levels will encourage BBD producers to manufacture higher volumes of fuel that will contribute to the advanced biofuel and renewable fuel requirements, while also leaving considerable opportunity within the advanced biofuel mandate for investment in and production of other types of advanced biofuel with comparable or potentially superior environmental or other benefits."[53]

EPA then proposed to flow the cellulosic waiver through to reduce the statutory advanced biofuel and renewable fuel volume requirements.[54] Although EPA did not say so explicitly, it is evident that it would flow the cellulosic waiver through only partially because the proposed cellulosic waivers are greater than the proposed waivers of the advanced levels. Specifically, EPA proposed to reduce the cellulosic requirement by 1.717 bil gal in 2014, 2.894 bil gal in 2015, and 4.044 bil gal in 2015, but to reduce the advanced requirement only by 1.070 bil gal in 2014, 2.600 bil gal in 2015, and 3.850 bil gal in 2016.[55] EPA then proposed to also flow the cellulosic waiver through to the renewable fuels requirement for all three years by the same amounts as to advanced.[56]

EPA also proposed to use its general waiver authority in two ways: "in a supplemental fashion with respect to the volumes [it] propose[s] waiving using the cellulosic waiver authority, [and] as the sole authority for [further] reductions [in] total renewable fuel" volumes.[57] In EPA's view, the general waiver provision is "ambiguous" and "is reasonably and best interpreted to encompass the full range of constraints that could result in an inadequate supply of renewable fuel to the ultimate consumers, including fuel infrastructure and other constraints. This would include, for instance, factors affecting the ability to produce or import qualifying renewable fuels as well as factors affecting the ability to distribute, blend, dispense, and consume those renewable fuels in vehicles."[58]

According to EPA, the principal limitations on supply so understood are the E10 blendwall and the apparent barriers to surmounting it: "The decrease in total gasoline consumption in recent years which resulted in a corresponding and proportional decrease in the maximum amount of ethanol that can be consumed if all gasoline was E10, the limited number and geographic distribution of retail stations that offer higher ethanol blends such as E15 and E85, the number of FFVs that have access to E85, as well as other market factors, combine to place significant restrictions on the volume of ethanol that can be supplied to vehicles at the present time."[59] EPA therefore explained that it "believe[s] that limitations in production or

[52] *Id*. at 33,133, 33,136.

[53] *Id*. at 33,106; *see also id.* at 33,136.

[54] *Id*. at 33,110-33,111.

[55] *See id*. at 33,122.

[56] *Id*. at 33,110.

[57] *Id*. at 33,111.

[58] *Id*.

[59] *Id*. at 33,109.

importation of qualifying renewable fuels, and factors that limit supplying those fuels to the vehicles that can consume them, both constitute circumstances that warrant a waiver ….”[60]

Apart from the E10 blendwall, however, EPA did not attempt to quantify the effect of any of these apparent restrictions. EPA proposed to base the 2014 renewable fuel volume requirement on the actual net RIN generation for that year.[61] EPA determined its proposed renewable fuel volume requirements for 2015 and 2016 by attempting to predict how much growth of fuels other than E10 "is within reach of a responsive market" based on past levels.[62]

For 2015, EPA proposed to set the renewable fuel requirement 370 mil gal above the proposed 2014 level. "Much of the increase from 2014"—about 220 mil gal—"would result from the increase in the advanced biofuel standard of 2.90 billion gallons" (compared to 2.68 bil gal for 2014).[63] Thus, EPA's 2015 proposal implies that conventional renewable fuels would grow by 150 mil gal from 2014, to 13.4 bil gal, instead of to the statutorily implied level of 15.0 bil gal. EPA declared that this growth "is possible" because in 2014 renewable fuel grew by 390 mil gal.[64]

Turning to 2016, EPA observed that because obligated parties "will have the full compliance year to respond to the standards [EPA] set[s] for 2016, … the supply of renewable fuels to vehicles can grow more dramatically in 2016 than in 2015."[65] Specifically, EPA proposed to grow total renewable fuel in 2016 by 1.1 bil gal, 500 mil gal of which would come from growth under the advanced volume requirement, "while the remainder (the non-advanced portion)" would grow by 600 mil gal, to 14.0 bil gal, instead of to the statutorily implied level of 15.0 bil gal.[66]

In EPA's view, because the proposed 2016 advanced biofuel and renewable fuel volume requirements "represent significant increases from 2014, … it would be unreasonable to expect the market to supply more than the proposed volumes."[67] But EPA offered no analysis of whether more could be supplied to consumers. Instead, it tried to determine whether these modest proposed increases are "achievable."[68]

To do this, EPA began with the E10 blendwall. Relying on gasoline projections by the Energy Information Administration ("EIA") issued in May 2015, EPA projected the E10

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[60] *Id*. at 33,109-33,110.

[61] *Id*. at 33,121.

[62] *Id*. at 33,122-33,123.

[63] *Id*. at 33,122.

[64] *Id*.

[65] *Id*. at 33,123.

[66] *Id*.

[67] *Id*. at 33,126.

[68] *Id*.

blendwall at 13.78 bil gal for 2015 and 13.69 bil gal for 2016.[69] Although "the E10 blendwall is a function of several factors, some legal, and some market-driven," EPA stated that it "believe[s] that [the market] can respond to the standards we set to drive the use of higher ethanol blends, the E10 blendwall notwithstanding."[70] EPA's 2016 proposed renewable fuel volume would require 0.84 bil gal of renewable fuel above the E10 blendwall, after accounting for non-ethanol cellulosic biofuel and the required level of BBD.[71] EPA identified several "options … to the market to fulfill the need for 0.84 billion gallons," including increasing BBD beyond the proposed standard, increasing importation of sugarcane ethanol, and increasing corn ethanol.[72] However, EPA concluded that "[e]fforts to increase the use of ethanol beyond the blendwall is primarily a function of the volume of E85 that is consumed, since volumes of E15 are likely to continue to be small in 2016."[73] Admitting that it "cannot … predict how the market will choose to meet [the proposed] requirements," EPA presented "a range of possibilities" using the various market options it identified, all based on 100-600 mil gal of E85.[74]

Finally, although EPA estimated that after 2013 compliance, there will be a "bank" of "approximately 1.8 billion [carryover] RINS,"[75] it "propos[ed] not to count those RINs as part of the 'supply' for 2014 or later years."[76] EPA explained that it would be prudent, and would advance the long-term objectives of the Act, not to set standards for 2014, 2015, and 2016 so as to intentionally draw down the current bank of carryover RINs," so that obligated parties could keep these banked RINs to "address[] significant future uncertainties and challenges."[77]

III. EPA'S PROPOSED RENEWABLE FUEL VOLUME REQUIREMENTS WOULD THWART THE GROWTH OF RENEWABLE FUEL FOR YEARS, CONTRARY TO CONGRESS' INTENT AND EPA'S STATED GOAL

As EPA recognizes, "Congress expected the RFS program to compel the industry to make dramatic changes in a relatively short period of time."[78] To accomplish this, the statute mandates that annually increasing levels of renewable fuels be blended into transportation fuel. The proposal repeatedly expresses EPA's apparent belief that its proposal accomplishes Congress's goal by creating necessary market incentives. For example, EPA says: "Because the standards that we are proposing would compel the market to supply higher volumes than would

[69] *Id*. at 33,115, Table II.A.5-1.

[70] *Id*. at 33,126.

[71] *Id*. at 33,127.

[72] *Id*.

[73] *Id*. at 33,126.

[74] *Id*. at 33,127.

[75] *Id*. at 33,130. Excess RINs can be carried over into the next compliance year. 42 U.S.C. § 7545(*o*)(5)(D).

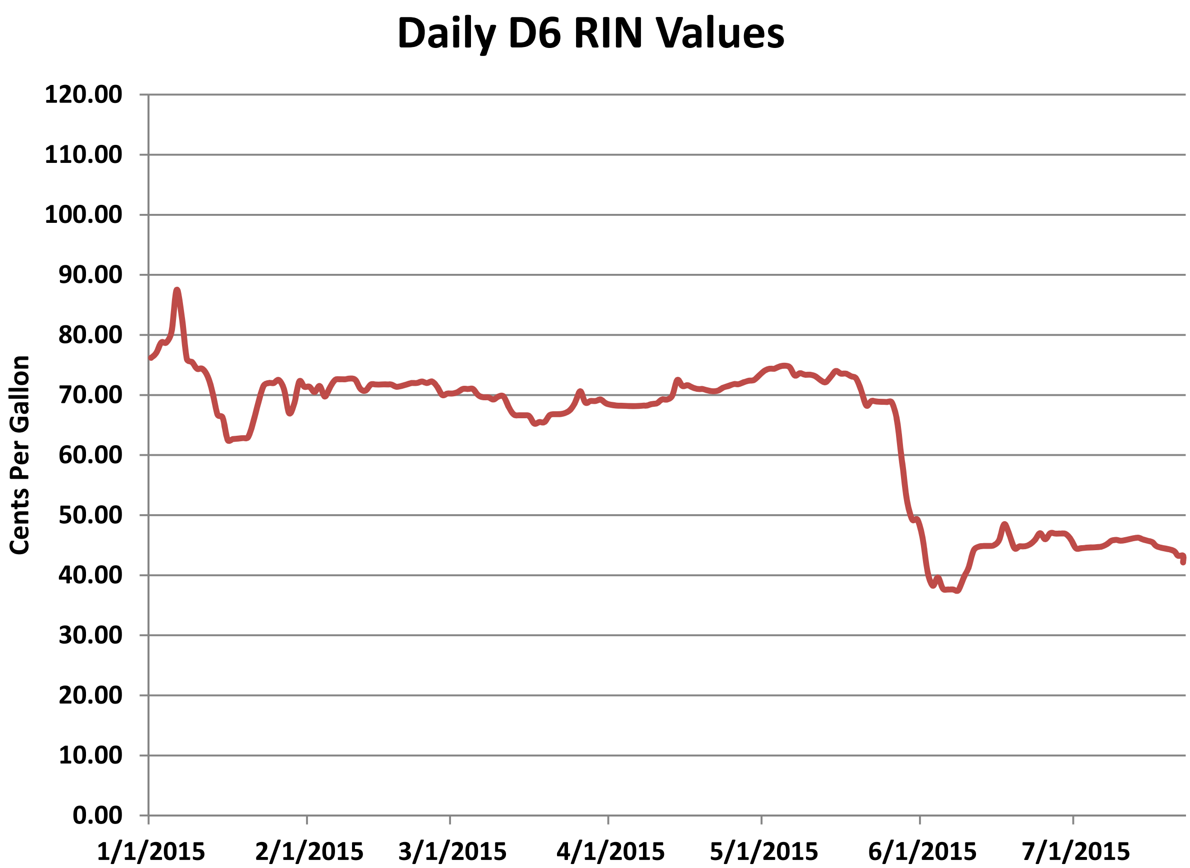
[76] 80 Fed. Reg. at 33,121 n.59.

[77] *Id*. at 33,130.

[78] *Id*. at 33,118.

occur in the absence of an RFS program and indeed higher volumes than are currently being supplied, RIN prices are likely to be higher than historical levels."[79]

The market begs to differ. Review of RIN prices before and after EPA's proposal was released on May 29, 2015, provides a stark reality check:



Source: Oil Price Information Service

This graph shows the daily price of D6 RINs (which corresponds to non-advanced renewable fuel) performing a "cliff div[e]"[80] as EPA announced its proposal. That "should make it obvious which way the RINs market voted with regard to the degree of push in the EPA proposal."[81] To put it bluntly, the smart money knows that the proposed renewable fuel volumes mean little or no push beyond current usage levels. Notably, even after accounting for EPA's

[79] *Id*. 33,129; *see also id*. 33,105-33,106, 33,109.

[80] Scott Irwin & Darrel Good, *The EPA's Proposed Ethanol Mandates for 2014, 2015, and 2016: Is There a 'Push' or Not?*, Farmdoc Daily No. (5):102, at 5 (June 3, 2015), *at* http://farmdocdaily.illinois.edu/pdf/fdd030615.pdf.

[81] Irwin & Good, *supra* note 80, at 5.

latest RFS proposal, EIA still projects that the pool-wide ethanol content will be just 9.94% in 2016, which is below the 10% level of the E10 blendwall.[82]

The reasons for this are clear. EPA's proposal would not drive growth in 2016, and it strongly suggests that EPA will continue to stifle growth in 2017 and thereafter.

A. EPA's Proposed Volume Requirements Would Not Drive Growth In Renewable Fuel Through 2016

The bank of carryover RINs, which EPA has intentionally declined to account for when proposing the volume requirements, could and likely would be used to achieve compliance through 2016 with minimal growth, if any. With the 2014 renewable fuel volume proposed to be set to the level of actual net RIN generation (15.93 bil), and thus requiring no banked RINs for compliance, EPA's proposal and calculations imply that, if the industry maintained its 2014 level through 2016, an additional net 1.84 bil RINs would be needed to comply with the proposed 2015 and 2016 volume requirements.[83] That amount of additional RINs, however, is virtually identical to the size of the bank of carryover RINs that EPA expects "after obligated parties fulfil their compliance obligations for 2013," namely, "approximately 1.8 billion RINs."[84] Therefore, obligated parties could use the RIN bank to achieve full compliance with EPA's proposal through 2016 while barely expanding the use of renewable fuels above 2014 levels.

And that is not even accounting for EPA's understatement of 2014 net D6 RIN generation based on its erroneous treatment of some exported ethanol. As discussed below, 2014 net D6 RIN generation was at least 370 mil higher than the proposal assumed.[85] As it turns out, the corrected net *2014* RIN generation is the same as the proposed *2015* renewable fuel volume requirement: 16.3 bil.[86] In other words, if the industry simply maintained its 2014 level of renewable fuel use in 2015, it would comply with the proposed requirement for both years, and have 370 mil RINs to spare. After that excess is added to the RIN bank, the industry could then maintain its (corrected) 2014 level through 2016, fully comply with the proposed renewable fuel volume requirements for 2014, 2015, and 2016, and still have more than one billion RINs in the bank, which it could use in 2017 and thereafter to continue to avoid having to make investments to grow renewable fuels. Table 2 summarizes this analysis.

[82] *See* EIA, *Short-Term Energy Outlook*, Table 4a (July 2015) (Motor Gasoline and Fuel Ethanol blended into Motor Gasoline).

[83] 0.370 = 16.3 [2015 proposed volume] – 15.93 [2014 actual volume]. 1.47 = 17.4 [2016 proposed volume] – 15.93 [2014 actual volume]. 0.370 + 1.47 = 1.84.

[84] 80 Fed. Reg. at 33,130.

[85] *See infra* Part VIII.

[86] 16.3 = 15.93 + 0.37.

Table 2: Compliance with Proposed Volume Requirements After 2014 Export Correction			
	2014	**2015**	**2016**
2014 net RIN generation assumed by EPA	15.93	N/A	N/A
Correction for 2014 exported ethanol	.37	N/A	N/A
Corrected 2014 net RIN generation (sustained through 2016)	16.30	16.30	16.30
EPA proposed renewable fuel requirement	15.93	16.30	17.40
RIN drawdown	-0.37	0.00	1.10
Carryover RIN bank balance*	2.17	2.17	1.07

All numbers in billions of RINs

** Initial carryover RIN bank balance is 1.8 bil*

EPA's proposal, therefore, would utterly fail to further Congress's goal of using the RFS program to stimulate rapid expansion in the production and use of renewable fuels, and instead would simply maintain the status quo. As discussed below, EPA should at a minimum treat carryover RINs as "supply" for purposes of the general waiver provision so that this could not happen.[87]

B. EPA's Proposed Volume Requirements Would Enable EPA To Continue To Stifle Growth In 2017 And Beyond

EPA's proposal would fail to drive growth in renewable fuels not only through 2016, but also likely in 2017 and beyond. As just noted, obligated parties would have more than one billion RINs in the bank after fully complying with EPA's proposal through 2016 without even increasing their levels above 2014 levels. But it gets worse. EPA's proposed renewable fuel volume requirements appear to have been calibrated to enable EPA to trigger its "reset" authority so that EPA could continue to stifle growth in the long term, rather than to pursue the goals of the statute, which would render its proposal unlawful.[88]

Section 7545(*o*)(7)(F) creates what is commonly referred to as the "reset" (or "off ramp") authority because, once triggered, it enables EPA to discard the statutorily prescribed volume requirements and set new volumes without having to invoke the general waiver authority—a freedom EPA would not otherwise have until 2023, after the statutory levels had expired. EPA's current proposal would trigger EPA's "reset" authority for advanced biofuel and cellulosic biofuel by a wide margin. EPA proposed to waive the advanced biofuel volume down by 47% in 2015 and 53% in 2016; and to waive the cellulosic biofuel volume down by more than 95% for both 2015 and 2016.[89] EPA then conspicuously also proposed to set the renewable fuel volume

[87] *See infra* Part IX.

[88] *See Michigan v. EPA*, No. 14-46, slip op. at 5 (U.S. June 29, 2015) ("[A]gency action is lawful only if it rests 'on a consideration of the relevant factors." (quoting *Motor Vehicle Mfrs. Ass'n of United States, Inc. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983)).

[89] *See* 80 Fed. Reg. at 33,103.

requirements at nearly precisely the levels necessary to trigger its reset authority for 2017. EPA's proposed renewable fuel volume requirement is 20.49% lower than the statutory level in 2015 (16.3 bil gal, rather than 20.5 bil gal) and 21.80% lower in 2016 (17.4 bil gal, rather than 22.25 bil gal).[90] As a result, EPA would be released from the congressionally prescribed volume requirements not only for cellulosic biofuels and advanced biofuels, but also for renewable fuels, six years ahead of Congress's schedule. (EPA was already released with respect to BBD.) EPA would then have substantial autonomy to set new volume requirements as it sees fit, without having to justify invocation of the general waiver authority, and subject only to the six pliable factors laid out in Section 7545(*o*)(2)(B)(ii). In addition, EPA would potentially be able to avoid having to annually go through the process of setting volume requirements, an obligation that has clearly presented significant challenges for the agency.

Although EPA never mentions the reset power in its proposal, the fact that the proposal would trigger the reset power appears to have been deliberate. Just a few weeks after the proposal was issued, EPA Acting Administrator for Air and Radiation Janet McCabe testified to Congress that "we actually think it makes a lot of sense to focus a reset on all volumes at one time."[91] Accordingly, she said, "the minute 2016 is done, we will be turning our full attention to the 2017 rule and the reset."[92] Indeed, Ms. McCabe added, EPA staff are "already thinking about the kinds of things they needed to be thinking about for the reset."[93] (Ms. McCabe also emphasized that the reset process would be time-consuming—"likely … longer than the one year required for the annual volumes"[94]—and thus cause yet more uncertainty for the renewable fuel industry.)

That EPA's proposal would trigger the reset power is especially troubling given that the substance of its proposal, in conjunction with the prior proposal for 2014, leaves little doubt that EPA will embrace its self-aggrandized autonomy to continue to treat the RFS program as a backward-facing accounting mechanism that largely preserves the status quo rather than as the mechanism for the driving rapid expansion in the production and use of renewable fuel that Congress intended and that would best serve the Nation. That outcome, which the market surely recognizes, will further undermine any growth in renewable fuel in the short term. If the market believes there is a substantial probability of a reset in 2017, then the presence of the RIN bank would make it especially unlikely that actual biofuel volumes would increase in 2015 and 2016, compared to 2014. Instead, operating under the assumption that carryover RINs will be worth little once the reset occurs because of the likely soft volume requirements, obligated parties would have a strong incentive to consume the RIN bank and maintain past volumes.

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[90] *See id*.

[91] Testimony of Janet McCabe, *supra* note 5, at 21 (June 18, 2015) (emphasis added), *at* http://www.cq.com/doc/financialtranscripts-4711934?6&search=1E4v24rR.

[92] *Id.* at 23.

[93] *Id.*

[94] *Id.* at 22.

IV. BECAUSE THE AMOUNT OF RENEWABLE FUEL IS ADEQUATE FOR OBLIGATED PARTIES TO MEET THEIR STATUTORY OBLIGATIONS AFTER THE PROPOSED CELLULOSIC WAIVER FLOW-THROUGH, EPA MAY NOT USE ITS GENERAL WAIVER AUTHORITY TO FURTHER REDUCE THE RENEWABLE FUEL VOLUME REQUIREMENTS

EPA may invoke its general waiver authority only if there is "inadequate domestic supply."[95] EPA interprets the phrase "inadequate domestic supply" to "encompass the full range of constraints that could result in an inadequate supply of renewable fuel *to the ultimate consumers*."[96] EPA explains that this would include not only "factors affecting the ability to produce or import qualifying renewable fuels," but also "factors affecting the ability to distribute, blend, dispense, and consume those fuels in vehicles."[97]

EPA's interpretation of the general waiver authority is impermissible. The statute's text, structure, purpose, and legislative history all clearly show that Congress intended "supply" to refer to the amount of renewable fuel for obligated parties to comply with the applicable statutory volume requirements, not the amount that can ultimately make it into drivers' gas tanks as an ingredient in blended transportation fuel.

Besides this strong statutory evidence, discussed presently, the ordinary usage of the word "supply" shows that it cannot be interpreted to include constraints on the ability to distribute renewable fuel as an ingredient in another product (transportation fuel) that is delivered to the ultimate consumer or on the ability to consume it. It would be like saying that in order to measure of supply of sugar, one must take into account whether Nabisco has decided to cut production of Oreos and Chips Ahoy! cookies, or whether New York City has enacted an ordinance limiting the amount of shelf space that grocery stores could devote to cookies. True, Nabisco's decision to cut production of cookies or New York City's ordinance limiting shelf space for cookies might reduce the supply of *cookies* available for retailers (and in turn consumers). Likewise, retailers' lack of suitable underground storage tanks might limit the supply of a particular *transportation fuel to consumers*. But those constraints in the middle of the value chain would actually function only as limitations on *demand* for the upstream good, i.e., the sugar, or the renewable fuel.

In fact, the primary supposed constraints of interest to EPA cannot be understood as supply to *anyone*—they can only be understood as demand. For example, as EPA even acknowledges, "[t]he amount of ethanol associated with the E10 blendwall is driven by the total *demand* for gasoline."[98] What limits consumption of ethanol as E10 is that the driving public

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[95] 42 U.S.C. § 7545(*o*)(7)(A).

[96] 80 Fed. Reg. at 33,111.

[97] *Id.* at 33,111; *see also, e.g., id.* at 33,106 ("the infrastructure available for distributing, blending, and dispensing renewable fuels"); *id.* ("the ability of available renewable fuels to be used as transportation fuel, heating oil, or jet fuel"); *id*. at 33,112 ("the capacity to distribute the product to the ultimate consumer.").

[98] *Id*. at 33,126 (emphasis added).

does not want to consume any more, whether because they have nowhere else to drive or because they find gasoline prices too high.[99] Similarly, that some consumers lack a vehicle that is compatible with a particular type of transportation fuel (e.g., an FFV for E85), or might *believe* they lack such a vehicle (e.g., if their car was made after 2000 but its warranty does not explicitly approve the use of E10), is a matter of demand because even if abundant volumes of the transportation fuel were available to them, such consumers would still decline to use it. To say otherwise, as EPA does, would be like saying that there is limited "supply" of DVDs because of a shortage of DVD players.

In other words, EPA is trying to expand "supply" of "renewable fuel" to include "demand," all the way down the value chain to the ultimate consumer. Those concepts are, of course, antitheses. Words are not infinitely malleable, and EPA is not free to treat them interchangeably or to give them their opposite meaning when interpreting a statute. Even if the term "supply" in the general waiver provision were ambiguous in the abstract, EPA's proposed interpretation would still be foreclosed because it "goes beyond the limits of what is ambiguous and contradicts what … is quite clear"—that "supply" cannot mean "demand."[100] It is particularly unreasonable to consider constraints on demand for renewable fuel when, as described below, the very mechanism Congress chose to spur growth in renewable fuels was to *mandate demand* for renewable fuels through increasing volumetric requirements.

Properly understood, the general waiver authority cannot be exercised with respect to the renewable fuel requirements for 2014-2016. In each of those years, there was, or will be, sufficient supply to meet the statutory volumes after the proposed flow-through of the cellulosic waiver. EPA seems to understand this, remarking that "at least for 2014 and possibly 2015 and 2016, there is no shortage of ethanol and other types of renewable fuel that could be used to satisfy the statutory applicable volume of total renewable fuel."[101]

A. The General Waiver Provision Accounts Only For The Amount Of Renewable Fuel Available To Obligated Parties, Not The Amount Of Transportation Fuel Available To Consumers

1. The statute's text and structure show that "supply" means the supply of renewable fuel available to obligated parties

EPA asserts that the general waiver provision is "ambiguous" because "it does not specify what the general term 'supply' refers to."[102] In particular, EPA says, the waiver

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[99] *See id.*

[100] *Whitman v. American Trucking Ass'ns*, 531 U.S. 457, 481 (2001); *see also City of Arlington, Texas v. FCC*, 133 S. Ct. 1863, 1874 (2013) ("Where Congress has established a clear line, the agency cannot go beyond it; and where Congress has established an ambiguous line, the agency can go no further than the ambiguity will fairly allow.").

[101] 80 Fed. Reg. at 33,113.

[102] *Id.* at 33,111.

provision "does not specify what product is at issue … or the person or place at issue … in determining whether there is an 'inadequate domestic supply.'"[103]

It is true that the provision ends with the phrase "an inadequate domestic supply," full stop. But Congress' economical prose hardly makes the provision "ambiguous." "In determining whether Congress has specifically addressed the question at issue," EPA (like the courts) "should not confine itself to examining a particular statutory provision in isolation."[104] Rather, "[s]tatutory construction … is a holistic endeavor."[105] Because "[t]he meaning—or ambiguity—of certain words or phrases may only become evident when placed in context," "[i]t is a fundamental canon of statutory construction that the words of a statute must be read in their context and with a view to their place in the overall statutory scheme."[106] Indeed, a "provision that may seem ambiguous in isolation is often clarified by the remainder of the statutory scheme—because the same terminology is used elsewhere in a context that makes its meaning clear or because only one of the permissible meanings produces a substantive effect that is compatible with the rest of the law."[107] That is the case here.

The text of the statute as a whole makes unmistakably clear that Congress intended "supply" to refer to renewable fuel, and nothing more. EPA previously agreed with this position, declaring that "it is ultimately *the availability of qualifying renewable fuel* … that will determine the extent to which EPA should issue a waiver of RFS requirements on the basis of inadequate domestic supply."[108] There is no sound basis for reading the general waiver provision differently today.

In providing for waiver authority, section 7545(*o)*(7)(A) mentions one and only one product: "renewable fuel." It is therefore plain that the product to which "supply" refers is renewable fuel. Reading "supply" to refer to the transportation fuel dispensed to consumers is as unreasonable and inconsistent with the plain language as reading it to refer to toasters: neither is mentioned anywhere in the general waiver provision.

At times, EPA seems to agree that "supply" refers to the supply of renewable fuel; the real locus of EPA's perceived ambiguity appears to be in the term "renewable fuel."[109] EPA points out that "various parties interact across several industries to make renewable fuel available for use by the ultimate consumers as transportation fuel."[110] In EPA's view, the general waiver

[103] *Id.*

[104] *FDA v. Brown & Williamson Tobacco Corp.*, 529 U.S. 120, 132 (2000).

[105] *United Sav. Ass'n of Tex. v. Timbers of Inwood Forest Assocs.*, 484 U.S. 365, 371 (1988).

[106] *Brown & Williamson*, 529 U.S. at 133.

[107] *United Sav. Ass'n*, 484 U.S. at 371.

[108] EPA, *Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program*, 75 Fed. Reg. 14,670, 14,698 (Mar. 26, 2010) (hereinafter 2010 RFS2 Impact Analysis) (emphasis added).

[109] *See* 80 Fed. Reg. at 33,111.

[110] *Id.*

provision is ambiguous because it "does not specify" whether it refers to "neat renewable fuel or renewable fuel that is blended with transportation fuel."[111] EPA thus proposes to interpret the general waiver provision to account for the entire renewable-fuel value chain: "factors affecting the ability to produce or import qualifying renewable fuels as well as factors affecting the ability to distribute, blend, dispense, and consume those fuels in vehicles."[112]

EPA is wrong that "renewable fuels" is ambiguous. First, the statute defines "renewable fuel" to mean "fuel that is produced from renewable biomass and that is used to replace or reduce the quantity of fossil fuel present in a transportation fuel."[113] And it defines "transportation fuel" to mean "fuel for use in motor vehicles, motor vehicle engines, nonroad vehicles, or nonroad engines (except for ocean-going vessels)."[114] In other words, according to Congress, renewable fuel is something supplied to refiners and others to be inserted into transportation fuel, and transportation fuel is something supplied to and consumed by consumers; renewable fuel is not supplied to consumers.

Congress's use of these terms elsewhere in the statute confirms this understanding.[115] The heart of the RFS program is the statute's specification of "the applicable volume of renewable fuel" over many years, and the corresponding "renewable fuel obligation" imposed on "refineries, blenders, and importers, as appropriate."[116] EPA has rightly never suggested in the context of implementing these provisions that these parties could satisfy their obligations by refining fuel containing a certain level of *transportation* fuel—something that does not even make sense.

Perhaps EPA would stress that it is proposing to interpret "renewable fuel" not to mean "transportation fuel" but rather "the renewable fuel that has been blended into transportation fuel."[117] This subtle difference would only amplify the absurdity of its proposed interpretation. It would mean, for example, that the statute required EPA to promulgate regulations to "ensure that transportation fuel sold or introduced into commerce in the United States … contains at least the applicable volume of renewable fuel [blended into transportation fuel]."[118] It would also mean that the statute required EPA to provide for "the generation of an appropriate amount of

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[111] *Id.*

[112] *Id.*; *see also, e.g.*, *id.* at 33,106 ("the infrastructure available for distributing, blending, and dispensing renewable fuels"); *id.* ("the ability of available renewable fuels to be used as transportation fuel, heating oil, or jet fuel"); *id.* at 33,112 ("the capacity to distribute the product to the ultimate consumer.").

[113] 42 U.S.C. § 7545(*o*)(1)(J).

[114] *Id.* § 7545(*o*)(1)(J).

[115] *See Envtl. Def. v. Duke Energy Corp.*, 549 U.S. 561, 574 (2007) ("[W]e presume that the same term has the same meaning when it occurs here and there in a single statute").

[116] 42 U.S.C. § 7545(*o*)(2)(A)(iii)(I), (3)(B)(ii)(I).

[117] 80 Fed. Reg. at 33,111.

[118] 42 U.S.C. § 7545(*o*)(2)(A)(i).

credits by any person that refines, blends, or imports gasoline that contains a quantity of renewable fuel [blended into transportation fuel] that is greater than the quantity required under paragraph (2)."[119] How can transportation fuel contain something known as renewable fuel blended into transportation fuel? How can someone blend into gasoline a quantity of something called renewable fuel blended into transportation fuel? Such sentences do not even compute. Clearly that is not what Congress intended.

Notably, it is solely in the context of the general waiver provision that EPA tries to stretch "renewable fuel" to encompass the downstream products that might contain it. EPA offers no explanation for treating one instance of a term used throughout the statute differently from all the other instances. That alone renders its proposed interpretation of the general waiver authority arbitrary and capricious.

EPA also maintains that there is ambiguity insofar as the general waiver provision "does not specify … the person or place at issue (for example, obligated party, blender or ultimate consumer)."[120] Thus, again EPA finds license to consider the entire value chain, down "to the ultimate consumer."[121] EPA attempts to justify this interpretation by averring that "the concept of 'supply' does not occur in isolation, but in reference to the person intending to make use of the product."[122] Regardless of whether EPA can introduce a relational "concept of 'supply'" into the statute, that concept does not provide additional support for EPA's interpretation of the general waiver provision; at best, it begs the question. As just explained, the product whose supply is to be measured for purposes of the general waiver provision is renewable fuel—or neat renewable fuel, as EPA wants to term it just for purposes of the general waiver. That product is supplied only to obligated parties. Therefore, even if "supply" must account for constraints on distribution to the person who will use the product, it still only reaches the distribution of renewable fuel to obligated parties and no further down the value chain.

This analysis is confirmed by the general waiver provision's references to paragraph (2), which direct the Administrator to revise regulations "to ensure that transportation fuel sold or introduced into commerce in the United States" contains the specified volumes of renewable fuels.[123] Paragraph (2) also provides that these regulations are to apply to the obligated parties.[124] The statutory scheme here is clear: obligated parties fulfill their obligations by blending specified amounts of renewable fuel into transportation fuel, not by selling the blended transportation fuel or by enabling consumers to use the blended transportation. The point of the general waiver authority, then, is to relieve obligated parties of that blending obligation if they cannot obtain enough of the renewable fuel they need to comply with it. EPA reveals its basic misunderstanding of the RFS program and the general waiver provision when it remarks to the

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[119] *Id.* § 7545(*o*)(5)(A)(i).

[120] 80 Fed. Reg. at 33,111.

[121] *Id.*

[122] *Id.* at 33,112.

[123] 42 U.S.C. § 7545(*o*)(2)(A)(i).

[124] *Id.* § 7545(*o*)(2)(A)(iii)(I).

contrary, for example, that the proposed general waiver rests on its concern that "marketplace and infrastructure constraints … prevent the fuel market from *supplying vehicles the volumes of ethanol needed to meet the statutory level* of total renewable fuel."[125] Paragraph (2) makes clear that neither vehicles nor their drivers are subject to any obligations under the statute, and compliance with volume obligations is not determined by whether blended transportation fuel reaches or is consumed by ultimate consumers.

In contrast, where Congress intended for EPA to consider the capacity to distribute a type of fuel further down the chain, it said so explicitly. Time and again, Congress used the term "distribution capacity" or a similar term—often in juxtaposition with "supply"—making clear that they have distinct meanings and that by omitting "distribution capacity" from the general waiver provision, Congress intended to exclude it from consideration rather than adopt an anomalous definition of "supply" to include it:

- Section 7545(m)(3)(C) allows EPA to delay the effective date of certain oxygenated gasoline requirements if EPA finds "an inadequate domestic supply of, or distribution capacity for, oxygenated gasoline" or fuel additives needed to make it.[126] It then mandates that "[i]n granting waivers under this subparagraph the Administrator shall consider distribution capacity separately from the adequacy of domestic supply."[127]

- Section 7545(*o*)(2)(B)(ii)(IV) authorizes the Administrator to consider "the sufficiency of infrastructure to deliver and use renewable fuel" in setting applicable volumes after 2022.[128] There would have been no reason for Congress to direct EPA to consider distribution infrastructure *after* 2022 if the general waiver provision already directed EPA to consider distribution infrastructure *anytime*.

- Section 7545(*o*)(8) allowed a waiver in 2006, the first year of the RFS program, based on an evaluation of renewable fuel "(i) supplies and prices; (ii) blendstock supplies; and (iii) supply and distribution system capabilities."[129] This provision explicitly treats supply and distribution capacity as distinct.

- Section 7545(c)(4)(C)(v)(IV) permits EPA to approve certain controls or prohibitions applicable to new fuels if EPA finds that the new control "will not cause fuel supply or distribution interruptions."[130] Again, this provision explicitly treats supply and distribution constraints as distinct.

[125] 80 Fed. Reg. at 33,113 (emphasis added).

[126] 42 U.S.C. § 7545(m)(3)(C)(i).

[127] *Id.* § 7545(m)(3)(C)(iii).

[128] *Id.* § 7545(*o*)(2)(B)(ii)(IV).

[129] *Id.* § 7545(*o*)(8)(B) (emphasis added).

[130] *Id.* § 7545(c)(4)(C)(v)(IV).

EPA's attempt to import distribution capacity into the general waiver provision therefore defies the traditional canon of statutory construction that "Congress generally acts intentionally when it uses particular language in one section of a statute but omits it in another."[131]

EPA points to section 7545(k)(6), but that is not to the contrary. EPA ignores the fact that the provision immediately preceding it, paragraph (5), prohibits the "sale or dispensing by any person of conventional gasoline to ultimate consumers," and the "sale or dispensing by any refiner, blender, importer, or marketer of conventional gasoline for resale" after a certain date.[132] In short, it prohibits all wholesale and retail sales—at any point along the distribution chain—of conventional gasoline. The purpose of these prohibitions is to encourage the regulated entities to sell "reformulated gasoline" ("RFG"), which must be certified.[133] Paragraph (6) allows the Administrator to delay the application of paragraph (5)'s prohibitions under certain circumstances. EPA observes that paragraph (6)(A)(ii) allows the Administrator to delay application of the prohibitions upon a finding that "there is insufficient domestic *capacity to produce*" certified RFG, whereas paragraph (6)(B)(i)(I) and (iii) allows the Administrator to delay application of the prohibitions upon a finding that there "there is insufficient *capacity to supply* [RFG]."[134] EPA "believe[s] Congress likely intended the 'capacity to supply' RFG as being broader in scope than the 'capacity to produce' RFG"—"capacity to produce" is merely how much RFG can be manufactured, whereas "the term 'capacity to supply' would … be expected to include consideration of the infrastructure needed to deliver RFG to vehicles."[135]

Even if EPA's interpretation of section 7545(k)(6) is correct, it does not hold the lesson for the general waiver provision that EPA believes. Section 7545(k)(6), in conjunction with paragraph (5)'s prohibitions, explicitly focuses on the entire distribution chain for conventional gasoline, from the refiner on down to the retailer. Accordingly, it may be reasonable to interpret "capacity to supply" to encompass infrastructure needed to deliver RFG to consumers and intermediate parties up the chain. In contrast, as discussed above, the general waiver provision, in conjunction with the prohibitions and penalties imposed by the volume requirements, explicitly focuses solely on an upstream input—renewable fuel—and the upstream parties who acquire it—the refiners and other obligated parties. Because there are no distribution or infrastructure barriers that prevent biofuel producers from delivering their product to obligated parties, production equals supply for purposes of the general waiver.

EPA also points to section 7545(c)(4)(C)(ii), but that provision does not support EPA's interpretation of the general waiver authority either. Section 7545(c)(4)(C)(ii) allows the Administrator to temporarily waive certain prohibitions upon a finding that "extreme and

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131 *Department of Homeland Sec. v. MacLean*, 135 S. Ct. 913, 919 (2015) (quoting *Russello v. United States*, 464 U.S. 16, 23 (1983)) (where statute used the phrase "not specifically prohibited by law" in one place and the phrase "law, *rule, or regulation*" elsewhere, the Supreme Court held that "law" "standing alone" was "meant to exclude rules and regulations").

132 42 U.S.C. § 7545(k)(5).

133 *See, e.g.*, *id.* § 7545(k)(1)(A), (2) & (4).

134 *Id.* § 7545(k)(6)(A)(ii), (B)(i)(I) & (iii) (emphasis added).

135 80 Fed. Reg. at 33,112.

unusual fuel or fuel additive supply circumstances exist in a State or region of the Nation which prevent the distribution of an adequate supply of the fuel or fuel additive to consumers."[136] Here again, Congress has explicitly used the word "distribution" when it meant to account for distribution constraints, unlike in the general waiver provision. In any event, even if section 7545(c)(4)(C)(ii) shows that Congress uses "supply" to include the infrastructure needed to deliver that supply, what would make it reasonable to interpret "supply" in section 7545(c)(4)(C)(ii) to include infrastructure constraints all the way down to consumers is that section 7545(c)(4)(C)(ii) *explicitly says so*: "prevent the distribution of an adequate supply of the fuel or fuel additive *to consumers*." Again, the general waiver provision does not contain such language.[137]

2. EPA's proposed interpretation contravenes the purpose of the RFS program

EPA asserts that "allowing RFS waivers only where there is insufficient 'capacity to produce' renewable fuel would be extremely problematic" because ethanol production capacity exceeds the amount of ethanol currently being consumed and expanding consumption through E15 or E85 would face challenges.[138] EPA believes that "[i]mposing RFS volume requirements on obligated parties without consideration for the ability of the obligated parties and other parties to deliver the renewable fuel to the ultimate consumers would [not] achieve [the RFS programs' desired] benefits and would fail to account for the complexities of the fuel system that delivers transportation fuel to consumers."[139]

EPA's reasoning amounts to a repudiation rather than an interpretation of the statute. A statute must not be "interpret[ed] … to negate [its] own stated purpose[],"[140] but that is precisely what EPA's proposal would do by interpreting the general waiver provision to permit consideration of constraints on the distribution and consumption of transportation fuel (containing renewable fuel) downstream from the obligated parties.[141]

Congress designed the RFS program to stimulate the innovation needed to "increase the production of clean renewable fuels."[142] Congress sought to do this by dictating annual increases in obligated parties' use of various types of renewable fuels, including conventional ethanol-

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[136] 42 U.S.C. § 7545(c)(4)(C)(ii)(I).

[137] EPA also says that the waiver provision is ambiguous because it "does not specify what factors are relevant in determining the adequacy of the supply." 80 Fed. Reg. at 33,111. Of course it does: the availability of renewable fuel to obligated parties, for all the reasons just stated.

[138] *Id.* at 33,112 n.25.

[139] *Id*.

[140] *New York State Dep't of Social Servs. v. Dublino*, 413 U. S. 405, 419-420 (1973).

[141] *See* Energy Policy Act of 2005, Pub. L. No. 109-58, 119 Stat. 594; Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492.

[142] 121 Stat. at 1492.

based fuel, in the preparation of transportation fuel—that is, by mandating increasing demand for renewable fuels. Congress did not design the RFS to wilt in the face of obligated parties' inadequate investment in infrastructure to facilitate the distribution and consumption of more renewable fuel. To the contrary: as EPA knows, Congress was well aware of the E10 blendwall and the associated limitations on the distribution and consumption of blended gasoline when it established the current RFS program in 2007.[143] Fully cognizant of that challenge, Congress deliberately chose to mandate volumes that would require widespread deployment of transportation fuels containing more than 10% ethanol. The self-evident purpose for mandating those volumes was to vault the level of renewable-fuel consumption over obstacles like the E10 blendwall. If Congress were content to stop at the blendwall, it could simply have mandated nationwide E10.

In order to surmount obstacles like the blendwall, the RFS program requires obligated parties to blend a certain amount of renewable fuel and then creates a market mechanism to incentivize obligated parties to find an outlet for the resulting blended transportation fuel. This market mechanism—RINs[144]—is, as the Department of Agriculture has observed, "intended to provide economic incentives to facilitate additional ethanol production and use when the RFS exceeds the market equilibrium"—that is, when the statutory volume requirements exceed the amount that would be blended, distributed, and consumed otherwise.[145] The RIN mechanism would work—if EPA would let it—because, as detailed below, the primary barriers to consuming higher-blend transportation fuel are fundamentally economic.

Higher RIN prices, driven by mandated volumes above the blendwall, would put the necessary pressure on obligated parties to find ways to distribute transportation fuel and to encourage consumers to buy it, lest they be stuck with large inventories. As the D.C. Circuit remarked, "high RIN prices should, in theory, incentivize precisely the sorts of technology and infrastructure investments and fuel supply diversification that the RFS program was intended to

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[143] 80 Fed. Reg. at 33,118 ("At the time EISA was passed in 2007, EIA's Annual Energy Outlook for 2007 projected that 17.3 billion gallons of ethanol is the maximum that could be consumed in 2022 if all gasoline contained E10 and there was no E0, E15, or E85. However, 17.3 billion gallons is far less than the 35 billion gallons of renewable fuel other than BBD that Congress targeted for use in 2022. Thus, if the statutory targets were to be achieved, 17.7 billion gallons of renewable fuel would need to be consumed in 2022 either as higher level ethanol blends (E11-E85), or as non-ethanol fuels.").

[144] *See* 42 U.S.C. § 7545(*o*)(5).

[145] Paul C. Westcott & Lihong L. McPhail, *High RIN Prices Signal Constraints to U.S. Ethanol Expansion*, USDA Econ. Res. Serv., Situation and Outlook No. FDS-13d-SA, at 5 (Apr. 12, 2013), *at* http://www.ers.usda.gov/media/1158986/fds-13d-sa.pdf.

promote."[146] But "large incentives to invest in the infrastructure that can reduce compliance costs can be created *only* if EPA sets mandates at levels that will result in high RIN prices if no investments are made."[147] Those incentives in turn would create pressure for the obligated parties to figure out ways to distribute and sell the necessary inventory of transportation fuel containing higher levels of ethanol or other forms of renewable fuels, including by lowering prices for such fuels relative to E10 in order to encourage consumers to buy more of it. Put simply, higher volume requirements give obligated parties an economic incentive to figure out how to distribute and sell their product. The RFS program thus functions by *creating* demand for renewable fuels, not by reacting to it. Waivers based on inadequate demand for renewable fuels (or transportation fuel downstream) would undermine the entire structure of the RFS program—especially when, as detailed below, sufficient infrastructure to distribute (and consume) levels of transportation fuel commensurate with the statutory volume requirements for renewable fuel could be achieved within 2016 and with modest investment.

By contrast, setting volume requirements based on existing levels of, or capacity for, distribution and consumption of blended transportation fuel, as EPA proposes to do, would perversely reward obligated parties for *refusing* to invest in renewable-fuel distribution infrastructure and for maintaining relatively high retail prices. After all, as EPA said just a few years ago, "[s]takeholders in the refining sector have been aware of the E10 blend wall since passage of EISA in December of 2007."[148] Had stakeholders begun investing in renewable-fuel distribution infrastructure in 2007, when the statutory volumes were enacted, in anticipation of

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[146] *See Monroe Energy*, 750 F.3d at 919; *see also* Bruce Babcock, *RFS Compliance Costs and Incentives to Invest in Ethanol Infrastructure*, Iowa State University CARD Policy Brief 13-PB 13, at 12 (Sept. 2013) ("When the mandate is set at a level that is not easily met with existing infrastructure, then the incentive to invest in infrastructure is large."), *at* http://www.card.iastate.edu/publications/dbs/pdffiles/13pb13.pdf; Bruce Babcock & Sebastien Pouliot, *The Economic Role of RIN Prices*, Iowa State University CARD Policy Brief 13-PB 14, at 3 (Nov. 2013) (hereinafter Babcock, *Economic Role of RIN Prices*) ("Because high RIN prices imply high compliance costs," higher mandates "create a large incentive to lower compliance costs."), *at* http://www.card.iastate.edu/publications/dbs/pdffiles/13pb14.pdf; Jonathan Coppess, *EPA Doubles Down on Questionable Reading of the RFS Statute*, Farmdoc Daily No. (5):108, at 2 (June 11, 2015) ("The RFS is a technology-forcing mandate…."), http://farmdocdaily.illinois.edu/pdf/fdd110615.pdf.

[147] Babcock, *RFS Compliance Costs and Incentives to Invest in Ethanol Infrastructure*, *supra* note 146, at 14 (emphasis added); *see also* Bruce Babcock & Sebastien Pouliot, *How Much E85 Can Be Consumed in the United States?*, Iowa State University CARD Policy Brief 13-PB 15, at 5 (Nov. 2013) ("Whether investment in E85 fueling infrastructure actually occurs depends on whether EPA sets biofuel mandates at levels that can be met only by increasing the amount of ethanol that is sold in E85."), *at* http://www.card.iastate.edu/publications/dbs/pdffiles/13pb15.pdf; *see also* Babcock, *Economic Role of RIN Prices*, *supra* note 146 at 4 (high RIN prices drive obligated parties to reduce compliance costs by investing "in E85 and E15 infrastructures, which, in turn, would allow for the higher future biofuel consumption levels that are envisioned in current policy.").

[148] EPA, *Notice of Decision Regarding Requests for a Waiver of the Renewable Fuel Standards*, 77 Fed. Reg. 70,752, 70,773 (Nov. 27, 2012) ("*Decision for RFS Waiver*").

the day when the statutory volume requirement would exceed the E10 blendwall, there would be no blendwall problem today. The challenges EPA cites as a basis for its waiver are almost entirely of obligated parties' own making, as they have spent years dragging their feet and refusing to invest in renewable-fuel distribution infrastructure precisely to try to entrench the E10 blendwall in hopes that EPA would waive the volume requirements.[149] Again, EPA recognized this not long ago: "The affected industries have had and continue to have the ability to achieve widespread adoption of E85 through working with partners in the retail and terminal infrastructure sectors to increase the number of stations that offer E85 or other intermediate ethanol blends and improve the pricing structure relative to E10."[150] All that has changed since then is that EPA now proposes to reward the oil industry's strategic recalcitrance, thwarting Congress's plan and depriving the Nation of the numerous substantial benefits that the RFS program could provide, including environmental benefits that EPA has already assumed, as discussed below. EPA suddenly treats this as a regrettable happenstance,[151] but as EPA well knows, it is no accident. EPA's market signals through this and its prior RFS proposal, along with obligated parties' refusal to prepare for the E10 blendwall, have brought us to this point.

Congress designed the RFS program to motivate obligated parties to invest in biofuel infrastructure, not to protect the status quo. EPA therefore should not—indeed, cannot—interpret "supply" in the general waiver provision to encompass constraints on the distribution and consumption of blended transportation fuel.

3. The legislative history makes clear that "supply" means the amount of renewable fuel available to obligated parties

The legislative history confirms that the general waiver authority may be invoked only when the amount of renewable fuel is inadequate for obligated parties to meet their volume obligations. Congress in fact specifically removed distribution capacity from the trigger for the general waiver authority, foreclosing any interpretation that would restore it.

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[149] *See, e.g.*, *infra* pp.49-50; *infra* n.337; *see also* Renewable Fuels Association, *Protecting the Monopoly: How Big Oil Covertly Blocks the Sale of Renewable Fuels* (July 2014) ("*Protecting the Monopoly*"), *at* http://www.ethanolrfa.org/page/-/Protecting%20the%20Monopoly.pdf?nocdn=1; Bruce Babcock & Sebastien Pouliot, *Feasibility and Cost of Increasing US Ethanol Consumption Beyond E10*, CARD Policy Brief 14-PB 17, at 2, 13 (Jan. 2014) (estimating that by investing $65 million to equip 500 more stations to dispense E85, oil companies could have reduced the value of RINs needed for RFS compliance by more than $7 billion"), *at* http://www.card.iastate.edu/publications/dbs/pdffiles/14pb17.pdf; Letter from Bob Dineen, President and CEO, Renewable Fuels Association, to Robert Perciasepe, Acting Administrator, U.S. Environmental Protection Agency (Mar. 19, 2013) (describing Conoco-Phillips retaliation against franchisee for offering E15), *at* http://ethanolrfa.org/page/-/PDFs/RFA%20Zarco%20Letter%203-19-13.pdf?nocdn=1.

[150] 77 Fed. Reg. 70,752, 70,773 (Nov. 27, 2012).

[151] *E.g.*, 80 Fed. Reg. at 33,114 ("it is nevertheless the case as of today that there are a limited number of fueling stations selling high-ethanol blends, and as a result, the number of stations operates as a constraint on how much ethanol can be delivered").

The version of the amendment that was passed in the House would have permitted waivers "based on a determination by the Administrator ... that there is an inadequate domestic supply *or distribution capacity* to meet the requirement."[152] But during Conference, the reference to "distribution capacity" was excised, and Congress passed the bill as amended and the President signed it without that phrase. EPA dismisses this history as "uninformative,"[153] but Supreme Court precedent instructs otherwise: "drafting history showing that Congress cut out [specific] language … from the final statute … precludes any hope of a sound interpretation of" of the statute that would in effect restore the "trimmed" language.[154] The history of the statute therefore shows that Congress specifically intended that "supply" in the general waiver provision not encompass distribution capacity. EPA is not free to countermand Congress by adding "distribution capacity" back in through other linguistic means.

Still, EPA argues that Congress's choice to exclude "distribution capacity" from the general waiver provision was intended to communicate that EPA would be permitted but not required to consider distribution capacity when assessing whether "supply" was adequate. That argument strains common sense, especially in the face of the various statutory provisions distinguishing between supply and distribution capacity noted above. Congress could have given EPA discretion to consider distribution capacity simply by using the word "or," as in: "inadequate domestic supply *or distribution capacity*." In fact, Congress did exactly that in section 7545(m)(3)(C), as discussed above. Or Congress could have written, "inadequate domestic supply and, if appropriate, distribution capacity." Indeed, the reasonable possibilities are innumerable, but the language Congress actually used in the general waiver provision is not among them.

B. There Is Adequate Supply Of Renewable Fuels To Meet The Statutory Requirements Reduced No Further Than The Proposed Cellulosic Waiver Flow-Through In 2014-16

There is more than enough supply of renewable fuels for obligated parties to meet the renewable fuels volume requirements in 2014, 2015, and 2016 without a general waiver. Below, we consider only the domestic production capacity for two categories of renewable fuel: ethanol and biomass-based diesel (both biodiesel and renewable diesel). Were we to consider other categories of renewable fuel, such as biogas, or to consider imports of renewable fuel, the supply of renewable fuel would be markedly higher.[155]

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[152] H.R. 6, 109th Cong. § 1501(a), at 710 (engrossed Apr. 21, 2005) (emphasis added).

[153] 80 Fed. Reg. at 33,113.

[154] *Doe v. Chao*, 540 U.S. 614, 622-623 (2004).

[155] For example, EPA projects 0.173 bil gal in non-ethanol cellulosic biofuels in 2016. 80 Fed. Reg. at 33,128, Table II.D.2-2 n.a. Stratas Advisors estimates, using conservative historical data after expiration of the biodiesel tax incentive, that an amount of biodiesel sufficient to support about 0.748 bil RINs could readily be imported, given appropriate RIN incentives. Stratas Advisors, *Non-Ethanol Potential for RFS Compliance*, at 9 (July 16, 2015) ("Stratas Report") (attached as Exhibit 2). Stratas Advisors further estimates that an amount of renewable diesel sufficient to support about 0.742 bil RINs could readily be imported. *Id.* at 9-10.

1. Ethanol supply

According to the Renewable Fuels Association, domestic ethanol production capacity was 14.8795 bil gal per year ("bgy") as of January 2014, 15.077 bgy as of January 2015, and 15.401 bgy as of July 1, 2015.[156] EIA reports that U.S. fuel ethanol plant production capacity was only 13.681 bgy as of January 1, 2014, and 14.575 bgy as of January 1, 2015.[157] But EIA's 2014 capacity figure (at a minimum) is patently too low because it was exceeded by *actual* production. EIA reports that the average weekly U.S. oxygenate plant production of fuel ethanol was 0.919 mil barrels per day as of January 3, 2014, which annualizes to 14.088 bgy, 0.949 mil barrels per day as of January 2, 2015, which annualizes to 14.548 bgy, peaked at 0.994 mil barrels per day as of June 19, 2015, which annualizes to 15.238 bgy, and was 0.984 mil barrels per day as of July 10, 2015, which annualizes to 15.085 bgy.[158] There is no reason to believe that ethanol production capacity would be lower in 2016 than it is today.

These figures are summarized in Table 4.

Table 4: U.S. Ethanol Production Capacity

Source	January 2014	January 2015	June 2015	July 2015
RFA U.S. ethanol production capacity	14.8795	15.077	N/A	15.401
EIA U.S. fuel ethanol plant production capacity	13.681	14.575	N/A	N/A
EIA annualized average weekly U.S. oxygenate plant production of fuel ethanol	14.088	14.548	15.238	15.085

All numbers in billions of gallons per year

2. Biomass-based diesel supply

EPA states that registered biodiesel production capacity is "about 2.8 billion gallons,"[159] which could generate 4.2 bil RINs.[160] Similarly, *Biodiesel Magazine* reports that biodiesel

[156] Renewable Fuels Association, *Historic U.S. Fuel Ethanol Production*, *at* http://www.ethanolrfa.org/pages/statistics; http://www.ethanolrfa.org/bio-refinery-locations.

[157] *See* U.S. EIA, *U.S. Fuel Ethanol Production Capacity Archives*, at http://www.eia.gov/petroleum/ethanolcapacity/archive/2014/index.cfm (2014 data); http://www.eia.gov/petroleum/ethanolcapacity/ (2015 data).

[158] *See* U.S. EIA, *Weekly U.S. Oxygenate Plant Production of Fuel Ethanol*, *at* http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPOOXE_YOP_NUS_MBBLD&f=W.

[159] 80 Fed. Reg. at 33,116. EPA notes that there may be up to 0.800 bil gal of additional biodiesel capacity at *unregistered* facilities. *Id.* Because our capacity analysis does not account for unregistered facilities, to the extent that those facilities could register in time to yield RINs in 2016, our analysis is conservative.

[160] "Each gallon of biodiesel generates 1.5 RINs due to its higher energy content per gallon than ethanol." *Id.* at 33,132 n.86.

production capacity is 2.796 bgy.[161] And a recent report by Stratas Advisors concluded that maximum biodiesel production capacity is sufficient to generate about 4.140 bil RINs.[162] These levels have been steady throughout 2014 and 2015, and there is no reason to believe they would decline in 2016.[163]

EPA provides no reason that production could not reach these levels. EPA previously and correctly recognized that it is "relatively straightforward for much of the current unused capacity to be brought on line, something we believe will occur once sufficient incentive is put in place, such as the combined … volume requirement in this rule."[164] EPA further recognized at that time that "wide swings in production can occur extremely rapidly" and "[b]iodiesel plants have the ability to restart rapidly as evidenced by the long history of facilities shutting down temporarily and then starting back up again when economic conditions improve."[165] The same is true today.[166]

EPA also alludes to a need to secure sufficient feedstocks, but the proposal does not indicate this would be a problem.[167] Just the opposite. The proposal states that "[t]he combined volumes of soybean oil, corn oil, and waste oils produced annually is *far more than would be needed* to produce 2.1 billion gallons of biodiesel."[168] The proposal explains that "[i]t is possible that the market could divert additional feedstocks from food and other domestic uses or exports to the production of biodiesel. For instance, in 2014 exports of soy oil were 250 million gallons and exports of rendered fats and greases were 440 million gallons."[169] Further, according to a report by Stratas Advisors, over 100 domestic and foreign biodiesel plants are "grandfathered" to allow production of RINs from a wider source of sustainable feedstocks.[170] And a recent

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[161] *See* Biodiesel Magazine, USA Plants, http://biodieselmagazine.com/plants/listplants/USA/ (last accessed July 25, 2015).

[162] Stratas Report at 15 (attached as Exhibit 2).

[163] 80 Fed. Reg. at 33,128 n.72.

[164] *See* EPA, "Renewable Fuel Standard Program (RFS2) Summary and Analysis of Comments," at 3-187 (Feb. 2010), *at* http://www.epa.gov/otaq/renewablefuels/420r10003.pdf.

[165] *Id.* at 3-189.

[166] For this reason, EPA correctly did not limit itself to EIA's calculation that as of March 2015, biodiesel operating capacity was 2.125 bgy. *See* http://www.eia.gov/biofuels/biodiesel/production/table4.pdf; *see also* Stratas Report at 6 (attached as Exhibit 2). There is every reason to believe the registered capacity is available.

[167] 80 Fed. Reg. at 33,116.

[168] *Id.* at 33,128 (emphasis added).

[169] *Id.*

[170] Stratas Report at 7 (attached as Exhibit 2).

analysis by LMC International Ltd. found that available qualifying feedstocks in 2015 are equivalent to *7.6 bil gal* of biodiesel.[171]

In addition, domestic production capacity of renewable diesel is capable of generating about 0.362 bil RINs per year, according to Stratas Advisors.[172] According to EPA, in 2014 renewable diesel generated 0.269 bil RINs.[173]

Therefore, there is sufficient BBD production capacity to generate between 4.409 bil RINs (4.14 bil from biodiesel and 0.269 bil from renewable diesel) and 4.562 bil RINs (4.2 bil from biodiesel and 0.362 bil from renewable diesel).

3. Renewable fuel supply is sufficient to meet statutory levels after the cellulosic waiver flow-through

Whether the top end or the bottom end of the production capacity ranges described above are considered, the combined production capacity of ethanol and BBD is plainly substantial and far higher than EPA's proposal expects. And EPA cannot use its general waiver authority to reduce volume requirements below the level of supply. But the fact that that combined capacity might not quite reach the statutory renewable fuel volumes does not mean EPA may invoke its general waiver authority to reduce them. In particular, given the supply of renewable fuel, EPA lacks authority to waive the renewable fuel volume requirements further than the cellulosic waiver flow-through would support alone.

As described above, EPA has exercised its cellulosic waiver authority based on the supply of cellulosic biofuels, and it has decided to partially flow that waiver through to the advanced biofuel and renewable fuels volume requirements. The statutory renewable fuel volume requirements, after being reduced by EPA's proposed cellulosic waiver flow-through, are 17.08 bil gal for 2014, 17.90 bil gal for 2015, and 18.40 bil gal for 2015.[174] If EPA maintained these cellulosic waiver flow-throughs, the combined production capacity of ethanol and BBD alone would be more than enough to meet the adjusted volume requirements.[175] In fact, even in the worst case, supply would suffice to support 1 bil RINs in excess of these requirements. Consequently, EPA lacks the power to invoke its general waiver authority to

[171] Testimony of Andrea Kavaler, LMC International Ltd., EPA-HQ-OAR-2015-0111-0993 (June 25, 2015).

[172] Stratas Report at 15-16 (attached as Exhibit 2).

[173] 2014 RIN Supply, EPA-HQ-OAR-2015-0111-0004.

[174] As explained above, EPA proposed to reduce the cellulosic requirement by 1.717 bil gal in 2014, 2.894 bil gal in 2015, and 4.044 bil gal in 2015, but to flow that waiver through only by 1.070 bil gal in 2014, 2.600 bil gal in 2015, and 3.850 bil gal in 2016. *See* 80 Fed. Reg. at 33,122.

[175] We assume for purposes of this comment that EPA performed its projection calculations properly when calculating the cellulosic waiver. If we discover that EPA made errors in this assessment, we reserve the right to object to the cellulosic waiver at a later time.

reduce the renewable fuel volume requirements for 2014-2016 further than it proposes to do by flowing the cellulosic waiver through. Table 3 summarizes this analysis.

Table 3: Supply to Meet Renewable Fuel Volumes After Cellulosic Waiver Flow-Through					
	Ethanol	**BBD**	**Total**	**Statutory After Cellulosic Flow-Thru**	**Excess RINs**
2014					
Maximum	14.8795	4.562	19.4415	17.080	2.3615
Minimum	13.681	4.409	18.090	17.080	1.010
2015					
Maximum	15.077	4.562	19.639	17.900	1.739
Minimum	14.548	4.409	18.957	17.900	1.057
2016					
Maximum	15.238	4.562	19.800	18.400	1.400
Minimum	15.085	4.409	19.494	18.400	1.094

All numbers in billions of RINs

V. EVEN IF EPA'S INTERPRETATION OF THE GENERAL WAIVER PROVISION WERE VALID, EPA COULD NOT INVOKE THAT AUTHORITY TO REDUCE THE RENEWABLE FUEL VOLUME REQUIREMENTS FURTHER THAN THE PROPOSED CELLULOSIC WAIVER FLOW-THROUGH BECAUSE SUPPLY WOULD STILL BE ADEQUATE

As discussed above, EPA believes that "factors that limit supplying [renewable fuels] to vehicles that can consume them," not just "limitations in production or importation of qualifying renewable fuels, … constitute circumstances that warrant a waiver."[176] In EPA's view, such factors include the blendwall, the number and distribution of retail stations offering the fuel, and the number of vehicles qualified to consume the fuel, among others.[177] We explained above why EPA's interpretation of the general waiver provision is impermissible. In this Part, we *assume* that it is permissible, and then show that even still, "supply" so construed—again focusing only on ethanol and BBD—is adequate to reach the statutory renewable fuel volume requirements for 2014-2016, at least after the proposed flow-through of the cellulosic waiver. EPA, therefore, again lacks authority to exercise its general waiver authority to further reduce the renewable fuel volume requirements.

[176] 80 Fed. Reg. at 33,109-33,110.

[177] *Id.* at 33,109.

A. Existing Infrastructure Could Support Substantially More Distribution And Consumption Of E85

EPA asserts that 100-600 mil gal of ethanol could be distributed and consumed as E85 in 2016.[178] EPA offers no quantitative evidence or analysis supporting those numbers. They appear to have been pulled out of thin air. Vastly more robust analyses, described below, show that existing infrastructure could enable between 1 bil gal and 2.15 bil gal of ethanol to be distributed and consumed as E85 over the course of next year.

EPA focuses on the number of FFVs that can access them and the number of stations dispensing E85. EPA assumes that there were about 14 million FFVs in the fleet in 2014, and that this will grow to about 16 million FFVs in 2016, though there is evidence that there could already be as many as 17.4 million FFVs on the road today.[179] And EPA assumes that there are about 3,000 E85 stations nationwide.[180] That is reasonable, as other sources provide similar estimates.[181] Although that means that only about 2 percent of stations offer E85, EPA correctly recognizes that "the fraction of FFVs with access to E85 is higher than 2% since the vast majority of vehicles are within reasonable range of more than one retail station on typical trips."[182]

EPA makes no effort, however, to then estimate the actual proportion of FFVs with access to E85. It notes that *if* that number is 5%, then 800 mil gal of E85 could be consumed under favorable pricing conditions.[183] EPA does not explain its choice of 5%; the number appears to be entirely arbitrary. It also appears irrelevant to EPA's analysis, because EPA immediately proceeds to assert that "it is possible for the market to reach volumes perhaps as high as *600* million gallons under favorable pricing conditions."[184] But EPA does not stop there, spinning out a series of hypothetical scenarios in which between 200 and 600 mil gal of E85 are consumed in 2016.[185] These scenarios equate to merely 66 million to 400 mil gal of incremental

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[178] *Id.* at 33,127-33,128.

[179] *Id*. at 33,121, 33,128 & n.71; *see also* Air Improvements Resource, Inc., *Analysis of Fleet Percentage of 2001+ Model Year Group In Calendar Years 2014, 2015, and 2016*, at 4 (July 27, 2015) ("AIR, *Analysis of Fleet 2001+ Model*") (attached as Exhibit 3).

[180] 80 Fed. Reg. at 33,121 (citing Alternative Data Fuels Center); *see also* 2013 Notice of Proposed Rulemaking E85 Memorandum at 3 (relying on e85prices.com).

[181] Relying on 2013 data from e85prices.com (a source on which EPA has previously relied), Babcock and Pouliot based their analysis on 3,072 stations E85 stations. *See* Babcock & Pouliot, *Price It and They Will Buy, supra* note 11, at 10. E85prices.com now states that there are 3,173 E85 stations.

[182] 80 Fed. Reg. at 33,128.

[183] *Id.*

[184] *Id.*

[185] *See id.*

ethanol being consumed through E85 in 2016.[186] EPA does all this without any analysis whatsoever of why 600 mil, 100 mil, or any other volume is the *right* projection, and does not even explain what kind of uncertainty is driving EPA to suggest that there is a range of possible volumes that could be distributed. This is the epitome of arbitrary and capricious action.

The only analyses that could possibly support EPA's levels are those rooted in historical consumption of E85. EPA purports to recognize that historical consumption is an improper basis for this analysis, stating that EPA is required to "envision[] growth in supply beyond historical levels as envisioned by the statute."[187] Yet, EPA remarks, for example: "The fact that the market only achieved about 130 million gallons of E85 in 2013 despite substantial increases in the production and import of non-ethanol blends and the substantial draw-down in the bank of carryover RINs indicates that E85 consumption was constrained," and "a similar situation existed in 2014."[188] EPA's reasoning is fallacious. That market participants decided to draw down banked RINs instead of selling more E85 demonstrates only that at actual RIN price levels, E85 has not been priced at parity with E10 on an energy-equivalent basis. Thus, "[h]istorical consumption of E85 provides a poor predictor of the level of possible consumption because the price of E85 has never been low enough to save owners of flex vehicles money."[189] EPA describes the "poor pricing of E85 relative to E10" as a "constraint[]."[190] It is not; rather, it is an economic consequence of, in part, EPA's failure to set appropriately high renewable fuel volume requirements, as Congress intended.

Nor does EPA explain why it abandoned the approach it took in November 2013 to answer this same question. There, EPA estimated "the fraction of FFVs that have access to E85" to be 8.6%, based on the notion that it would be reasonable to assume that an FFV had access to E85 if one out of four stations near it offered E85.[191] This led EPA to determine that 1.3 bil gal of E85 could be consumed per year (containing 860 mil gal of ethanol)—more than *double* the

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[186] *Id.* at 33,116 n.39 (calculating that it takes 1.51 gallons of E85 to equal one incremental gallon of ethanol in E85).

[187] *Id.* at 33,118.

[188] *Id.* at 33,120.

[189] Babcock & Pouliot, *Feasibility and Cost of Increasing US Ethanol Consumption Beyond E10*, *supra* note 149, at 1.

[190] 80 Fed. Reg. at 33,120.

[191] Memorandum from David Korotney to EPA Air Docket EPA-HQ-OAR-2013-0479, "Application of one-in-four E85 access methodology to 2014," at 5 (Nov. 21, 2013) ("EPA 2013 E85 Memorandum"). EPA further assumed in this analysis that "the geographic distribution of FFVs is consistent with the geographic distribution of service stations." *Id.* at 1.

high-end of the range it uses now.[192] Where did all that E85 distribution capacity go? EPA does not say, which is especially perplexing given that, as EPA itself notes, "[s]ince 2013, the number of FFVs in the fleet and the number of retail stations offering E15 and E85 have grown."[193]

Although EPA's 2013 methodology is better than its current methodology, it too is deficient. For one thing, as we explained in our prior comments, "a driver has access to E85 [so] long as he or she has access to a single E85 station," not whether one in four nearby stations have E85.[194]

A better model that has long been available to EPA would be that of Professors Bruce Babcock and Sebastian Pouliot. They addressed with precision the question of how much E85 could be distributed to FFVs given current infrastructure.[195] Cross-correlating a database of FFV registrations by zip code with a database of E85 stations by zip code, they found that 55% of FFVs were within ten miles of an existing E85 station.[196] Using this ten-mile radius and assuming that each E85 station could dispense no more than 45,000 gal per month, Babcock and Pouliot calculated that with existing infrastructure and adequate pricing, about 1 bil gal of ethanol would be consumed via about 1.2-1.3 bil gal of E85 per year.[197] And if each station could dispense 90,000 gal per month, then about 1.8 bil gal of ethanol would be consumed via about 2.4 bil gal of E85 per year.[198] Although Babcock and Pouliot's analysis was conducted in 2013, their model valid and their results, if anything, understate the amount of E85 that could be

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[192] *See id.* at 5. Although EPA calculated this number in 2013 as available distribution capacity, it then discounted this figure significantly because it was improperly seeking to project how much E85 would be consumed without the mandate. *See* 78 Fed. Reg. at 71,762 (calculating "proposed mean volume of 180 mill gal for E85"). EPA now admits that this discounting was erroneous, *see* 80 Fed. Reg. at 33,117 (recognizing that "the approach we took in the November 2013 NPRM underestimated achievable volumes"). But rather than following the natural result of this concession and using its previously calculated 1.3 bil gal distribution capacity, it now simply ignores that it ever calculated this number at all.

[193] 80 Fed. Reg. at 33,121.

[194] Growth Energy Prior Comments on 2014 RFS at 28.

[195] *See* Babcock & Pouliot, *Price It and They Will Buy*, *supra* note 11; Bruce A. Babcock and Sebastien Pouliot, "Impact of Sales Constraints and Entry on E85 Demand" (Aug. 2013), *at* http://www.card.iastate.edu/publications/dbs/pdffiles/13pb12.

[196] *See* Babcock & Pouliot, *Price It And They Will Buy*, *supra* note 11, at 9-10 (calculating that 8 million out of 14.6 million FFVs at the time were located in zip codes with a geographic center within 10 miles of an E85 station).

[197] Babcock & Pouliot, "Impact of Sales Constraints and Entry on E85 Demand," *supra* note 195, at 3; Babcock & Pouliot, *Feasibility and Cost of Increasing US Ethanol Consumption Beyond E10*, *supra* note 149, at 5. Conversion to 1.33 bil gal of E85 uses Babcock's assumption that E85 contains 75% ethanol. Babcock & Pouliot, "Impact of Sales Constraints and Entry on E85 Demand," *supra* note 195, at 5 n.6.

[198] Babcock & Pouliot, "Impact of Sales Constraints and Entry on E85 Demand," *supra* note 195, at 3.

distributed in 2016. Again, according to EPA, "[s]ince 2013, the number of FFVs in the fleet and the number of retail stations offering E15 and E85 have grown."[199] Indeed, whereas Babcock and Pouliot relied on a database indicating that there were 14.6 million FFVs as of January 2013,[200] as discussed above, there will be at least 16 million FFVs, and possibly more than 17.4 million FFVs, on the road in 2016.

A more recent analysis by Stillwater Associates, a respected transportation fuel consultancy, confirms Babcock and Pouliot's assumption that a station could dispense 45,000 gal of E85 per month. In fact, Stillwater's analysis shows this to be a conservative assumption. Stillwater explains that the 45,000 figure is very close to the amount supported by a *single* dispenser using the standard rule of thumb in the industry for the relationship between dispensers and total gasoline sales.[201] In other words, assuming conservatively that every E85 station has just one E85 dispenser, the 45,000 gal per month throughput would simply mean that this E85 dispenser would be as active as any other E10 dispenser in the station. Treating the *average* E10 dispenser's throughput as the *maximum* throughput of an E85 dispenser renders Babcock and Pouliot's analysis extremely conservative.

Stillwater also prepared a realistic estimate of the maximum amount of fuel that an E85 dispenser could feasibly deliver to customers, assuming that RFS obligations are properly calibrated to ensure that E85 is priced at attractive levels. To conduct this analysis, Stillwater made several reasonable and even conservative assumptions: that each E85 station only has one dispenser with two hoses offering E85; that the average customer fill-up is for 12 gallons, that customers can fill up at only 3 gal per minute; that the transition from one car to the next would take minutes; and that higher concentrations of customers fill up during peak hours.[202] Stillwater concluded that not only is Babcock and Pouliot's upper throughput assumption of 90,000 gal per month per dispenser reasonable, but in fact a single E85 dispenser could feasibly dispense up to 115,000 gal per month—more than 2.5 times Babcock's base assumption.[203]

Taking this throughput and confirmation of Babcock and Pouliot's basic assumption, Stillwater then calculated independently the incremental amount of ethanol that could be consumed given existing E85 infrastructure. Adopting EPA's assumption that there are 3,000 existing E85 stations, assuming that E85 has "an average ethanol concentration of 74 percent,"[204] and accounting for the displacement of E10, Stillwater determined that, if station throughput is 45,000 gal per month, the stations could supply an additional 1.08 bgy of ethanol via E85. Moreover, a recent economic analysis concluded that under these circumstances, D6 RIN prices

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[199] 80 Fed. Reg. at 33,121.

[200] *See* Babcock & Pouliot, *Price It And They Will Buy*, *supra* note 11 at 9.

[201] Stillwater Associates, *Infrastructure Changes and Cost to Increase RFS Ethanol Volumes through Increased E15 and E85 Sales in 2016*, at 12 (July 27, 2015) ("Stillwater Study") (attached as Exhibit 4).

[202] *Id.* at 11.

[203] *Id.* at 11.

[204] *Id.* at 9.

would increase by only about $1.45.[205] Stillwater further found that if station throughput is 90,000 gal per month, the stations could instead supply an additional 2.15 bgy of ethanol via E85.[206]

Stillwater also analyzed the supply chain for E85 and found no bottlenecks. E85 tanks are typically 8,000 to 12,000 gallon capacity.[207] Stations generally receive new deliveries of fuel on a daily basis, and can receive multiple deliveries in a single day when needed.[208] Even assuming a smaller E85 tank, a station receiving a single delivery each day could potentially receive 240,000 gal per month of E85 (8,000 gallons per day times 30 days), which is far more than needed under Babcock and Pouliot's or Stillwater's analysis. This increased consumption of E85 would "have little impact on the distribution system."[209]

In short, EPA's estimate for how much E85 could be distributed to consumers is fundamentally flawed and facially unreasonable. Even the most conservative defensible estimate establishes that, using existing infrastructure, more than 1 bil gal of additional ethanol could be distributed and consumed via E85 annually, and a more realistic estimate indicates that that figure could be more than 2 bil gal.

B. Infrastructure Could Readily Be Expanded To Support Even More Consumption Of E85 In 2016

In addition to the volumes that could be delivered to FFVs using existing infrastructure, the Stillwater study further explains how the industry is more than capable of quickly and cost-effectively growing infrastructure. This additional infrastructure could provide another path to achieving substantially greater consumption of ethanol as E85 in 2016, even taking into account that EPA will not finalize this rule until November 30, 2015.

There are two principal paths by which E85 infrastructure could be expanded: (1) adding a second E85-capable dispenser to existing E85 stations or (2) adding an E85-capable dispenser to stations that do not currently offer E85. Given the distribution and consumption capacity of existing infrastructure, as explained above, this expansion is unnecessary to achieve high volumes of additional E85 consumption in 2016. But these expansion options provide another path to achieving such volumes, and EPA's failure to consider their feasibility further underscores the unreasonableness of EPA's proposed requirements.

Adding an E85 dispenser to an existing E85 station requires minimal investment. Because the station already has an existing E85 tank, there would be no work underground, and all the necessary piping is in place.[210] Rather, all that would be necessary is replacing an existing

[205] *Impact on Motor Fuel Prices* at 5 (attached as Exhibit 1).

[206] Stillwater Study at 9, 12 (attached as Exhibit 4).

[207] *Id.* at 6.

[208] *Id.* at 16.

[209] *Id.* at 16.

[210] *Id.* at 13.

E10 dispenser with an E85-compatible dispenser (which could be used for E10 if later desired). An E85-compatible dispenser on its own costs $15,000 to purchase and install.[211] For an additional cost, the station could instead install a blender pump, giving it the ability to sell intermediate blends such as E15 or E30 as well.[212]

If the station does not currently offer E85, then in addition to replacing the dispensers it would have to do some modest underground work. Generally, this work would involve cleaning one of the station's E10 tanks, and then replacing certain piping equipment that may not be compatible with E85.[213] Most stations will have no problem using one of their current E10 tanks for E85.[214] At least 50% of stations have at least 3 gasoline tanks, and a number have even 4.[215] Just one would need to be compatible with E85, and virtually all tanks are: all steel tank manufacturers as well as the Steel Tank Institute have affirmatively stated that their tanks are compatible with any ethanol blend up to E100.[216] Among fiberglass tanks (the other type besides steel), double-walled fiberglass tanks built since 1990 can handle up to E100, as can single-walled fiberglass tanks built since 2005.[217] Stillwater estimates the total conversion cost to start offering E85, including installation of the dispenser, to be approximately $30,000.[218]

As Stillwater explains, implementation of this infrastructure expansion could be made faster and more cost-effective by taking advantage of the industry practice of replacing dispensers every seven years.[219] First, the cycle provides the opportunity to substantially reduce the incremental costs of the dispenser replacement: obtaining an E85-compatible dispenser would cost the station just the incremental $5,000 over the $10,000 the station was going to pay anyway for an E10 dispenser.[220] And second, the cycle dramatically increases the ability of the industry to make these changes rapidly. With approximately 155,000 stations nationwide,[221] over 22,000 stations are upgrading every year, and nearly 2,000 stations are upgrading every month. The several thousand stations that will be upgrading in December 2015 and the early

[211] *Id.* at 12.

[212] *Id.* at 29.

[213] *Id.* at 14.

[214] *Id.* at 13.

[215] *Id.* at 29. Though the oil industry speciously claims that expanded E85 can come only at the expense of premium and midgrade gasoline, Stillwater's analysis demonstrates that this is inaccurate. A station only needs 3 gasoline tanks to offer all grades of E10 and E85 because the midgrade E10 can be blended between the regular and premium tanks in the dispenser itself. There are more than enough stations out there with adequate gasoline tanks.

[216] NREL E15 and Infrastructure (http://www.nrel.gov/docs/fy15osti/64156.pdf) at 24.

[217] NREL E15 study at 24 & Appendix C.

[218] Stillwater Study at 14 (attached as Exhibit 4).

[219] *Id.* at 12.

[220] *Id.*

[221] *Id.* at 9.

months of 2016 will be ideal candidates for rapid expansion of E85 infrastructure in response to EPA's enforcement of the RFS. These stations are already planning for the business interruption and will be hiring contractors that can do the necessary work.

Accordingly, taking advantage of this upgrade cycle, Stillwater explains that by phasing in a second E85 pump at about 2,629 existing E85 stations over the course of 2016, enough E85 could be dispensed for 1.52 bil gal of ethanol to be consumed beyond the blendwall, at a total cost of just $35.1 mil.[222] Stillwater's scenario analysis assumes conservatively that throughput is just 45,000 gal per month per dispenser. With that same assumption, Stillwater also finds that by adding a second E85 pump at existing E85 stations that would be replacing a pump anyway according to the seven-year cycle and also phasing in an E85 pump at about 4,150 stations that do not yet offer it over the course of 2016, enough E85 could be dispensed for 1.84 bil gal of ethanol to be consumed beyond the blendwall, at a total cost of $126.6 mil.[223] Stillwater conservatively assumed that preparatory work, such as engineering, hiring contractors, and ordering equipment would occur in December 2015 and January 2016, and that the new dispensers would not come online until February 2016.[224] Finally, building on these assumptions, Stillwater considered a hybrid case, with the same number of stations bringing a new E85 pump online, but this time at both existing and new E85 stations; this scenario yields 1.84 bil gal of ethanol that can be consumed beyond the blendwall, at a total cost of just $93.6 mil.[225] Even at that high level of E85, only about half of the fuel usage by FFVs within 10 miles of an E85 station would need to be E85 to consume it.[226]

These infrastructure costs are exceedingly minor in light of the amount of renewable consumption that they support. For example, in Stillwater's hybrid case, the expanded infrastructure costs $93.6 mil for an additional 760 mil gal of annual production (1.84 bil minus 1.08 bil).[227] That's roughly $0.12 per annual gallon. But since the infrastructure expansion has value for seven years, this cost should be amortized over sales over that extended period. Moreover, this does not even consider the additional profits that a station would garner by attracting more E85 sales and in-store traffic. In short, stations or obligated parties would need to capture an exceedingly small portion of the RIN price to justify these investments

In fact, there is ample reason to believe that, given this potential, the market already will have a strong head-start on reaching the 1.84 bil gal target before EPA finalizes this rule. Speedway, one of the Nation's largest chains, has stated that it is adding E85 capability in every newly built station and most upgraded stations: it informed Stillwater that they are targeting 275 E85 pumps in 2015 and the same number in 2016.[228] Furthermore, as Stillwater indicates, a

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[222] *Id.* at 13.

[223] *Id.* at 14-15.

[224] *Id.* at 14.

[225] *Id.* at 15.

[226] *Id.* at 16.

[227] *Id.* at 15.

[228] *Id.*

"number of other companies, such as Kum & Go, Kwik Trip, Thorntons, Spinx, Rebel Oil, Break time (MFA), MFA Oil, Meijer Gas, Super Pantry, Bosselman's Pump & Pantry, Kroger, Murphy, Petro Serve USA, and Road Ranger all have significant programs to increase E85 stations, such that E85 will be offered at 18 percent to more than 25 percent of each companies' stations."[229] These convenience store chains offer a particularly strong competitive advantage to grow infrastructure quickly, as they bring economies of scale and can apply the lessons of prior experience to many stations at once.

Further accelerating this investment will be the USDA's Biofuel Infrastructure Partnership grant program. That program will pay up to $100 million in infrastructure costs associated with bringing ethanol blends above E10 to market, including 75% of pump costs and 25% of tank and related equipment costs.[230] Through the industry's "Prime the Pump" initiative, many States have already filed applications for grants under this program. USDA expects to transfer the funding by September 30, 2015, giving plenty of time for these funds to be useful in delivering renewable volumes throughout 2016.

To be sure, one challenge with growing E85 infrastructure is the vise grip that the oil industry has over stations that sell their branded gasoline—approximately half of the stations nationwide.[231] Oil refiners often contractually require distributors to sell only those branded fuels that the refiner produces or makes available, but then the refiners rarely make available branded forms of renewable fuels like E85.[232] Such agreements also typically preclude retailers from offering higher-blend fuels like E85 under the branded canopy or at all.[233] Should a retailer violate the terms of its onerous agreement with an oil company, the penalties are typically severe, including termination of the entire agreement.[234] Thus, as of July 2014, independent or unbranded stations were four to six times more likely to offer E85 than stations carrying a "Big Five" oil brand.[235]

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[229] *Id*. at 15-16.

[230] *See* U.S. Department of Agriculture, "Notice of Funds Availability (NOFA): Biofuel Infrastructure Partnership (BIP) Grants to States," 80 Fed. Reg. 34,363 (June 16, 2015).

[231] *See, e.g.*, Elizabeth Douglas & Gary Cohn, *Refiners Maintain a Firm but Legal Grip on Supplies*, L.A. TIMES, June 18, 2005 ("[D]eclining station count has weakened competition and made it easier for the state's major oil companies to impose their will on gas station owners, down to the profit earned on each gallon sold, dealers contend."), *at* http://www.latimes.com/news/la-fi-calgas18jun18,0,3198403.story?page=1.

[232] *Id.* at 4.

[233] *See* Clean Fuels Foundation, *E85 and Blender Pumps: A Resource Guide to Ethanol Refueling Infrastructure*, at 23 (2011) ("[F]ranchise agreements generally do not allow the sale of ethanol blends other than 10% or 85% by volume."), *at* http://www.ffv-awareness.org/docs/11CFDC-004_Pump_Brochure_Indv.pdf.

[234] Renewable Fuels Association, *Protecting the Monopoly*, *supra* note 149, at 10.

[235] *See id.* at 1. The "Big Five" oil companies are BP, Chevron, ConocoPhillips, ExxonMobil, and Shell.

But these restrictions are certainly no basis on which EPA could grant a general waiver. Congress recognized that higher volume requirements would create the right incentives for the oil industry to ease or eliminate these restraints so that E85 could flow more freely to consumers. EPA therefore has the power to force the change that Congress sought when it enacted the EISA. In any event, because 50% of stations are *not* branded by one of the top fifteen oil refiners,[236] there is plenty of opportunity for independent stations to double E85 capacity without the cooperation of major oil companies.

C. Infrastructure Could Readily Be Expanded To Support Significant Consumption Of E15 In 2016

In 2013, the oil industry told the United States Supreme Court that EPA's authorization to use E15 gave its members "the opportunity—and, in light of the RFS requirements, the obligation—to introduce E15 into their systems to increase the total volume of renewable fuel."[237] Indeed it does. Yet EPA assumes that no meaningful level of E15 could be consumed in 2016 and places no pressure on the industry to change that. EPA says that there are only about 100 stations offering E15, and asserts that "[e]ven if this number grows more quickly in 2015 and 2016 than it did previously, such increases would probably not increase total ethanol consumption by more than 5-10 million gallons in comparison to the use of ethanol in E10."[238] Besides the number of stations, EPA limits E15 potential on the ground that customers with vehicles of model year 2000 or later ("MY2001+") may "be reluctant to use E15 even if legally permitted to do so" because they believe that their engine warranty does not cover using E15 or

[236] NACS, "How Branded Stations Operate," http://www.nacsonline.com/YourBusiness/FuelsReports/GasPrices_2013/Pages/ChallengesRemainBeforeE15UsageIsWidespread.aspx (last visited July 27, 2015).

[237] *See* Pet. for a Writ of Cert., *AFPM v. EPA*, No. 12-1229, at 25-26 (U.S. Apr. 10, 2013).

[238] 80 Fed. Reg. at 33,126.

for other (unstated) reasons.[239] So significant are these constraints in EPA's mind that EPA omits consideration of E15 from its 2016 analysis.[240]

One would naturally then expect to find somewhere in the proposal or EPA's supporting materials, some analysis explaining why the number of E15 stations could not grow significantly in the next year if provided incentive to do so under the RFS program, or a concrete assessment of how many drivers might actually have warranty concerns. Yet, EPA provides nothing of the sort. Rather, EPA takes the 100 stations offering E15 as a *given*, without any justification, and proceeds to estimate how much incremental ethanol would be sold through those same stations.[241] It does this by calculating the average gasoline sales in a station, and then discounting the result by an arbitrarily selected factor of 50% based on the possibility that vehicle owners may nevertheless choose to buy E10, particularly those whose vehicle warranties may not cover E15 usage.[242]

There are numerous flaws with this analysis, not least of which is that it flies in the face of EPA's acknowledgment that "the market is capable of responding to ambitious standards by expanding infrastructure and modifying fuel pricing to provide incentives for the production and use of renewable fuels."[243] Methodologically sound analysis shows in fact that, through infrastructure expansion that could be executed quickly and cheaply, more than 21 bil gal of E15, containing more than incremental 1 bil gal of ethanol over E10, could be distributed in 2016.

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[239] *See* Memorandum from David Korotney to EPA Air Docket EPA-HQ-OAR-2015-0111, "Projection of potential E15 consumption and its impacts on total ethanol consumption," at 3 (June 10, 2015) ("EPA 2015 E15 Memorandum")

[240] EPA considers E15 to be a wash with E0, of which it estimates will reduce ethanol consumption (versus E10) by 13 mil gal in 2016. 80 Fed. Reg. at 33,126. Apart from that, EPA correctly recognizes that E0 poses no meaningful constraint on ethanol consumption. Although the oil industry (taking a page out of its E15 playbook) continues to manufacture concern about damage E10 could do to small engines, in fact that concern does not exist and is unwarranted. Even the Outdoor Power Equipment Institute states that "We pump E10 without a second thought." http://opei.org/power-gear-group-warns-against-high-ethanol-gas-store-signs-highlight-damaging-effects-of-e15-gas-2/. E10 has been used successfully in marine engines for 30 years, being approved for use by numerous popular marine manufacturers. *See* Governors' Biofuels Coalition, *Ethanol Industry Weighs in on API E0 Claims, at* http://www.governorsbiofuelscoalition.org/?p=13412. And as EPA recognized in its E0 docket memorandum, the entire volume of marina gasoline consumption is 250 mil gal per year. "Estimating E0 Volume Sold in U.S. at marinas" Docket Memorandum at 2 [on share drive under supporting materials]. One need not tarry with how much of this is actually E0; even if it all were, this would indicate a microscopic adjustment to total gasoline consumption of 137 bil gal per year, having no effect on the amount of ethanol that can be consumed as E10.

[241] *See* EPA 2015 E15 Memorandum.

[242] *Id*.

[243] 80 Fed. Reg. at 33,108.

1. Distribution constraints

Despite the substantial market uncertainty caused by EPA's failure to promulgate RVOs for 2014 or 2015, the number of stations offering E15 has been growing. In April, Kum & Go, the Nation's fifth largest privately owned and company-managed convenience store chain, announced that it will add E15 to 65 stores across seven states.[244] This followed Sheetz Convenience Stores' announcement that it would add E15 to 60 stores in North Carolina over the next year,[245] and Murphy USA's decision to bring E15 to Chicago and Houston after successful tests in Iowa.[246] In 2014, MAPCO Express, Inc. announced that it would offer E15 at all pumps in 100 locations.[247] EPA's analysis—which appears to have been written in early 2014—discusses the MAPCO expansion but is not updated for the more recent announcements.[248] As with E85, there is simply no room to doubt that the industry could bring even more E15 to market if only EPA would provide the necessary price incentives by implementing the RFS program as Congress intended.

There are two principal paths for expanding the availability of E15, neither of which EPA considers in its proposal: (1) blending E15 at the terminal, or (2) blending E15 at the station. Both can be accomplished quickly and with only modest investment.

The first readily available path for bringing E15 to market would be to start blending it at the terminal. Typically gas stations obtain fuel from a distributor, which in turn buys that fuel at a refining terminal (colloquially, the "rack"). Distributors can purchase E10 from refining terminals, but to our knowledge E15 is not sold in a single terminal anywhere in the country. There is no reason for this limitation, however, apart from the oil industry's efforts to obstruct the expansion of E15. Because the terminal blends the ethanol into the gasoline while it is dispensing the fuel to the tanker truck, a simple change to terminal programming would allow it to increase the blend from 10% to 15%.[249]

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[244] *Kum & Go to Offer E15 Fuel Options in 2015* (Apr. 27, 2015), *at* http://www.kumandgo.com/2015/04/e15-fuel-options/.

[245] *Sheetz to Offer E15 Fueling Option in 2015* (Jan. 20, 2015), *at* http://www.prnewswire.com/news-releases/sheetz-to-offer-e15-fueling-option-in-2015-300023113.html

[246] *Murphy USA Bringing E15, E85 to Chicago & Houston*, CSP net.com, CSP Daily News (Feb. 12, 2015), *at* http://www.cspnet.com/fuels-news-prices-analysis/fuels-news/articles/murphy-usa-bringing-e15-e85-chicago-houston.

[247] Renewable Fuels Association, *Major Breakthrough for E15—MAPCO to Offer E15 in 2014*, *at* http://www.ethanolrfa.org/news/entry/major-breakthrough-for-e15-mapco-to-offer-e15-in-2014/.

[248] The memorandum is undated, but uses data as of February 2014 and discusses what might occur over the course of March to December 2014. *See* EPA 2015 E15 Memorandum at 1.

[249] Stillwater Study at 20 (attached as Exhibit 4).

Once terminals start offering E15—which would happen if EPA actually adhered to the volume requirements mandated by Congress and E15 proved to be a relatively cost-effective means for obligated parties to comply—stations would require very little additional investment to receive and dispense E15. Most stations are already E15-compatible.[250] The vast majority of stations already have a tank compatible with E15.[251] Both manufacturers of fuel dispensers fully warranty their standard dispensers for E15 usage.[252] Stations would only need to purchase a retrofit kit, which costs $2,000 per dispenser including installation, in order to comply with any Underwriter Laboratories listing requirements.[253]

With respect to piping and other equipment, Stillwater explains that the costs of upgrading depend on how recently the station has been upgraded. Stations upgraded in the last five years will have already done the work to get most of their equipment E15-compatible, because since 2010, the equipment used in these upgrades has been E15-compatible, even if the station was not seeking to add E15.[254] It would cost these stations only $1,000-$1,500 to upgrade, on top of the retrofit kits.[255] Stations that last upgraded longer ago than that would cost $7,000-$8,000, in addition to the dispenser retrofit kit.[256]

The second readily available path for bringing E15 to market would be to blend it at the stations. That is, the station generally would put E85 into an existing gasoline tank, and then it could deliver E15 to the consumer through a blender pump that blends E85 with E10 to make E15 as the consumer is filling up his or her vehicle. This alternative is more expensive because of the required investment in blender pumps.[257]

The next question is where these investments could be made to achieve meaningful volumes in 2016. A full nationwide switch from E10 to E15 is currently limited by various regulatory constraints, including EPA's refusal to accord E15 a one pound-per-square-inch Reid Vapor Pressure ("RVP") waiver and by certain states' restrictions on E15 consumption.[258] We

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[250] *Id*. at 27.

[251] *Id*. at 6, 13.

[252] Letter from Patrick Jeitler, Dispenser Project Manager—North America, Wayne, dated Jan. 14, 2014 (attached as Exhibit 5); Gilbarco Veeder-Root, *Gilbarco Expands Standard Fuel Dispenser Warranty From E10 to E15* (Mar. 31, 2010), *at* http://www.gilbarco.com/us/content/gilbarco-expands-standard-fuel-dispenser-warranty-e10-e15.

[253] Stillwater Study at 27 (attached as Exhibit 4); Gilbarco Veeder-Root, *Frequently Asked Questions*, *at* http://www.ethanolretailer.com/images/uploads/GilbarcoRetrofitKitE15(2).pdf (explaining UL-listing issue).

[254] Stillwater Study at 27-28 (attached as Exhibit 4).

[255] *Id*.

[256] *Id*.

[257] *Id*. at 29.

[258] *Id*. at 17-19.

discuss below why EPA's refusal to grant E15 an RVP waiver is mistaken. In any event, a recent Stillwater analysis assumed all of these constraints would remain in place in 2016,[259] and still concluded that there is substantial opportunity for growth in renewable usage through E15.

In particular, Stillwater conservatively estimated that under current regulations E15 sales could generate an incremental 1.6 bil gal of ethanol consumption in 2016, by displacing 32 bil gal of E10 sales in strategically targeted parts of the country.[260] These volumes come from three different types of markets:

- *RFG zones.* E15 can be sold in any RFG zone that is in a state without E15 restrictions. This is because the gasoline blendstock for RFG gasoline already has a lower RVP, and so E15 would not require a waiver in these areas.[261] E15 sales in these areas could account for 670 mil gal incremental ethanol consumption annually.[262]

- *Conventional zones outside of the summer season.* Because the RVP issue only applies during the summer ozone season, E15 can be sold in any part of the country without existing state restrictions from mid-September to the end of May.[263] Conservatively reducing this timeframe by one month to account for station transitions, Stillwater concluded that incremental ethanol consumption in this market could be 880 mil gal annually through E15.[264]

- *Areas near low RVP-blendstock terminals.* A number of terminals throughout the country sell gasoline blendstock with a low RVP; stations close to such terminals and in States without restrictions can purchase this blendstock and then use station blending to produce an E15 blend that satisfies RVP requirements, any time of year.[265] Stillwater conservatively estimates 60 mil gal of annual incremental ethanol consumption from this pathway.[266]

In a further conservative adjustment, Stillwater reduces these volumes to account for the fact that about 11% of the vehicle miles traveled in 2016 will be by MY2000 and earlier

[259] *Id*. at 17-24.

[260] *Id*. at 25.

[261] *Id*. at 22.

[262] *Id*. at 25.

[263] *Id*. at 22.

[264] *Id*. at 25.

[265] *Id*. at 22-23.

[266] *Id*. at 25.

("MY2000-") vehicles that cannot use E15.[267] As a result, the total E15 market potential should be reduced from 1.60 bil gal of incremental ethanol per year to 1.43 bil gal.[268]

2. Infrastructure expansion plan

Implementing the pathway described above in time to have an impact on 2016 consumption levels would be feasible. EPA would not issue an appropriately higher 2016 renewable fuel volume requirement until November 30, 2015, leaving the industry with little time to expand infrastructure before 2016. But contrary to EPA's refusal to even consider the possibility of E15 expansion, substantial growth in E15 stations is nonetheless achievable in a rapid timeframe when focused on the above market opportunities.

Applying a layered phase-in that takes advantage of the industry's seven-year upgrade cycle but does not begin until after EPA finalizes the volumes on November 30, 2015, Stillwater presents a terminal-blending scenario in which the market achieves 710 mil gal in incremental ethanol distribution through E15 over the course of 2016.[269] This number is lower than the 1.60 bil gal potential because Stillwater assumes that no volume is produced in the last month of 2015, and that station upgrades are then spread out over the course of the following year.[270] Stillwater also presents an expedited implementation scenario, where the expansion is spread over just the first six months of 2016.[271] Under the expedited scenario, the market could provide 1.06 bil gal of incremental ethanol beyond the blendwall in 2016.[272]

All told, Stillwater calculates that this expansion could be achieved with approximately $255 million in total costs.[273] Stillwater also explains why this scenario is quite realistic with the right price incentives, even though it envisions upgrades at approximately 32,000 stations over 2016.[274] Because the market regularly handles upgrades at 22,000 stations a year,[275] the number of stations that would be making these E15 upgrades would be on the order of typical upgrade patterns. In fact, the upgrades made by the retrofit kits are orders of magnitude *less* intensive than tearing out and replacing the dispensers at a particular station. The work could proceed in parallel by various contractors, and in the face of EPA enforcing a strong RFS mandate, some stations would be eager to lead the crowd and thereby drive sales.

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[267] *See* Air, *Analysis of Fleet 2001+ Model*, at 3 (attached as Exhibit 3).

[268] *See* Stillwater Study at 25 (attached as Exhibit 4).

[269] *See id*. at 25-26.

[270] *Id.*

[271] *Id*. at 26.

[272] *Id*.

[273] *Id.* at 29.

[274] *Id.* at 25.

[275] *Id.*

To be sure, achieving this scenario would be difficult if oil companies continue to obstruct E15 at every turn. Refining terminals would have to start offering E15 at the refining terminal, as using blender pumps to achieve the same volumes would be significantly more expensive. And oil companies would have to stop contractually restricting branded stations from selling E15. But just as with E85, EPA cannot permit oil company obstruction to become a self-fulfilling prophesy. Rather, EPA should assess the general waiver from the perspective of whether the requisite volumes could be achieved if all industry players were cooperatively working towards that goal, and set volume requirements at levels that would encourage such action. Just as E10 consumption increased substantially over a number of years when the industry, faced with appropriate incentives, began to cooperate, there is no doubt that the same could happen for E15 when unimpeded by oil industry obstruction.

3. Consumption constraints

One might reasonably think that even if "supply" means "supply of blended transportation fuel (containing renewable fuel) to consumers," it would stop at the pump. By any reasonable definition, anything that affects consumers' willingness to consume the product must be demand. But in EPA's view, "the availability of qualifying renewable fuels and constraints on their *supply to vehicles that can use them* are valid considerations under … the general waiver authority."[276] Thus, under EPA's interpretation of the general waiver provision, we must consider the volume of vehicles that can consume E15.

FFVs, of course, can consume E15. And several years ago, EPA determined that E15 is safe to use in MY2001+ vehicles, and accordingly approved E15 for use in those vehicles.[277] Today, about 85% of miles traveled and energy consumed are by vehicles approved for E15 use.[278] That figure is expected to increase to about 89% in 2016.[279] The notion that E15 could be harmful to the engines in most vehicles on the road, whether warrantied for E15 or not, is

[276] 80 Fed. Reg. at 33,106 (emphasis added).

[277] *See* EPA, *Partial Grant and Partial Denial of Clean Air Act Waiver Application Submitted by Growth Energy To Increase the Allowable Ethanol Content of Gasoline to 15 Percent; Decision of the Administrator*, 75 Fed. Reg. 68,094, 68,122 (Nov. 4, 2010) ("[W]e believe that the durability testing performed by DOE as discussed in section IV.A.1 above is sufficient to provide assurance that MY2007 and newer motor vehicles will not exhibit any serious materials incompatibility problems with E15."); *see id.* at 68,120-68,122 (discussing, among other things, possible damage to fuel pumps); EPA, *Partial Grant of Clean Air Act Waiver Application Submitted by Growth Energy To Increase the Allowable Ethanol Content of Gasoline to 15 Percent; Decision of the Administrator*, 76 Fed. Reg. 4662, 4681 (Jan. 26, 2011) ("EPA does not expect that there will be materials compatibility issues with E15 that would cause MY2001-2006 light-duty motor vehicles to exceed their evaporative emission standards over their FUL. … In addition, the results of the DOE Catalyst Study support this conclusion, as E15 was used for long-term aging of the vehicles and the Study did not uncover any emissions deterioration problems with E15 in comparison to E0 that would result in materials compatibility issues.").

[278] Air, *Analysis of Fleet 2001+ Model*, at 3, Table 1 (attached as Exhibit 3).

[279] *Id.*

baseless, and EPA rightly does not credit it. EPA's decision was based partially on its own analysis and partially on a "rigorous, thorough, and peer-reviewed study" of the effects of E15 conducted by the Department of Energy's Oak Ridge National Laboratory, which had found "no statistically significant loss of vehicle performance (emissions, fuel economy, and maintenance issues) attributable to the use of E15 fuel compared to straight gasoline."[280] And the National Renewable Energy Laboratory critically analyzed 33 unique research studies on E15 and concluded that these studies "do not show meaningful differences between E15 and E10 in *any* performance category."[281]

Nevertheless, for years the oil industry has engaged in a sustained disinformation campaign to manufacture doubt about E15, scaring consumers about potential engine damage.[282] The cornerstone of this effort has been a 2012 paper by the Coordinating Research Council ("CRC").[283] In a detailed critique, the Department of Energy called the CRC study "significantly flawed."[284] DOE explained that CRC "failed to establish a proper control group, a standard component of scientific, data-driven testing," and in fact did not include E10 in its testing, even though E10 is "the de facto standard gasoline for all grades."[285] Moreover, it used an "arbitrary criterion" in its testing that is "not [a] reliable indicator of durability issues" and "not a standard previously employed by either industry or federal agencies during testing."[286] And, "the CRC

[280] *Getting It Right: Accurate Testing and Assessments Critical to Deploying the Next Generation of Auto Fuels*, energy.gov, (May 16, 2012) ("*Getting It Right*"), *at* http://energy.gov/articles/getting-it-right-accurate-testing-and-assessments-critical-deploying-next-generation-auto.

[281] Robert L. McCormick et al., National Renewable Energy Laboratory, Review and Evaluation of Studies on the Use of E15 in Light-Duty Vehicles 1 (Oct. 2013) (emphasis added), *at* http://ethanolrfa.org/page/-/rfa-association-site/studies/RFA%20NREL%20Review%20and%20Evaluation%20of%20E15%20Studies.pdf.

[282] *See* Laura Litvan, *Bid to Repeal Ethanol Mandate Seen Diluted by EPA Change*, BLOOMBERG, Aug. 8, 2013 ("The American Petroleum Institute began an advertising blitz last month designed to build pressure for a repeal of the federal biofuel rule, with TV, radio and print ads that focus on potential costs to consumers. One print ad says the higher ethanol mandate 'could damage your engine, and void your warranty. Your engine won't like it, but your mechanic will.'"), *at* http://www.bloomberg.com/news/2013-08-08/bid-to-repeal-ethanol-mandate-seen-diluted-by-epa-change.html. A clip of the advertisements can be seen here: http://www.keloland.com/newsdetail.cfm/ad-against-ethanol-causes-controversy/?id=150809.

[283] *See* API-AFPM Pet. for Partial RFS Mandate Waiver, Dkt # EPA-HQ-OAR-2013-0747, at 17-18 (Aug. 13, 2013) (relying on this study in seeking RFS waiver).

[284] *Getting It Right*, *supra* note 280.

[285] *Id.*

[286] *Id.*

decided to select several engines already known to have durability issues, including one that was subject to a recall involving valve problems when running on E0 gasoline and E10."[287]

Apart from the baseless concern that E15 could damage engines in approved vehicles, another category of apparent constraint on greater use of E15 is the suggestion, which EPA apparently credits, that consumer fear that use of E15 in MY2001+ vehicles, although approved by EPA, will nonetheless void engine warranties that do not explicitly approve use of E15. Even if these concerns were legitimate, they would not be an appropriate basis for exercising EPA's general waiver authority because they affect only consumer demand, not supply of transportation fuel (or renewable fuel). As EPA itself puts it, these factors relate to whether "vehicle owners may be reluctant to use E15,"[288] which would be the case even if stations were overflowing with E15. These concerns, therefore, are not relevant to ascertaining the amount of "supply" for purposes of the general waiver provision, even under EPA's flawed interpretation.

In any event, such warranty concerns are wildly overstated. Drivers of FFVs, of which there will be at least 16.32 million on the road in 2016,[289] will not have any warranty concerns about using E15. Nor will drivers of non-FFVs whose warranties explicitly approve the use of E15. Based on a conservative analysis of information from automaker manuals and EPA's own models, it is projected that 32.9 million vehicles on the road in 2016 will carry E15 warranties.[290] This number will only get higher over time because newer cars are far more likely to be warrantied for E15 and older cars are retired. In addition, owners of vehicles that are out of warranty should not be concerned that using E15 could nonetheless void the warranty. It is projected that at least 101.6 million non-FFV MY2001+ vehicles on the road in 2016 will be out of warranty.[291] Combining these three groups (FFVs, vehicles explicitly warrantied for E15, and out-of-warranty vehicles approved by EPA for E15), in 2016 at least 150.82 million vehicles—65% of the total vehicle population[292]—could consume E15 not only safely but also without fear that doing so would void the engine warranty.

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[287] *Id.* The oil industry also has relied on another flawed study by the CRC, published in January 2013. *See* CRC, *Durability of Fuel Pumps and Fuel Level Senders in Neat and Aggressive E15*, CRC Report No. 664 (Jan. 2013), *at* http://www.crcao.com/reports/recentstudies2013/CRC%20664%20%5BAVFL-15a%5D/AVFL%2015a%20%5BCRC%20664%5D%20Final%20Report%20only.pdf. This study was very limited, finding that a single type of fuel pump failed when soaked in E15, but recognizing that this result contradicted two prior studies, including one by CRC. *Id.* at 11-12. NREL determined that this January 2013 CRC study was "inconclusive." NREL Study at 3.

[288] EPA 2015 E15 Memorandum at 3.

[289] 80 Fed. Reg. at 33,121, 33,128 & n.71; *see also* AIR, *Analysis of Fleet 2001+ Model*, at 4 (attached as Exhibit 3).

[290] Air, *Analysis of Fleet 2001+ Model*, at 6 (attached as Exhibit 3).

[291] *Id.* at 7.

[292] The total vehicle population for 2016 is projected to be 232.1 million. *Id.* at 4.

Finally, the oil industry has also tried to discourage consumers from using E15 by sometimes requiring E15 to be sold from the yellow hoses (typically devoted only to E85 FFVs)[293] or by requiring dire warnings (in addition to the warnings already required by federal or state law) on dispensers that are patently intended to confuse and deter potential customers.[294] Such practices further demonstrate that certain obligated parties have been actively engaging in behavior to suppress the distribution of higher volumes of E15. If EPA proposed a higher renewable fuel volume requirement, however, obligated parties would have the proper incentives to stop such efforts to undermine the RFS program.

4. EPA should take additional actions to facilitate greater expansion of E15 distribution and consumption

Aside from setting higher volume requirements, EPA should take other actions to facilitate the expansion of E15 distribution and consumption.

First, EPA should grant a one-pound RVP waiver for E15. The nine-pound RVP limit applies from May to September. Unless made using low-RVP gasoline blendstock, E15's volatility will exceed 9.0 psi. Because low-RVP blendstock is scarce, EPA's denial of a one-pound waiver effectively prevents the sale of E15 during the summer months. Section 7545(h)(4) permits EPA to waive the 9.0 psi limit by one pound, setting a maximum RVP limit of 10 psi for "fuel blends containing gasoline and 10 percent denatured anhydrous ethanol." EPA has flexibly interpreted that phrase to cover "blends of 9-10% ethanol."[295] Although there is no scientific basis for having a different RVP limits for E15, as E15 has a similar volatility to E10 and would behave similarly in terms of evaporative emissions and effects on emissions-control devices,[296] EPA has interpreted section 7545(h)(4) not to permit a one-pound RVP waiver for E15.[297]

[293] *E15 Pioneer Rebrands Stations*, American Fuels Blog (Oct. 14, 2013) ("The major only allowed him to sell E15 under the canopy from the yellow-hosed flex-fuel dispenser, which would restrict sales to flex-fuel vehicles."), *at* http://www.zarcousa.com/americanfuelsblog/; Cezary Podkul, *Insight: Ethanol lobby sees red over a yellow gas hose in Kansas*, REUTERS (June 10, 2013), *at* http://www.reuters.com/article/2013/06/10/us-e15-rules-phillips66-insight-idUSBRE95907G20130610.

[294] *See* Renewable Fuels Association, *Protecting the Monopoly*, *supra note* 149, at 7 (citing a BP requirement for a gas station in Nebraska that must post labels stating: "**WARNING**: This product is not supplied by BP, and BP does not guarantee this product…. Serious damage can occur to the vehicle if the product is used in a non-compatible vehicle.").

[295] 76 Fed. Reg. at 44,435.

[296] *See* Growth Energy Comments on E15 Misfueling Regulation, EPA-HQ-OAR-2010-0448-83, at 15 (posted Jan. 4, 2011).

[297] *See* 76 Fed. Reg. at 44,433-44,435.

EPA's interpretation is clearly wrong. Just as it would be unreasonable to interpret a sign saying, "You must have four people in your car to use the high-occupancy-vehicle lane,"[298] as prohibiting cars with five or more passengers from using the HOV lane, it is unreasonable to interpret section 7545(h)(4) as setting a maximum for ethanol blends that are eligible for a one-pound RVP waiver. The purpose of section 7545(h)(4) is to promote higher concentrations of ethanol in gasoline, like the purpose of HOV lanes is to promote higher concentrations of people in cars. Thus, it is clear that Congress intended for section 7545(h)(4) to establish a minimum rather than a maximum threshold for the RVP waiver.

Alternatively, and consistent with the purpose of section 7545(h)(4), EPA could invoke section 7545(h)(4)'s "deeming compliant" clause to extend the one-pound RVP waiver to E15.[299] In the E15 misfueling rule, EPA wrote that this clause "is not written as a free standing RVP limit that acts separate and apart from the 1 psi waiver for 9-10% blends of ethanol."[300] That makes no sense and would nullify the deeming clause, whose obvious purpose is to bring within the statute behavior that otherwise would not qualify. Thus by its terms, this clause encompasses *any* fuel that complies with the terms of (A)-(C). EPA also points out that applying the deemed-compliant clause to "blends containing 1%, or 2%, or 5% ethanol" would make no sense in light of the rest of the paragraph, whose function is to create a unique permission for fuels with 10% ethanol content.[301] But again, that rationale does not apply to ethanol blends *above* 10%, such as E15.[302]

Additionally, EPA should finalize its Guidance for E85 Flexible Fuel Vehicle Weighting Factor for Model Years 2016-2019 Vehicles Under the Light-Duty Greenhouse Gas Emissions Program, which it proposed in March 2013, and in doing so revise the proposed treatment of E15.[303] The draft guidance would in effect penalize FFVs for using E15 by not treating it as an alternative fuel (unlike E85). When E15 consumption is high, those volumes of E15 would be considered as having been blended into the base gasoline pool and the amount of alternative fuel is reduced significantly. More importantly, automobile manufacturers receive no greenhouse gas

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[298] *See, e.g.*, National Transportation Library, "4 Rider Pool Cars Only," *at* http://ntl.bts.gov/DOCS/images/HOVFPI/RETKP16.GIF.

[299] That clause provides that a party "shall be deemed to be in full compliance with the provisions of the subsection and the regulations promulgated thereunder if it can demonstrate that— (A) the gasoline portion of the blend complies with the Reid vapor pressure limitations promulgated pursuant to this subsection; (B) the ethanol portion of the blend does not exceed its waiver condition under subsection (f)(4) of this section; and (C) no additional alcohol or other additive has been added to increase the Reid Vapor Pressure of the ethanol portion of the blend."

[300] 76 Fed. Reg. at 44,433.

[301] *Id.* at 44,434.

[302] Insofar as section 7545(f)(4) may present additional questions with respect to a 1 psi waiver for E15, Growth Energy is actively working to address those questions with EPA.

[303] EPA, *Draft Guidance for E85 Flexible Fuel Vehicle Weighting Factor for Model Years 2016-2019 Vehicles Under the Light-Duty Greenhouse Gas Emissions Program,* 78 Fed. Reg. 17,660 (Mar. 22, 2013).

emissions credit for using E15 (or higher blends). Ethanol's greenhouse-gas emissions performance is up to 52% better than baseline gasoline (i.e., E0) on a life-cycle basis, so moving from E10 to E15 or higher blends would yield additional greenhouse-gas benefits for light-duty vehicles.[304] Issuing revised guidance to count E15 and medium-blend fuels as alternative fuel for purpose of calculating the "F" factor, which would more accurately reflect these blends' environmental benefits and would encourage car makers to produce more FFVs.

D. Combining Infrastructure Expansion For E85 And E15 Could Readily Support Even Greater Consumption Of Ethanol In 2016

Even greater expansion of E15 infrastructure could be achieved in 2016 by combining E85 and E15 paths. Given that there is little overlap between them, adding a second E85 dispenser to existing E85 stations and also pursuing the expedited expansion of E15 could enable 2.90 bgy of additional ethanol to be delivered in 2016, at a total cost of $348.5 mil.[305]

E. Existing Infrastructure Could Support The Distribution And Consumption Of Nearly The Entire Supply Of Biomass-Based Diesel

EPA also substantially underestimates the amount of BBD that could be distributed and consumed in excess of the proposed BBD mandate. As discussed above, EPA recognizes that existing BBD production capacity is sufficient to generate at least 4.2 bil RINs per year. Yet EPA appears to assume that total BBD production will generate hundreds of millions or even more than one billion fewer RINs than capacity in 2016.[306] EPA gives no explanation for why more available production capacity could not be used.

EPA's low BBD assumption cannot be explained by any distribution- or consumption-related constraint, even if such constraints were cognizable in assessing the general waiver. "The standard heating oil and diesel specifications allow up to 5% biodiesel" blends ("B5"), and thus "all diesel and heating oil equipment and infrastructure is de facto compatible" with B5.[307] Moreover, as EPA recognizes, "essentially all engine manufacturer warranties permit up to 5%

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[304] *See infra* Section X.B; *see also* U.S. Dept. of Energy, Alternative Fuels Data Center, *at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html (last visited June 22, 2015); Air Improvement Resource, Inc., *Emissions Reductions from Current Natural Gas Corn Ethanol Plants* (July 27, 2015) (attached as Exhibit 6).

[305] Stillwater Study at 31 (attached as Exhibit 4).

[306] *See* 80 Fed. Reg. at 33,127, Table II.D.2-2-2 & n.b (indicating EPA's expected range of BBD and conventional biodiesel RIN generation in 2016).

[307] *See* Stratas Report at 11 (attached as Exhibit 2); *see also* http://noraweb.org/wp-content/uploads/2015/05/Developing-a-Renewable-Biofuel-Option-May-2015-R1.pdf (noting that in 2008, definition of No. 2 oil, most common heating oil grade, "was changed to allow up to 5% biodiesel content with the resulting blend being considered fully equivalent to No.2 oil").

biodiesel."[308] Given projected diesel consumption for 2016, 4.091 bil RINs could still be generated from biodiesel up to the B5 blendwall.[309]

The closest EPA comes to explaining its lower expectation is its suggestion that some diesel fuel must "contain no biodiesel to accommodate that used in northern states during the coldest months of the year."[310] This is nonsense. Minnesota—hardly known as a mild winter state[311]—has for years implemented a year-round B5 mandate.[312] Oregon has done the same.[313] New grade specifications have been adopted for biodiesel that are specifically designed to accommodate multi-season use.[314]

Further underscoring the ability of the market to reach well over full B5 consumption is the existence of even higher biodiesel blends. Since 2014, Minnesota has mandated B10 in summer months; it now requires B10 from April through September.[315] Illinois has a history of selling B11 due to certain tax incentives.[316] Moreover, B20 has substantial potential. As EPA recognizes, "most medium and heavy-duty engine manufacturers warrant the use of blends up to B20 in their most recent models"[317]; these vehicles make up over 90% of on-road consumption of diesel.[318]

In addition, as EPA purports to recognize, renewable diesel is not even subject to a blend-wall because it is chemically "indistinguishable from conventional diesel fuel."[319] Thus, there is

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[308] 80 Fed. Reg. at 33,128.

[309] Stratas Report at 15 (attached as Exhibit 2).

[310] 80 Fed. Reg. at 33,128.

[311] *See* Minnesota Department of Natural Resources, Minnesota Facts & Figures—Climate, *at* http://www.dnr.state.mn.us/faq/mnfacts/climate.html (average winter temperature 6 degrees Fahrenheit in northern part and 16 degrees Fahrenheit in southern part) (last accessed: July 17, 2015).

[312] Stratas Report at 13 (attached as Exhibit 2).

[313] *Id.*

[314] *Id.* at 12-13.

[315] *Id.* at 13; *see also* Minnesota Department of Agriculture, "About the Minnesota Biodiesel Program," http://www.mda.state.mn.us/renewable/biodiesel/aboutbiodiesel.aspx (last accessed July 17, 2015).

[316] Stratas Report at 12 (attached as Exhibit 2); *see* Ron Kotrba, "Illinois supports state B11 tax incentive through 2018," *Biodiesel Magazine* (Dec. 14, 2011), *at* http://www.biodieselmagazine.com/blog/article/2011/12/illinois-supports-state-b11-tax-incentive-through-2018.

[317] 80 Fed. Reg. at 33,128 (noting further that "B20 could be used in a number of centrally-fueled fleets composed of newer engines without violating manufacturer warranties").

[318] Stratas Report at 11-12 (attached as Exhibit 2).

[319] 80 Fed. Reg. at 33,128.

simply no distribution- or consumption-based constraint whatsoever on using the entire domestic production capacity, which again could generate about 0.362 bil RINs per year.[320]

None of this is to say that EPA's proposed BBD volume requirement is erroneous. That determination is based on EPA's analysis of a number of statutory factors.[321] Because the BBD standard is nested within the advanced biofuel standard, EPA explained that it has "[a]llow[ed] for a larger portion of the advanced biofuel to be unspecified, by setting a lower BBD standard" in order to "maintain[] an incentive for the development and deployment of other non-advanced biofuels."[322] That approach is reasonable. What was not reasonable was failing to fully account for the BBD that could be distributed and consumed in excess of the proposed BBD volume when setting the total renewable fuel volume requirement. In that analysis, the only factor to consider is whether there is "inadequate domestic supply." And even if EPA were right that that factor accounts for constraints on distribution and consumption, EPA would still have substantially understated the supply of BBD.

F. Sufficient Ethanol And BBD Could Be Delivered To Meet The Statutory Renewable Fuel Volume Requirements After The Proposed Cellulosic Waiver Flow-Through Even Under EPA's Erroneous Interpretation of "Supply"

Accounting for the higher-blend ethanol and BBD that could be distributed and consumed, as described above, shows that, even under EPA's flawed interpretation of the general waiver provision, there is adequate domestic supply to support at least the statutory renewable fuel requirements for 2014, 2015, and 2016, after flowing through the proposed cellulosic waiver. Therefore, EPA may not invoke the waiver authority to reduce the renewable fuel volume requirements further.

EPA explains that, under its proposal for 2016, after accounting for the required volume of non-ethanol cellulosic biofuel and BBD, and for the maximum amount of ethanol that can be consumed as E10 (i.e., the E10 blendwall), an additional 0.84 bil RINs would be needed to reach the renewable fuel volume of 17.40 bil. Because, as explained above,[323] the statutory renewable fuel volume requirement after flowing through the proposed cellulosic waiver is 1 bil higher than EPA's proposed requirement—18.40 bil—this same calculation would mean that an additional 1.84 bil RINs would be needed to reach the statutory requirement after the cellulosic waiver flow-through. Even the most conservative path outlined above could achieve that level, and other paths could far exceed it.

First, consider ethanol. As just discussed, existing E85 distribution and consumption capacity would support the generation of at least 1.08 bil RINs above the E10 blendwall. (Expanded infrastructure could support up to 2.90 bil RINs above the E10 blendwall.) Given

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[320] Stratas Report at 16 (attached as Exhibit 2).

[321] 42 U.S.C. § 7545(*o*)(2)(B)(ii), (v).

[322] 80 Fed. Reg. at 33,135.

[323] *Supra* p.31.

that EPA projects the E10 blendwall for 2016 at 13.69 bil gal, the total amount of ethanol that could be delivered and consumed would be at least 14.77 bil gal. Because that is less than the minimum ethanol production capacity established above of 15.085 bgy, the full 14.77 bil gal could actually be produced and consumed in 2016, which would be 1.08 bil gal above the E10 blendwall that formed the basis of EPA's calculation.

Next, consider BBD. As just discussed, the B5 blendwall would limit the consumption of biodiesel supply to the equivalent of 4.091 bil RINs, and renewable diesel could support another 0.362 bil RINs, for a total of 4.453 bil RINs. And as also discussed above, the production capacity for both of those fuels is at least as high. Therefore, at least 1.753 bil RINs above EPA's proposed BBD volume requirement of 2.7 bil RINs (1.8 bil gal volumetric) could be supported in 2016.

Therefore, under the most conservative assumptions, the feasible production, distribution, and consumption of ethanol and BBD would support 2.833 bil RINs above the E10 blendwall and the proposed BBD requirement in 2016, 0.993 bil more the 1.84 bil additional RINs needed to reach the 2016 statutory requirement for renewable fuel after the cellulosic waiver flow-through.

Moreover, because these conservative throughput volumes of ethanol above the E10 blendwall and BBD are based on infrastructure that exists today and has existed to the same degree at least since 2014, they would have been achievable in 2014 and 2015, as well. Analysis similar to the one just performed for 2016 shows that there also would have been sufficient production, distribution, and consumption to meet the statutory renewable fuel volume requirements after the proposed cellulosic waiver flow-through in 2014 and 2015.

In 2014, the E10 blendwall was 13.64 bil gal.[324] Combined with 1.08 bil gal throughput for higher blends, the system could have delivered (at least) 14.72 bil gal of ethanol. But that exceeds the most conservative estimate of 2014 ethanol capacity, which, as described above, was 13.681 bil gal (though not the higher estimate of 14.8795 bil gal). Therefore, under the most conservative assumptions, only 0.041 bil gal of ethanol beyond the E10 blendwall could have actually been produced, distributed, and consumed in 2014. And given that 4.453 bil RINs could have been generated from BBD, there would have been 2.008 bil RINs from BBD above the proposed BBD volume requirement of 2.445 bil RINs (1.63 bil gal volumetric).

A similar phenomenon would occur for 2015, when EPA assumes the blendwall to be 13.78 bil gal.[325] Combined with 1.08 bil gal throughput for higher blends, the system could deliver (at least) 14.86 bil gal of ethanol. But that exceeds the most conservative estimate of 2015 ethanol capacity, which, as described above, was 14.548 bil gal (though not the higher estimate of 15.077 bil gal). Therefore, under the most conservative assumptions, 0.768 bil gal of ethanol beyond the E10 blendwall could actually be produced, distributed, and consumed in 2015. And given that 4.453 bil RINs would be generated from BBD, there would be 1.903 bil

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[324] *Impact on Motor Fuel Prices* at 3 n.12 (attached as Exhibit 1).

[325] 80 Fed. Reg. at 33,115, Table II.A.5-1.

RINs from BBD above the proposed BBD volume requirement of 2.55 bil RINs (1.70 bil gal volumetric).

Therefore, sufficient renewable fuel could have been produced and delivered to consumers, under the most conservative assumptions, to meet the statutory volume requirements for renewable fuel after the proposed cellulosic waiver flow-through—and in fact, to exceed those levels by about 1 billion RINs in each compliance year. Table 5 summarizes this analysis.

Table 5: Supply (Under EPA's Interpretation) to Meet Renewable Fuel Volumes After Cellulosic Waiver Flow-Through					
	E10 blendwall + EPA Proposed Required BBD	**Ethanol Above E10 Blendwall**	**BBD Above EPA Proposed Required BBD**	**Statutory Less Cellulosic Flow-Thru**	**Excess RINs**
2014	16.085	0.041	2.008	17.080	1.054
2015	16.33	0.768	1.903	17.900	1.101
2016	16.56*	1.08	1.753	18.400	0.993

All numbers in billions of RINs

** Also includes non-ethanol cellulosic biofuel*

In short, even under EPA's understanding of the general waiver authority, there was and will be plenty of "supply"—renewable fuel that can be produced and then distributed in transportation fuel to vehicles that can use it—to meet the statutory renewable fuel volume requirements after the cellulosic waiver flow-through in 2014-2016, and therefore EPA cannot exercise its general waiver authority to reduce those requirements further for any of those years.

VI. APPLYING VOLUME REQUIREMENTS WITHOUT A GENERAL WAIVER WOULD NOT BE UNREASONABLE UNDER THE CIRCUMSTANCES

For the many reasons stated above, regardless of which interpretation of the general waiver provision is correct, the supply of renewable fuels is, or will be, adequate in each of the three years subject to this rulemaking to meet the statutory renewable fuel volume requirements after the proposed cellulosic waiver flow-through, without a reduction under the general waiver authority. Although 2014 is long past and 2015 will be nearly over by the time EPA issues its final rule, imposing volume requirements for those years that are higher than actual net RIN generation levels is statutorily authorized and reasonable under the circumstances. Doing so, in fact, would serve Congress's intent far better than imposing requirements based on actual net RIN generation during those years, as EPA proposes.

As a threshold matter, there is no question that EPA has authority to issue renewable volume obligations for 2014 and those parts of 2015 already past.[326] The D.C. Circuit has squarely rejected in two prior cases the argument that a missed RFS deadline precludes EPA

[326] *See id*. at 33,108.

from promulgating renewable volume obligations.[327] As that court explained: "Congress directed EPA to 'ensure' that 'at least' the set volumes [of renewable fuel] were used each year; in light of that directive, and considering the overall statutory scheme and legislative history, … it [is] highly unlikely that Congress intended that EPA's failure timely to issue the … standard would lead to the drastic and somewhat incongruous result of precluding EPA from fulfilling its statutory mandate."[328]

The D.C. Circuit has also repeatedly held that delayed (and thus backward-looking) RVOs are not impermissibly retroactive.[329] "The statute set[s] the renewable fuel obligations, and [obligated parties] ha[ve] no legally settled expectation that EPA would exercise its waiver authority to reduce that obligation."[330] Indeed, EPA "ha[s] clear [but] implicit authority" to impose retroactive volume obligations "in order to achieve the statutory purpose."[331]

A court will uphold such retroactive obligations as long as EPA "balance[s] the benefits and burdens" of imposing them and "consider[s] the suggested alternatives."[332] For example, *Monroe Energy* found that EPA had proceeded reasonably where it mitigated its delayed issuance by extending the compliance deadline that program year.[333] By proposing to adjust the compliance deadline for 2014, EPA has taken a similar approach here.[334] *Monroe Energy* confirms, however, that EPA is not also obligated to reduce the required volumes in order for delayed renewable volume obligations to be upheld as reasonable.[335] To the contrary, the D.C. Circuit's decisions indicate that imposing higher volumes notwithstanding the delay would best "achieve the statutory purpose."[336]

Not only can obligated parties not expect to receive a waiver, they specifically have no basis to object to volume obligations that would require them to exceed the E10 blendwall. As discussed above, they have known about the E10 blendwall and the size of their statutory obligations for 2014-2016 since 2007, and thus they have had years to prepare to overcome the blendwall as necessary to meet those obligations. Their failure to do so is nobody's fault but their own—the product of their deliberate strategy to drag their feet in hopes of persuading EPA

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[327] *See Monroe Energy*, 750 F.3d at 919-920; *National Petrochemical & Refiners Ass'n v. EPA*, 630 F.3d 145, 156-157 (D.C. Cir. 2010) ("*NPRA*").

[328] *Monroe Energy*, 750 F.3d at 919-920 (quoting *NPRA*, 630 F.3d at 156-157 (some alterations and internal quotation marks omitted)).

[329] *Id.*; *NPRA*, 630 F.3d at 158-167.

[330] *Monroe Energy*, 750 F.3d at 920.

[331] *NPRA*, 630 F.3d at 163; *see also Monroe Energy*, 750 F.3d at 920 (rejecting argument that *NPRA*'s reasoning only applied to program's first year).

[332] *NPRA*, 630 F.3d at 166.

[333] *Monroe Energy*, 750 F.3d at 921.

[334] 80 Fed. Reg. at 33,108.

[335] *See Monroe Energy*, 750 F.3d at 921.

[336] *NPRA*, 630 F.3d at 163.

that the RFS program is unworkable.[337] By adhering to statutory volume requirements, EPA will properly teach obligated parties to assume that the statutory volume requirements apply and to invest in biofuel infrastructure, as Congress envisioned. Instead, EPA's proposal would teach obligated parties the opposite, that recalcitrance will lead to a decreased compliance obligation.

Moreover, the burden of complying with the statutory renewable fuel volume requirements (after the cellulosic waiver flow-through) for past years would not be difficult. Obligated parties could use the sizeable bank of carryover RINs and the ability to carry forward a RIN deficit[338] to help achieve compliance for 2014 and 2015. As noted above, the statutory renewable fuel volume requirements for 2014 and 2015 after adjusting for the proposed cellulosic waiver flow-through would be 17.08 bil and 17.90 bil. EPA estimates that actual net RIN generation during those years will be 15.93 bil and 16.3 bil.[339] If those estimates hold, there would be a combined RIN shortfall of 2.75 bil over 2014-2015.[340] EPA also estimates that after 2013 compliance, there will be a "bank" of "approximately 1.8 billion [carryover] RINS."[341] If that bank of RINs were to be fully drawn down for compliance, obligated parties could then carry forward a deficit of 0.95 bil RINs into 2016. As discussed below, deficits are a legitimate compliance mechanism under the RFS statutory scheme.[342]

Then, given that the 2016 statutory renewable fuel volume requirement after the proposed cellulosic flow-through is 18.4 bil, obligated parties would need 19.35 bil RINs to achieve full compliance in 2016.[343] That should not be a problem. If, as EPA claims, "supply" as used in the general waiver provision accounts for the volume of transportation fuel that can be delivered to vehicles that can use it, then supply could support, under the most conservative assumptions, at least 19.393 bil RINs in 2016.[344] Alternatively, if "supply" refers only to the amount of renewable fuel available to obligated parties (and it does, as explained above), then supply could support, under the most conservative assumptions, at least 19.494 bil RINs in 2016.[345]

Finally, EPA could further ease the compliance burden by flowing through the proposed cellulosic waiver through to the maximum extent. EPA proposes to waive the cellulosic volume requirement by 1.717 bil gal for 2014 and 2.894 bil gal for 2015. If those full amounts were flowed through, the advanced volume requirements would be 2.033 bil gal for 2014 and 2.606 bil

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[337] Growth Energy Prior Comments on 2014 RFS at 50-53.

[338] Obligated parties can "carry forward" a RIN "deficit" into the next compliance year. 42 U.S.C. § 7545(*o*)(5)(D).

[339] *See supra* Part II.C.

[340] 2.75 = 17.08 + 17.90 - 15.93 - 16.3.

[341] 80 Fed. Reg. at 33,130. Excess RINs can be carried over into the next compliance year. 42 U.S.C. § 7545(*o*)(5)(C).

[342] *See infra* pp.64-65.

[343] 19.35 = 0.95 + 18.4.

[344] 19.393 = 18.4 + 0.993. *See supra* Part V.F.

[345] *See supra* Part IV.B.3.

gal for 2015, and the renewable fuel volume requirements would be 16.433 bil gal for 2014 and 17.606 bil gal for 2015. Given EPA's estimates that actual net RIN generation during 2014 and 2015 will be 15.93 bil and 16.3 bil, the RIN shortfall under these volume requirements would be 1.809 bil—virtually identical to EPA's estimate of the RIN bank. In other words, if the cellulosic waiver were flowed through fully, obligated parties could fully comply with the 2014 and 2015 volume requirements without any need for EPA to exercise its general waiver authority or for obligated parties to carry a RIN deficit forward.

And none of this analysis accounts for the higher projected E10 blendwall level in 2015 and 2016, or for EPA's error in computing the net D6 RINs generated in 2014. Those adjustments would provide hundreds of millions of additional RINs for compliance.[346]

Although higher volume requirements for 2014 and 2015 could not spur greater renewable fuels production or use *in those years*, they would, as discussed in greater detail below, have the salutary effect of consuming the RIN bank, which will then clear the way for the renewable fuel volume requirement and the RIN market to stimulate growth in the production and use of renewable fuels in future, as Congress intended.

For all of these reasons, therefore, retroactively applying the statutory requirements for renewable fuel (with the proposed cellulosic waiver flow-through) in 2014 and 2015 would not be unreasonable.

VII. AT A MINIMUM, EPA SHOULD ADJUST ITS PROPOSAL TO ACCOUNT FOR HIGHER PROJECTED GASOLINE CONSUMPTION

Based on EIA's May 2015 Short-Term Energy Outlook ("STEO"), the proposal assumed that the E10 blendwall would be 13.78 bil gal in 2015 and 13.69 bil gal in 2016.[347] But according to EIA's latest projections of nationwide gasoline consumption, the E10 blendwall, calculated according to EPA's methodology, will be higher by 0.12 bil gal in 2015 (13.90 bil gal total) and by 0.15 bil gal in 2016 (13.84 bil gal total).[348]

Because the proposal bases the renewable fuel volume requirements for these years on the level of the E10 blendwall,[349] these increases in projected gasoline consumption and the E10 blendwall should correspondingly increase the renewable fuel volume requirements. Therefore, at a minimum, the renewable fuel volume requirement should be adjusted to 16.42 bil gal in 2015 and 17.55 bil gal in 2016. And insofar as other computations in this comment rest on EPA's assumptions about the level of the E10 blendwall, those volume requirements should also correspondingly be increased.

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[346] *See supra* Part VII & Part VIII.

[347] 80 Fed. Reg. at 33,115, Table II.A.5-1.

[348] *See* EIA, *Short-Term Energy Outlook*, Table 4a (July 2015); *Impact on Motor Fuel Prices*, at 3 nn.13-14 (attached as Exhibit 1).

[349] *See, e.g.*, 80 Fed. Reg. at 33,115, Table II.A.5-1; *id.* at 33,121-33,129.

VIII. AT A MINIMUM, EPA SHOULD ADJUST ITS PROPOSAL TO CORRECT ITS TREATMENT OF EXPORTED ETHANOL

EPA miscalculated the actual net D6 RIN generation in 2014.[350] Specifically, as the Renewable Fuels Association has pointed out, EPA erroneously assumed that a D6 RIN was generated on all 846 mil gal of exported ethanol and that all of those RINs would be retired and unavailable for compliance, when in fact much of that volume did not generate a RIN, including 370 mil gal of un-denatured ethanol.[351] EPA seems to have recently acknowledged that it erred in this regard.[352] Because EPA subtracted the entire volume of exported ethanol from the volume of produced and imported ethanol to determine net D6 RIN generation for 2014,[353] correcting this error would increase 2014 net D6 RIN generation by at least 370 mil, and would raise total 2014 net RIN generation to 16.3 bil.[354]

Correcting this error could have ramifications in subsequent years as well. That level of net RIN generation—16.3 bil—is identical to the proposed *2015* renewable fuel volume requirement. Because, as EPA recognizes, its task is to "increase the use of renewable fuels in the U.S. transportation system *every year*,"[355] it should at a minimum correspondingly increase its proposed 2015 renewable fuel volume requirement to account for this correction, and should also increase the volume requirement for 2016.

IX. AT A MINIMUM, EPA SHOULD TREAT CARRYOVER RINS AS SUPPLY FOR PURPOSES OF THE GENERAL WAIVER PROVISION

Even if EPA were correct that the statutory renewable fuel volume requirements (even with the cellulosic waiver flow-through) could not be met in 2014-2016, EPA would still have exceeded its authority under the general waiver provision set because of its failure to treat carryover RINs as supply when determining whether "supply" is "inadequate." As long as carryover RINs are available and not treated as supply, incentives will be insufficient to expand the production and use of renewable fuels.

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[350] *See* POET Comment on EPA's Proposed 2014-2016 Standards for the Renewable Fuel Standard Program, EPA-HQ-OAR-2015-0111, at 23 (July 27, 2015) ("POET July 27 Comments").

[351] *See* Renewable Fuels Association, *2014 U.S. Ethanol Exports and Imports, Statistical Summary*, at 1 (2015) ("Denatured ethanol for fuel use accounted for 54% of total exports in 2014, while undenatured ethanol for fuel use made up 43%. Denatured and undenatured ethanol for other industrial use totaled 3%."), *at* http://www.ethanolrfa.org/page/-/rfa-association-site/studies/2014%20U.S.%20Export-Import%20Report.pdf?nocdn=1.

[352] Memorandum from David Korotney to EPA Air Docket EPA-HQ-OAR-2015-0111-1219, "Calculation of ethanol export estimates for 2014" (July 24, 2015).

[353] 2014 RIN Supply, EPA-HQ-OAR-2015-0111-0004.

[354] 16.3 = 15.93 + 0.37.

[355] 80 Fed. Reg. at 33,101 (emphasis added).

A. EPA Must Treat Carryover RINs As Supply When Determining Whether There Is "Inadequate Domestic Supply" For Purposes Of The General Waiver Provision

In its proposal, EPA takes the view that the statute does not "specify how or whether EPA should consider … carryover RINs in exercising its waiver authorities."[356] Instead of requiring obligated parties to consume the RIN bank, EPA proposes to set the volume requirements at an unnecessarily low level in order to permit obligated parties to continue to carry over all these RINs and supposedly preserve "compliance flexibility, market liquidity, and program buffer functions" in future years.[357]

This position, which EPA first expressed in its prior proposal for 2014,[358] represents a significant departure from EPA's earlier position. In past proceedings, EPA took the position that carryover RINs must be counted as supply when determining whether there is "inadequate domestic supply" for purposes of the general waiver provision. For example, in 2010 EPA noted that "it is ultimately the availability of qualifying renewable fuel, *as determined in part by the number of RINs in the marketplace*, that will determine the extent to which EPA should issue a waiver of RFS requirements on the basis of inadequate domestic supply."[359] And in program year 2013, EPA found no basis for "reducing the national applicable volumes" because "the statutory volumes for both advanced biofuel and total renewable fuel can be met in 2013" in part by using RINs carried over from 2012.[360] Notably, the D.C. Circuit previously indicated it was appropriate for EPA to consider the availability of carryover RINs when determining whether supply was adequate for purposes of the general waiver authority.[361]

EPA's about-face is neither procedurally nor substantively valid. An agency must "provide reasoned explanation for its action," which "ordinarily demand[s] that" the agency "display awareness that it *is* changing position" when it does so.[362] EPA has not displayed such

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[356] *Id*. at 33,129.

[357] *Id*. at 33,130.

[358] 78 Fed. Reg. at 71,766-71,767.

[359] 2012 RFS2 Impact Analysis, 75 Fed. Reg. at 14,698; *see also id.* at 14,676 ("These 2009 and 2010 RFS1 RINs will be available and can be used towards the volume requirements of obligated parties for 2010. These RFS1 RINS combined with the RFS2 RINs that will be generated by renewable fuel producers are expected to provide an adequate supply of RINs to ensure compliance for all of the renewable volume mandates.").

[360] 78 Fed. Reg. at 49,795.

[361] 80 Fed. Reg. at 33,130; *Monroe Energy*, 750 F.3d at 919 ("But so long as sufficient RINs exist for obligated parties to meet the fuel standards, the court has no ground to conclude the 2013 standards are unlawful simply because RINs are costlier than in prior years, especially as high RIN prices should, in theory, incentivize precisely the sorts of technology and infrastructure investments and fuel supply diversification that the RFS program was intended to promote.").

[362] *FCC v. Fox Television Stations, Inc.*, 556 U.S. 502, 515 (2009); *see Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983).

awareness, let alone provided a reasoned explanation for its action. Its vague allusions to future "compliance flexibility" and a "buffer" in explaining why a RIN buffer is desirable as a matter of policy will not do.

In any event, EPA's approach is impermissible and misguided, for several reasons. First, it makes no economic sense—a RIN buffer simply would not work as EPA envisions. Second, RINs are a measure of the supply of renewable fuel and must be counted when determining whether "supply" is "inadequate" under the general waiver provision. Third, maintaining a RIN bank would undermine Congress's purpose for the RFS program; the RFS program can achieve its goal of spurring growth in renewable fuels only if carryover RINs are accounted for in determining whether there is "inadequate domestic supply." And fourth, by specifically providing certain mechanisms for "compliance flexibility" and "buffer," Congress foreclosed other means, including maintaining a carryover RIN bank.

As long as EPA refuses to account for carryover RINs, they will simply be used as a substitute for infrastructure investment. That is especially so given EPA's stated intent to maintain a RIN "buffer" by setting low volume requirements and its apparent intent to trigger the reset authority with this proposal. The clear signal EPA is sending the market is that future standards will not drive growth, and therefore banked RINs will not be valuable for much longer. Thus, obligated parties will have a strong incentive to achieve compliance now through low volumes and banked RINs, thereby charting a path to even lower volumes of renewable fuels in the future.

1. A RIN "buffer" would not work as EPA intends

There is no reason to believe that a RIN "buffer" would work as EPA envisions. The proposal assumes that, given the choice between using relatively cheap carryover RINs to meet volume obligations and investing in infrastructure to increase distribution and consumption of renewable fuels, the oil industry will choose the latter so as to preserve their RIN "buffer." Yet to date the oil industry, as described above, has done everything possible to obstruct the deployment of renewable fuel above the E10 blendwall, including refusing to make relatively economical investments in infrastructure for distributing higher-ethanol blends. Indeed, this is exactly what happened in 2013, which EPA recognizes was the first year in which the RFS program should have necessitated exceeding the blendwall; rather than make the requirement investments, however, the industry that year just drew down the carryover RIN bank by approximately 800 million RINs.[363] There is no reason to believe this attitude will change now—certainly EPA's proposal would not provide any economic incentive for such a change. Carryover RINs would only function as EPA hopes if their uses were circumscribed to natural disasters or other extreme scenarios, but they can be used for ordinary compliance.

This is particularly so in light of the signals this proposal sends the oil industry and the implications of the "reset" EPA anticipates. According to EPA Acting Administrator McCabe, the reset process "likely … would take longer than the one year."[364] In the meantime, despite the

[363] 80 Fed. Reg. at 33,130.

[364] Testimony of Janet McCabe, Testimony, *supra* note 5, at 22.

potential for uncertainty created by the reset process, EPA's current proposal, on the heels of its prior proposal for 2014, would give obligated parties strong reason to believe that EPA intends to use the reset power to substantially lower volume requirements in the future. Consequently, there would be little incentive for an obligated party (or any industry player) to choose now to invest in infrastructure it had previously fought to avoid—that investment could well be worthless if EPA were to reset the volume requirements lower. Similarly, there would be no reason for anyone to hold onto carryover RINs because they too would be worthless once EPA reset the volume requirements downward. EPA's assertion that obligated parties would maintain the RIN bank as a "buffer" in light of future "increasing … targets"[365] is therefore absurd. Indeed, the "cliff diving" seen in D6 RIN prices immediately after EPA's proposal was announced confirms that the oil industry believes future compliance, through 2016 and likely beyond, given the implications of EPA's proposal for the reset authority, will be relatively inexpensive under EPA's proposal.[366]

Nor does EPA offer any explanation for why the buffer would need to contain 1.8 bil RINs. In its prior proposal for 2014, EPA's position was that the full bank of 1.2 bil carryover RINs should be preserved as a buffer.[367] EPA, however, never explained why that specific volume was required to provide the desired "flexibility." And now it does not explain why 1.2 bil RINs would not provide a sufficient buffer, or why all 600 mil additional carryover RINs would need to be added to the buffer.

2. RINs are a statutorily prescribed measure of supply

Carryover RINs are, by definition, a measure of the past "supply" of renewable fuels, specifically the excess supply over prior volume requirements.

Congress directed that the regulations EPA promulgates under paragraph (2) of section 7545(*o*) not only ensure that obligated parties meet their volume obligations—obligations that may be waived under the general waiver provision—but also provide "for the generation of an appropriate amount of credits by any person that refines, blends, or imports gasoline that contains a quantity of renewable fuel that is greater than the quantity required under paragraph (2)."[368] Those credits—RINs—thus measure the amount of renewable fuel obligated parties have used in excess of their volume obligations. RINs may be used by obligated parties "to show compliance" with their volume obligations, not just during the compliance year when they were generated but also in the subsequent compliance year—in which case they are called carryover RINs.[369]

[365] 80 Fed. Reg. at 33,130.

[366] *See supra* Part III.V.

[367] 78 Fed. Reg. at 71,767.

[368] 42 U.S.C. § 7545(*o*)(5)(A)(i).

[369] *Id.* § 7545(*o*)(5)(C); *see* 2010 RFS2 Impact Analysis, 75 Fed. Reg. at 14,721 ("The accumulation of RINs will continue to be the means through which each obligated party shows compliance with its RVOs and thus with the renewable fuel standards.").

In other words, RINs, including carryover RINs, reflect the supply of renewable fuel and are part of the mechanism for compliance from which the general waiver may provide relief. Accordingly, carryover RINs must be accounted for when determining whether supply is inadequate for purposes of the general waiver provision.

3. EPA's proposal to exclude carryover RINs from consideration would subvert the RFS program

Invoking the general waiver authority to reduce volume requirements below the level where they could be satisfied with carryover RINs, i.e., excluding carryover RINs from consideration of whether "supply" is "inadequate," would also thwart the purpose of the RFS program by undermining Congress's market mechanism for increasing production and use of renewable fuels.

As explained above, the RFS relies on economic incentives to stimulate the distribution and consumption of renewable fuels. The RIN market is the mechanism, and high RIN prices convey the incentive. As blending requirements become more difficult to achieve, RIN prices rise. This gives obligated parties a powerful incentive to invest in new ways to bring renewable fuel to market, such as equipping gas stations to sell E85 and E15, and to stimulate increased consumer demand for those fuels by pricing them competitively. By contrast, low volume obligations yield low RIN prices—which leads to high prices for higher-ethanol blends and little incentive for obligated parties to invest in renewable-fuel distribution infrastructure. The proposal fails to grasp this straightforward economic logic.

Granting the waiver would thus make the recent RIN devaluation permanent, crippling the market incentive Congress intended to stimulate increased production and use of renewable fuel. By contrast, imposing the statutory volumes after the proposed cellulosic waiver flow-through and thereby requiring obligated parties to draw down banked carryover RINs would revive RIN prices and, critically, "incentivize precisely the sorts of technology and infrastructure investments and fuel supply diversification that the RFS program was intended to promote."[370]

4. EPA's "buffer" approach to carryover RINs is foreclosed by the statute's provision of other forms of "flexibility"

EPA maintains that it can and should exclude carryover RINs from consideration of whether "supply" is "inadequate" in order to provide obligated parties with "compliance flexibility" and a "program buffer."[371] But the statute already contains mechanisms to do this, and therefore forecloses EPA from creating a new mechanism for the same end, namely, the RIN bank.

As the proposal notes, Congress provided "compliance flexibility" and a "buffer" by allowing an obligated party "that is unable to generate or purchase sufficient credits" to carry forward a RIN deficit into the next compliance year, giving the obligated party extra time to buy

[370] *Monroe Energy*, 750 F.3d at 919.

[371] 80 Fed. Reg. at 33,130.

or develop the ability to generate more RINs.[372] As EPA's previous statements and regulatory actions demonstrate, the ability to carry forward a RIN deficit is a reasonable and sufficient flexibility mechanism for obligated parties. The 2014-16 proposal itself notes that the RIN-deficit mechanism is available should obligated parties "find compliance with a given year's standards infeasible," and cites this possibility as a reason why EPA can reasonably impose volume obligations for periods already in the past.[373] EPA similarly noted the availability of a deficit carryforward in its prior proposal for the 2014 program year.[374]

Most importantly, EPA has in the past relied on the deficit-carryforward mechanism to provide regulatory flexibility during difficult periods of transition in the RFS—in particular, in its 2010 decision to "combine the [already-past] 2009 and 2010 mandated volumes for biomass-based diesel into a single two-year obligation."[375] The oil industry opposed that decision, but EPA reminded them that under the statute obligated parties would have had a 2009 volume obligation and, "[i]f an obligated party did not satisfy their individual 2009 volume obligation by the end of 2009, then the statute allowed the party to carry the deficit over to 2010."[376] Put simply, the "compliance carryover provisions adopted by Congress" are a fundamental element of the RFS program, and EPA has never in the past found it unreasonable to call upon them.[377]

EPA's only response is to note that because the statutory volume requirements increase year over year, "it may be increasingly difficult" for obligated parties to pay back RIN deficits in future years. But that is entirely consistent with the statutory design: The sharply escalating volume obligations Congress imposed presuppose that it will be "increasingly difficult" for obligated parties to comply. The answer to both EPA and recalcitrant obligated parties is for obligated parties to make the investments needed to permit greater deployment of renewable fuel, which they will do if EPA maintains higher volume requirements.

Congress provided another mechanism for flexibility: the general waiver authority, but under appropriate circumstances. If it turned out that an obligated party was genuinely unable to meet its volume obligations because of "extreme circumstances or natural disasters,"[378] EPA potentially could issue a waiver *then*, on the ground that those circumstances could cause severe economic harm to a State, a region, or the country, or on the ground that *at that time* it had become evident that obligated parties could not obtain adequate renewable fuel to comply with

[372] 42 U.S.C. § 7545(*o*)(5)(D); *see* 80 Fed. Reg. at 33,130 n.81.

[373] *Id.* at 33,108.

[374] 78 Fed. Reg. at 71,770.

[375] RFS2 Summary and Analysis of Comments, *supra* note 164, at 3-187; *see* 2010 RFS2 Impact Analysis, 75 Fed. Reg. at 14,718.

[376] RFS2 Summary and Analysis of Comments, *supra* note 164, at 3-187.

[377] *Id.* at 3-188.

[378] 80 Fed. Reg. at 33,141.

their obligations.[379] It is premature and frustrates the proper function of the general waiver provision to issue such a waiver now when there is such a sizeable RIN bank.

Given that Congress has already provided EPA with appropriate means of being flexible with obligated parties consistent with the overall purpose of the RFS program, EPA is not free to override the statutorily mandated volumes in order to create another one, particularly when EPA's new mechanism would undermine Congress's intent.[380]

B. Properly Accounting For The Carryover RIN Bank Would Require Higher Total Renewable Fuel Volume Requirements Than EPA Proposes

For the above reasons, EPA must set renewable fuel volume requirements at levels that will consume the entire RIN bank and drive growth in renewable fuels. The simplest appropriate way to do this is to increase the proposed volume requirements up to the level of the cellulosic waiver flow-through, or until the RIN bank would be exhausted, whichever comes first. And this should begin in 2014, so that the 2015 and 2016 volume requirements have the opportunity to drive growth (the 2014 requirement, of course, could not because it covers a past year).

EPA reports that come 2014, the bank will contain "approximately 1.8 billion RINs."[381] As explained above, the statutory renewable fuel volume requirements, after being reduced by EPA's proposed cellulosic waiver flow-through, are 17.08 bil gal for 2014, 17.90 bil gal for 2015, and 18.40 bil gal for 2015.[382] The difference between those volumes and EPA's proposed volumes, which reflect EPA's estimate of actual net RIN generation, is 1.15 bil gal in 2014, 1.60 bil gal in 2015, and 1.00 bil gal in 2016. Consequently, if the 2014 renewable fuel volume requirement were set at the statutory level after the cellulosic waiver flow-through, and if we accept EPA's proposed volume as actual net RIN generation, then 1.15 bil banked RINs would be consumed, leaving 0.65 bil banked RINs. Those RINs could then be fully consumed in 2015 by setting the volume requirement to 16.95 bil.[383] Table 6 summarizes this analysis.

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[379] *See* 42 U.S.C. § 7545(*o*)(7)(A).

[380] *See Alexander v. Sandoval*, 532 U.S. 275, 290 (2001) ("The express provision of one method of enforcing a substantive rule suggests that Congress intended to preclude others.").

[381] 80 Fed. Reg. 33,130.

[382] *See supra* p.31.

[383] 18.63 = 17.9 + 0.73.

Table 6: Renewable Fuel Volumes With Maximum Carryover RIN Drawdown			
	2014	**2015**	**2016**
Adjusted Volume Requirement	17.08	16.95	17.40
Carryover RIN Drawdown	1.15	0.65	0.00
EPA Proposed Volume Requirement (actual/projected net RIN generation)	15.93	16.30	17.40
Carryover RIN Bank*	0.65	0.00	0.00

All numbers in billions of RINs

** Initial carryover RIN bank balance is 1.8 bil*

Moreover, treating carryover RINs as supply for purposes of the general waiver provision should be done in conjunction with the other adjustments to the volume requirements called for in this comment, lest those other adjustments be undermined by the availability of a substantial volume of carryover RINs. Doing so would of course result in still higher volume requirements.

X. ADHERING TO THE STATUTORY VOLUMES WOULD BETTER ACHIEVE THE BENEFITS CONGRESS SOUGHT

In enacting the 2007 update to the RFS, Congress sought to achieve several important policy goals. These include encouraging development of new fuels and technologies[384]; protecting the environment, in part by reducing greenhouse gas emissions[385]; stimulating job creation and economic development, especially in rural America[386]; lowering consumer prices for gasoline[387]; and boosting energy independence and security by reducing the United States' reliance on imported oil.[388]

President Obama's recent Climate Action Plan makes clear that biofuels are to be central to his environmental agenda. Echoing Congress, the Plan declares that "[b]iofuels have an important role to play in increasing our energy security, fostering rural economic development, and reducing greenhouse gas emissions from the transportation sector. That is why the

[384] *See, e.g.*, 121 Stat. at 1492 (preamble); *American Petroleum Inst. v. EPA*, 706 F.3d 474, 475 (D.C. Cir. 2013); H.R. Rep. No. 110-306, pt. 1.

[385] *American Petroleum Inst.*, 706 F.3d at 476, 479; 121 Stat. at 1492; *NPRA*, 630 F.3d at 148; *see* 42 U.S.C. § 7545(*o*)(2)(A)(i).

[386] *See* 42 U.S.C. § 7545(*o*)(2)(B)(ii)(VI); S. Rep. No. 110-65, at 2.

[387] *See* 121 Stat. at 1492; 42 U.S.C. § 7545(*o*)(2)(B)(ii)(V).

[388] 121 Stat. at 1492; S. Rep. No. 110-65, at 1-2; *American Petroleum Inst.*, 706 F.3d at 476; *see* 42 U.S.C. § 7545(*o*)(2)(B)(ii)(II).

Administration supports the Renewable Fuel Standard, and is investing in research and development to help bring next-generation biofuels on line."[389]

Adhering to the volume requirements prescribed by Congress would better achieve Congress's and the President's policy goals than would EPA's proposal. In fact, EPA's proposal would in many respects disserve those goals, both through 2016 and afterward, when EPA would acquire reset authority.

A. The Statutory Volumes Would Continue To Encourage Critical Investment In Renewable Fuels, Whereas The Proposed Volumes Would Discourage It

EPA rightly recognizes that "spur[ring] investment in new technologies and production capacity" is "critical … if the market is going to continue expanding in future years according to Congress's intentions."[390] EPA also acknowledges that, "[i]n the longer term, sustained ambitious volume requirements are necessary to provide the certainty of a guaranteed future market that is needed by investors; the development of new technology won't occur unless there is clear profit potential, and it requires multiple years to build new production, distribution, and consumption capacity."[391] Yet the proposed rule falls far short of Congress's objective.

As detailed above, absolutely no expansion of infrastructure—and thus no investment—is needed to meet the proposed volume requirements for 2014, 2015, and, most important, 2016. The proposed volumes would be particularly damaging to the country's heartland—the center of ethanol production and a powerful antidote to imported fuel. In fact, in conjunction with the proposed advanced volume requirements, the proposed renewable fuel volume requirements would create a counterproductive scenario in which significant volumes of sugarcane ethanol are *imported* from Brazil to meet the advanced volume, while significant volumes of American corn ethanol are *exported* to meet Brazil's own demand for ethanol. This "ethanol shuffle" of course results in its own massive greenhouse gas emissions, as vast quantities of ethanol are shipped back and forth by tanker between the two countries to satisfy regulatory demands that, ironically, were designed in part to reduce the overall carbon footprint of the transportation sector.

Moreover, EPA's proposal will trigger the agency's reset power for total renewable fuel beginning in 2017. EPA appears eager to invoke that authority, thereby discarding the statutory volume requirements entirely. These actions send a strong signal to obligated parties and potential investors that infrastructure investment is likely to be unnecessary for the foreseeable future. If the statutory volume requirements can so easily be waived or discarded entirely and replaced with requirements that do little more than preserve the status quo, then investors will have little certainty regarding how much renewable fuel will be needed, and diminished economic incentive to invest in new technology. EPA's proposal would therefore destabilize the

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[389] *See* Executive Office of the President, *The President's Climate Action Plan* (June 2013), at 8, *at* https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

[390] 80 Fed. Reg. at 33,129.

[391] *Id.* at 33,118.

market for conventional renewable fuels and chill further, essential private investment in biofuel innovation and commercialization.[392]

EPA's proposal for 2014-2016 volume requirements would be particularly damaging to the important transition from first-generation renewable fuels to second-generation fuels, especially cellulosic fuels. A commitment to conventional renewable fuel through high total volume requirements would promote the development of second-generation fuels in at least two ways: by encouraging producers of conventional renewable fuels to continue investing in second-generation fuels, and by charting a path over the ethanol blendwall.

Producers of conventional renewable fuels, including members of Growth Energy, have made enormous investments in the development of cellulosic biofuels, often in conjunction with other energy companies.[393] These companies already have spent billions of dollars building facilities and harvesting cellulosic feedstocks based on Congress's direction that volume requirements continuously increase over fifteen years. And their efforts have begun to bear fruit.[394] EPA's proposal could well halt this trend. Much of the planned growth in advanced and cellulosic biofuel production is designed around a model of licensing technology to existing biofuel producers, who are able to engage in high-value asset financing and partnering investments. But EPA's proposal to use its general waiver authority to lower conventional biofuel volume requirements below existing capacity would cripple the industry's future ability

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[392] Congressional Research Service, *The Renewable Fuel Standard (RFS): Cellulosic Biofuels*, at 13 (Jan. 14, 2015) ("One source of uncertainty, particularly for investors in cellulosic biofuels ventures, concerns EPA's waiver authority. Investors may fear that the full cellulosic biofuels mandate will continually be waived to lower amounts by EPA, thus depriving them of the government-mandated market on which they had originally based their investment."), *at* http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R41106.pdf.

[393] The corn ethanol industry is critical to the development of cellulosic biofuel. *See* Ryan Fitzpatrick, *Cellulosic Ethanol is Getting a Big Boost from Corn, for Now* (Apr. 2, 2015), *at* http://thirdway.org/report/cellulosic-ethanol-is-getting-a-big-boost-from-corn-for-now (explaining "established companies with a sizable presence in the corn ethanol industry" are necessary to overcome the technological and economic challenges to scaling up cellulosic production). In fact, cellulosic projects sponsored by major corn ethanol producers (POET/DSM, Abengoa, and Quad City Corn Producers) account for more than 80% of total U.S. cellulosic capacity, and that percentage is expected to rise to 88% when a fourth major company (DuPont) opens its cellulosic facility later in 2015. *Id.*

[394] As the Congressional Research Service has found, "there were noteworthy occurrences in 2014 for the [cellulosic biofuel] industry, including the opening of three commercial-scale cellulosic ethanol plants in Iowa and Kansas with a combined production capacity of up to 52 million gallons per year." Congressional Research Service, *The Renewable Fuel Standard (RFS): Cellulosic Biofuels*, *supra* note 392 (Summary).

to make such investments.[395] Analysts at the International Council on Clean Transportation found that a waiver of the RFS would "have the indirect effect of eroding market confidence for all fuels that fall under the standard," especially for "companies that invest in second-generation fuels (cellulosic and other advanced fuels)," because "[t]hese second-generation plants rely heavily on market confidence to access and reduce the price of debt financing for plant expansions as they move to commercialize their technologies."[396]

Professor of Economics Bruce Babcock further explained the adverse effects on investments of reducing the volume requirements:

> A decision by EPA to reduce ethanol mandates in 2014 and 2015 would send a strong signal to car companies to reduce their production of flex vehicles, and to investors to not invest in high-ethanol-blend fueling stations or in next-generation plants that convert cellulosic material to ethanol. It likely also sends a negative signal to investors in biofuel plants that can convert cellulosic material to non-ethanol biofuels, such as synthetic diesel or gasoline. It might not seem that an EPA decision to decrease support for ethanol would imply a decrease in support for these "drop-in" fuels because they can be easily integrated into existing fuel channels. But the cost of constructing plants that can produce drop in fuels is high. High investment costs imply high risk. A reduction in public policy support for ethanol would only increase the perceived risk that in the future EPA would also reduce its support for other biofuels.[397]

Maintaining the statutory volume for conventional renewable fuel is also critical to breaking through the blendwall. Many next-generation cellulosic biofuels are ethanol-based and thus, like corn-based ethanol, must be blended into gasoline to be consumed. Bringing higher ethanol blends to market is thus of significant importance to ensuring growth in cellulosic ethanol. Without higher blends, incentives for bringing cellulosic ethanol brought to market would be eroded, since obligated parties are unlikely to bring higher ethanol blends to market

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[395] As explained in the comment on this proposed rule submitted by POET, a modest increase in the base renewable target would strengthen the D6 RIN price accordingly, and D6 RIN prices are essential for providing the demand pull necessary for infrastructure that will enable developing *advanced* biofuels. *See* POET July 27 Comments, at 5-8; *see also* BIO Comment on EPA's Proposed 2014-2016 Standards for the Renewable Fuel Standard Program, at 32-36 (July 27, 2015) ("EPA's proposed rule will destroy incentives to invest in development of advanced and cellulosic biofuels by eliminating both incentives for new methods of compliance beyond E10 and the profits of conventional biofuel producers who are most likely to be first-adopters of the technology.").

[396] Nathan Miller et al., International Council on Clean Transportation, *Measuring and Addressing Investment Risk in the Second-Generation Biofuels Industry*, at 25 (Dec. 2013), *at* http://www.theicct.org/sites/default/files/publications/ICCT_AdvancedBiofuelsInvestmentRisk_Dec2013.pdf.

[397] Bruce Babcock & Wei Zhou, Impact on Corn Prices from Reduced Biofuel Mandates, Iowa State University CARD Working Paper 13-WP 543, at 10 (Nov. 2013), at http://www.card.iastate.edu/publications/dbs/pdffiles/13wp543.pdf.

voluntarily, as shown by the actions of the oil industry to date.[398] Further, under the RFS, the cellulosic volume requirement is subject to adjustment each year based on projected production.[399] The cellulosic volume requirement is therefore an unreliable mechanism for piercing the blendwall; the conventional renewable fuel volume requirement is the only reliable mechanism to exert the necessary force.

In short, the base renewable RVO provides a critical platform for the development of advanced biofuels, and undercutting conventional biofuels as EPA proposes will cripple the future of cellulosic ethanol in the United States. It is therefore critically important that EPA not undermine the best tool for incentivizing consumption of higher ethanol blends—the conventional renewable fuel requirement.

B. The Statutory Volumes Would Benefit The Environment More Than EPA's Proposed Volumes

EPA professes to be well aware that Congress intended for the RFS program to reduce greenhouse gas emissions, and to be supportive of that objective. For example, EPA observed in its prior proposed 2014 rule that one of the "central policy goals underlying the RFS program" is "reductions in greenhouse gas emissions."[400] EPA previously concluded that the RFS program would accomplish this goal by reducing greenhouse gas emissions by 4.15 billion tons over 30 years, and that "the impact of increased volumes of renewable fuel is to lower the risk of climate change."[401] In the current proposed rule, EPA emphasizes that "we do not believe that it would be consistent with the energy security and greenhouse gas reduction goals of the statute to reduce the applicable volumes of renewable fuel set forth in the statute absent a substantial justification for doing so."[402] Yet EPA proposes to do just that, and in doing so risks substantial environmental harm.

Using less ethanol in fuel, as EPA proposes, will lead to more greenhouse gas emissions. The Department of Energy has determined that, relative to petroleum gasoline, corn-based ethanol production and use reduces greenhouse gas emissions by up to 52% on a life-cycle analysis basis.[403] Similarly, researchers at the U.S. Department of Energy's Argonne National Laboratory (ANL) determined that, relative to petroleum gasoline, corn-based ethanol can reduce greenhouse gas emissions by up to 19-48% on a life-cycle analysis basis.[404] The ANL study is

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[398] *See supra* pp.49-50; *supra* notes 149, 337.

[399] 42 U.S.C. § 7545(*o*)(7)(D)(i).

[400] 78 Fed Reg. at 71,778.

[401] 2010 RFS2 Impact Analysis, 75 Fed. Reg. at 14,798-14,799.

[402] 80 Fed. Reg. at 33,110.

[403] *See* U.S. Dept. of Energy, Alternative Fuels Data Center, *at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html (last visited June 22, 2015).

[404] Michael Wang et al., Argonne National Labs, *Well-to-Wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane, and cellulosic biomass for U.S. use*, at 9 table 7 (Dec. 13, 2012), *at* http://iopscience.iop.org/1748-9326/7/4/045905/pdf/1748-9326_7_4_045905.pdf.

noteworthy because unlike other studies, which were not harmonized with regard to methodologies and assumptions, the ANL study used a consistent modeling platform to examine greenhouse gas emissions, taking account of the full life cycle of emissions, including emissions associated with ethanol plants, fertilizer production, and corn farming.[405]

The ramifications of EPA's proposed rule for the RFS2 program overall would be significant. When it issued the RFS2 Final Rule in 2010, EPA estimated that the program would reduce greenhouse gas emissions by 138 million metric tons.[406] The current proposed rule, however, would undercut the RFS2 program by permitting the release of 6.3 million metric tons of additional greenhouse gas emissions over the 2014-2016 period when compared with Congress' intended volumes.[407] Moreover, the emissions benefits of ethanol are neither conjectural nor limited to the distant future. Analysis of 2014 data shows that current GHG emissions from corn ethanol plants range from 28% to 41% lower than emissions from gasoline plants—already lower than EPA had projected for 2022.[408]

The proposal's environmental effects would be particularly harmful with respect to cellulosic biofuels. To qualify as cellulosic biofuel, the fuel must have "lifecycle greenhouse gas emissions … at least 60 percent less than" "the average lifecycle greenhouse gas emissions … for gasoline or diesel … sold or distributed as transportation fuel in 2005."[409] The Department of Energy has determined that "[c]ellulosic ethanol use could reduce GHGs by as much as 86%."[410] But as discussed above, EPA's proposed reductions in volume requirements would impede the transition to cellulosic biofuel.

One reason that ethanol is so environmentally advantageous relative to gasoline is that corn growers have greatly improved the efficiency, minimized the local environmental impact of their operations, and adopted new technologies at ethanol facilities at a faster rate than anticipated by EPA.[411] In the last 30 years, per bushel land use has been reduced by 30 percent,

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405 *Id*. at 7-9. The ANL and other studies sometimes attribute emissions associated with "land use change" to corn ethanol production. Growth Energy does not believe that scientific evidence supports theories that "land use change" emissions are in fact associated with corn ethanol. However, for consistency with the underlying methodologies "land use change" was retained in this net emissions analysis.

406 *See* Renewable Fuel Standard Program Regulatory Impact Analysis, EPA-420-R-10-006, Section 5.5, at 964 (Feb. 2010).

407 Air Improvement Resource, Inc., *EPA Proposed Renewable Fuel Standards for 2014-2016: Lost Greenhouse Gas Benefits from Conventional Biofuel* (July 27, 2015) (attached as Exhibit 7).

408 *See Emissions Reductions from Current Natural Gas Corn Ethanol Plants* (attached as Exhibit 6). Again, *see supra* note 405, "land use change" emissions were retained in this analysis solely for purposes of consistency with EPA's RFS2 analysis.

409 42 U.S.C. § 7545(o)(1)(C) & (E).

410 *See* U.S. Dept. of Energy, Alternative Fuels Data Center, *at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html (last visited June 22, 2015).

411 *Id*.

erosion by 67 percent, irrigation by 53 percent, and energy use by 43 percent.[412] Production of a barrel of hydraulically fractured oil requires nearly twice as much water as production of a barrel of ethanol.[413]

C. The Proposed Volume Requirements Would Harm The Economy, Especially In Rural Areas

So far, as Congress intended, strong growth in renewable fuels has lifted many economic boats. EPA's proposal would halt that growth and the attendant economic development.

The ethanol industry is a significant contributor to the U.S. economy, particularly in the Midwest and rural areas. In 2014, ethanol production alone accounted for approximately 11,000 direct jobs and 90,000 jobs overall, while the ethanol industry as a whole accounted for about 84,000 direct jobs and 379,000 jobs overall.[414] Ethanol production generated almost $10 billion in income and contributed about $26 billion to GDP in 2014, while the ethanol industry as a whole generated almost $27 billion in income and contributed nearly $53 billion to GDP.[415] The Department of Energy, citing an analysis by the Renewable Fuels Association (RFA), found that the economic effects in 2013 were equally substantial: "ethanol production in 2013 added more than 87,000 direct jobs across the country, $44 billion to the gross domestic product, and $30.7 billion in household income."[416]

One reason the ethanol industry has such a significant effect on the broader economy is that spending attendant to ethanol production flows through the entire economy. For example, in 2014 alone, the ethanol industry spent nearly $28 billion on raw materials, other inputs, and goods and services necessary to produce 14.2 billion gallons of ethanol.[417] The renewable fuels industry is also a catalyst for research and development, particularly with regard to developing the advanced biofuels feedstock and technology needed to meet the statutory targets for

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[412] *See* Field to Market (The Keystone Alliance for Sustainable Agriculture), *Environmental and Socioeconomic Indicators for Measuring Outcomes of On-Farm Agricultural Production in the United States*, at 10 (Dec. 2012), *at* https://www.fieldtomarket.org/report/national-2/PNT_SummaryReport_A17.pdf.

[413] *See* Growth Energy, *Oil and Water Don't Mix*, *at* http://www.growthenergy.org/news-media/blog/oil-and-water-dont-mix/ (last visited July 21, 2015).

[414] *See* John M. Urbanchuk, ABF Economics, *Contribution of the Ethanol Industry to the Economy of the United States in 2014*, at 3 (Feb. 2015), *at* http://ethanolrfa.3cdn.net/94596be2e72251b795_nkm6ii26n.pdf.

[415] *Id.* at 9, Table 2.

[416] U.S. Dept. of Energy, Alternative Fuels Data Center, *at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html (last visited July 21, 2015), citing http://www.ethanolrfa.org/page/-/rfa-association-site/Resource%20Center/2014%20Ethanol%20Industry%20Outlook.pdf?nocdn=1.

[417] Urbanchuk, *Contribution of the Ethanol Industry to the Economy of the United States in 2014*, *supra* note 414, at 4, Table 1 (Feb. 2015).

cellulosic biofuels, with estimated research and design expenditures for biofuels in the United States totaling $1.8 billion in 2014.[418]

Increased income generated through ethanol growth has important collateral benefits. For example, in 2014, the income generated through the ethanol industry yielded $4.6 billion in state and local tax revenue.[419] That tax revenue can be used to support improvements in schools, roads, and other local services, facilities, and infrastructure—benefits that are especially important for the rural areas where much of the ethanol industry is concentrated.

The proposed rule would upend the industry that makes these important contributions to the U.S. economy, and harm the farmers and others who depend upon that industry. Unlike the oil industry, which can respond nearly instantaneously to changes in supply and demand, farmers decide how much corn to plant only once a year. Based in large part on the reasonable expectation that Congress's prescribed volume requirements would apply, America's farmers have made significant long-term investments in land, equipment, and seed to produce and bring to market sufficient amounts of corn to meet the statutory volumes.[420]

The broader economic impact of the proposed rule would also be profound, particularly in rural communities. The amount of available ethanol capacity in the United States exceeds the proposed volume of conventional biofuels in 2016; as a result, a reduced mandate would result in either the idling or permanent closure currently operating facilities, or the continued idling of facilities that are not currently producing, but would be if the volume requirements were increased.[421] Idling these ethanol facilities—which are often important economic engines in rural communities—would cause a series of cascading economic effects. Plants would lose operating profits generated by the current level of production, lay off workforces, cut back or cease inputs from local vendors, and reduce their local tax payments.[422]

Specifically, a recent study found that EPA's proposal would result in the closure or continued idling of approximately 13 ethanol plants, along with the direct loss of 800 jobs at those facilities and reduced revenues from ethanol and co-product sales of $2.6 billion.[423] These

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[418] *Id.* at 5.

[419] *Id.* at 11.

[420] The proposed rule is estimated to reduce corn demand by 1.3 billion bushels. *See Iowa Corn Growers Association Criticizes EPA Announcement on the Renewable Fuel Standard* (May 29, 2015), *at* http://www.iowacorn.org/index.cfm/30321/35759/iowa_corn_growers_association_criticizes_epa_announcement_on_the_renewable_fuels_standard. The USDA projects 2015/16 corn prices to average $3.75 per bushel, resulting in a $4.875 billion loss for corn growers. *See* Iowa State University, *Iowa Farm Outlook & News*, available at http://www2.econ.iastate.edu/ifo/.

[421] Edgeworth Economics, *The Impact of an RFS Waiver on the Ethanol Industry and Broader Economy in 2016*, at 1 (July 27, 2015) (attached as Exhibit 8).

[422] *Id.*at 1-2.

[423] *Id.* at 3.

economic impacts would fan through the local, primarily rural communities, ultimately resulting in the indirect loss of approximately 3,200 jobs in ethanol producing regions.[424] State and local government budgets would be harmed to the tune of approximately $31 million in lost tax revenues in regions hosting ethanol plants.[425]

D. Adhering to the Statutory Volume Requirements Would Not Appreciably Raise Retail Gasoline Prices

The proposed volume requirements could hurt American consumers at the gas pump. In fact, adhering to the volume requirements prescribed by Congress would not cause retail gasoline prices to rise appreciably, if at all, for two primary reasons. First, blending ethanol into gasoline tends to result in a significant *reduction* in retail gasoline prices. Second, as EPA itself has found, even if volume requirements caused RIN prices to increase, any such increase would have no discernible effect on retail gasoline prices.

First, focusing on potential costs from the marginal consumption of ethanol risks obscuring the massive *savings* increased ethanol consumption could provide to gasoline consumers. There is substantial evidence that blending ethanol lowers retail gas prices. One academic study found that the growth in ethanol production from January 2000 to December 2011 reduced wholesale gasoline prices by an average of 29 cents per gallon throughout the United States, in part due to the substantially increased overall volume of fuel available.[426] When crude oil prices are high, the marginal impact of ethanol can be even greater—as high as $1.09 per gallon in 2011.[427] Another analysis estimated that the RFS "cut annual consumer expenditures in 2013 between $700 billion and $2.6 trillion," which "translates to consumers paying between $0.50 and $1.50 per gallon less for gasoline."[428]

More to the point, the reduced blending of ethanol called for by EPA's proposal would cost U.S. drivers billions of dollars in 2016 alone. One recent analysis determined that reducing ethanol consumption by 1 bil gal—as EPA's proposal for 2016 would do—"will raise [gasoline prices by 4.1 cents per gallon."[429] Another study estimated that consumers saved an average of

[424] *Id.* at 4.

[425] *Id.*

[426] Xiaodong Du & Dermot J. Hayes, *The Impact of Ethanol Production on U.S. and Regional Gasoline Markets: An Update to 2012*, Iowa State University CARD Working Paper 12-WP 528, at 5, 9 (May 2012), *at* http://www.card.iastate.edu/publications/dbs/pdffiles/12wp528.pdf.

[427] *Id.* The study found that slightly lower energy density of ethanol had virtually no effect on the overall reduction gasoline prices caused by blending in ethanol. *Id.* at 5-6.

[428] Philip K. Verleger, Jr., *Commentary: Renewable Fuels Legislation Cuts Crude Prices* (Sept. 23, 2013), *at* http://www.pkverlegerllc.com/assets/documents/130923_Commentary1.pdf.

[429] *See* Renewable Fuels Association, Economic and GHG Impacts of EPA's 2014-2016 Proposed Rule at 1, *at* http://www.ethanolrfa.org/page/-/RFA%20Impact%20of%20EPA%20Proposal_2014-2016.pdf?nocdn=1.

six cents per gallon of gasoline for every billion gallons of ethanol produced.[430] Therefore, with EIA estimating that U.S. drivers will consume 137 bil gal of gasoline in 2016, the EPA's proposal could cost consumers between $5.6 and $8.2 billion.

Second, any increase in RIN prices would not change this analysis. As EPA has found, higher RIN prices do not result in higher retail transportation fuel prices.[431] This is primarily due to the lower net cost of renewable fuels enabled by high RIN prices: "While higher RIN prices increase the cost of RFS compliance for obligated parties purchasing separated RINs, these obligated parties generally recover these costs in the price of their petroleum blendstocks."[432] Other studies have reached the same conclusion: although RIN prices can at times increase in correlation with retail gasoline prices, increased RIN prices do not *cause* an in increase in gasoline prices.[433] To the extent retail prices do increase, any movement is modest at most. One recent study found that RIN prices in the range of $0.75 to $1.50 could incentivize consumption of 1-2 billion gallons of E85, and doing so would result in an E10 price increase of only 0.5-1.3%.[434]

RIN prices have a far less significant effect on gasoline prices than the oil industry claims in part because obligated parties do not purchase all of their required RINs on the open market—far from it. Obligated parties obtain a large percentage of their RINs directly by blending renewable fuel themselves, or indirectly through preexisting contractual relationships with blenders. One study estimated that between 70 and 85 percent of the RINs attached to ethanol used in the transportation-fuel distribution chain were either directly separated by obligated parties or indirectly transferred to them under contractual arrangements.[435]

Ultimately, the claim that the RFS increases gas prices is a misleading distraction. Wholesale ethanol has historically traded well below the price of wholesale gasoline. While modest short-term investments will be needed to overcome the E10 blendwall, those one-time costs will be dwarfed by the long-term benefit to consumers, who will be able to save money on

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[430] Hassan Marzoughi & P. Lynn Kennedy, *The Impact of Ethanol Production on the U.S. Gasoline Market*, at 15 (Feb. 2012), *at* http://ageconsearch.umn.edu/bitstream/119752/2/Kennedy%20Marzoughi%20SAEA%20-%202012.pdf.

[431] *See* Report of Dallas Burkholder, Office of Transportation and Air Quality, EPA-HQ-OAR-2015-0111-0062, *A Preliminary Assessment of RIN Market Dynamics, RIN Prices, and Their Effects*, at 1, 31 (May 14, 2015) ("Burkholder Report"); *see also* 80 Fed. Reg. at 33,119 n.49.

[432] Burkholder Report, *supra* note 431, at 31.

[433] Informa Economics, *Analysis of Whether Higher Prices of Renewable Fuel Standard RINs Affected Gasoline Prices in 2013*, Whitepaper Prepared for the Renewable Fuels Association, at 1, 7 (Jan. 2014) ("2014 Informa Study") (attached as Exhibit 9).

[434] *See Impact on Motor Fuel Prices* at 8 (attached as Exhibit 1).

[435] *See* Informa Economics, *Retail Gasoline Price Impact of Compliance with the Renewable Fuel Standard*, Whitepaper Prepared for the Renewable Fuels Association, at 5 (Mar. 2013) (attached as Exhibit 10).

every trip to the pump by choosing higher-ethanol blends. The more ethanol in the transportation-fuel supply, the more money American drivers will save.

E. Adhering to the Statutory Volume Requirements Would Have Minimal Effect On Feed Prices And Retail Food Prices

The Congressional Budget Office (CBO) found that adhering to the statutory volumes through 2017 would raise corn prices only minimally—about $0.25 per bushel—in part because corn production would be expected to increase.[436] That small estimated increase pales in comparison to the recent precipitous *decreases* in feed prices. In 2014, farmers produced the largest corn crop in history, as 14.2 billion bushels were harvested at a record rate of 171 bushels per acre.[437] This record crop came despite farmers' harvesting 5 percent *fewer* acres than in 2013.[438] The result of such historic production is abnormally low—not high—prices. Since November 2012, feed prices have plummeted, with corn feed prices down nearly 55%.[439] In the context of such historically low prices, any minimal increase in feed prices associated with meeting the statutory volumes would be insignificant.

The statutory volumes would likewise have little impact on livestock and poultry production. Only the starch from corn is used for the production of ethanol; the entirety of the protein, and vitamins, as well as much of the residual fats derived from the corn, is used in livestock and poultry feed.[440] Further, the historic low feed prices have led to improved returns for livestock and poultry producers.[441] For example, one academic study found that much

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[436] Congressional Budget Office, *The Renewable Fuel Standard: Issues for 2014 and Beyond*, at 14 (June 2014) (hereinafter CBO, *Renewable Fuel Standard*), *at* https://www.cbo.gov/sites/default/files/45477-Biofuels2.pdf.

[437] *See Final 2014 Crop Report Shows Record Corn and Soybean Harvest*, N.Y. TIMES (Jan. 12, 2015), *at* http://www.nytimes.com/aponline/2015/01/12/business/ap-us-crop-update.html

[438] *Id.*

[439] USDA, *Feed Outlook: June 2015*, Table 3 ("Cash Feed Grain Prices") (listing November 2012 corn prices as $7.39-$8.18 and May 2015 corn prices as $3.49-$3.67; November 2012 sorghum prices as $13.10 and February 2015 as $10.70; November 2012 barley prices as $5.49-$7.23 and May 2015 as $2.76-6.23), *at* http://www.ers.usda.gov/publications/fds-feed-outlook/fds-15f.aspx. Corn prices fell nearly 35 percent from 2013 to 2014 alone. *See* Urbanchuk, *Contribution of the Ethanol Industry to the Economy of the United States in 2014*, *supra* note 414, at 4.

[440] *Don't Blame Ethanol and the RFA for High Food Prices*, WALL ST. JOURNAL, May 10, 2015, *available* at http://www.wsj.com/articles/dont-blame-ethanol-and-the-rfa-for-high-food-prices-1432585106. Some corn oil is also used as a feedstock for biodiesel production, providing substantial greenhouse gas benefits in comparison to other feedstocks.

[441] Michael Jewison U.S. Dept. of Agriculture, *Outlook for Livestock and Poultry in 2015*, at 4 (Feb. 20, 2015) ("Feed costs fell to levels not seen in several years and producers responded to strong returns and increased finishing barn space by feeding hogs to record weights."), *at at* http://www.usda.gov/oce/forum/2015_Speeches/Livestock_Poultry.pdf.

cheaper feed is fueling expansion in the pork industry, and profits for 2014 were estimated at $27 per head—the most profitable year in a decade for pork producers.[442] In 2015, total livestock and poultry production is expected to expand by more than 3 percent, marking the largest year-over-year percentage increase in livestock production since 2002.[443] At most, adhering to the statutory volumes would result in a modest softening in these growing profits.

Denying an RFS waiver would also have little impact on retail food prices. Historically, as USDA Chief Economist Dr. Joseph Glauber testified to Congress, "increased biofuels production has likely had only a small effect on U.S. retail food prices."[444] Only approximately 15 percent of U.S. corn supply is used for food, and corn and food made with corn account for only a small fraction of total U.S. spending on food. As a result, the CBO concludes that adhering to the statutory volumes would increase total U.S. spending on food in 2017 only approximately one-fifth of one percent.[445]

On the other hand, EPA's proposed volume requirements would result in *higher* food prices. As explained above, reducing ethanol consumption would significantly raise fuel prices for consumers. The World Bank has found that "food prices respond strongly to … crude oil prices"; while many factors influence food prices, "[c]rude oil prices matter the most," with oil prices accounting for almost two-thirds of the food price changes from 1997 to 2012.[446] Indeed, "increases [in] petroleum prices have [approximately] twice the impact on consumer food prices as equivalent increases in corn prices."[447] Whereas "corn prices affect only a segment of consumer foods—livestock, poultry, and dairy"—"petroleum and energy prices affect *virtually all aspects* of agricultural raw material transportation, processing, and distribution of all finished consumer products."[448] As discussed above, EPA's proposal would substantially raise fuel prices for consumers. That increase in turn would raise food prices for consumers as well.

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[442] *See* National Hog Farmer, *Cheaper Feed Fuels Hog Expansion* (Jan. 7, 2014), *at* http://nationalhogfarmer.com/nutrition/cheaper-feed-fuels-hog-expansion.

[443] *See* Jewison, *Outlook for Livestock and Poultry in 2015*, *supra* note 441, at 1.

[444] Statement of Dr. Joseph Glauber, Chief Economist, U.S. Dep't of Agriculture, Before the House Comm. on Energy and Commerce, Subcomm. on Energy and Power, at 1 (June 26, 2013), *at* http://www.usda.gov/oce/newsroom/archives/testimony/2013files/STATEMENT_OF_JOSEPH_GLAUBER_06-26-2013.PDF.

[445] Congressional Budget Office, *Renewable Fuel Standard*, *supra* note 436, at 14-15.

[446] *See* John Baffes & Allen Dennis, *Long-Term Drivers of Food Prices*, The World Bank Policy Res. Working Paper 6455 (May 2013), at 3, 14, *at* http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/05/21/000158349_20130521131725/Rendered/PDF/WPS6455.pdf.

[447] *See* John M. Urbanchuk, *The Relative Impact of Corn and Energy Prices in the Grocery Aisle*, at 4 (June 2007), *at* http://ethanolrfa.org/page/-/objects/documents/1157/food_price_analysis_-_urbanchuk.pdf?nocdn=1.

[448] *See id*. at 5.

F. The Proposed Waiver Would Impede The Nation's Path To Energy Independence

Undermining the RFS, as EPA's proposal would do, would have negative effects on the Nation's energy independence, contrary to the express goal of the EISA to "move the United States toward greater energy independence and security"—after all, its full name is the Energy Independence and Security Act.[449]

As President George W. Bush, who signed the EISA, observed:

> Part of the problem is that some of the nations we rely on for oil have unstable government, or agendas that are hostile to the United States. These countries know we need their oil, and that reduces our influence, our ability to keep the peace in some areas. And energy supply is a matter of national security.[450]

The U.S. Department of Energy has more recently stated that "[d]epending heavily on foreign petroleum supplies puts the United States at risk for trade deficits and supply disruption."[451]

The RFS plays a crucial role in cushioning the impact of price disruptions due to shocks in the price and supply of oil, by stimulating increased production and consumption of domestic renewable fuels. As was anticipated in the RFS, ethanol in particular has been critical to the United States' improved energy independence. The surge in ethanol production due to the RFS has increased the volume of domestic fuel available by about 10%, and allowed the United States to switch from a net importer of finished gasoline to a net exporter.[452] In doing so, the RFS has decreased U.S. dependence on foreign energy sources and lowered gas prices.[453] In 2005—just prior to implementation of the RFS—60% of petroleum products were imported, but this was reduced dramatically to 33% in 2013.[454] As found by the Department of Energy, petroleum imports would have been markedly higher (41%) without ethanol.[455] In fact, ethanol production

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[449] 121 Stat at 1492.

[450] Transcript of President George W. Bush, *Energy Policy & America's Dependence on Oil: Address to the Renewable Fuels Association*, WASH. POST (Apr. 25, 2006), *at* http://www.washingtonpost.com/wp-dyn/content/article/2006/04/25/AR2006042500762.html.

[451] *See* U.S. Dept. of Energy, Alternative Fuels Data Center, *at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html (last visited June 22, 2015).

[452] Urbanchuk, *Contribution of the Ethanol Industry to the Economy of the United States in 2014*, *supra* note 414, at 5.

[453] Philip K. Verleger, Jr., *RFS Kept Gas Prices Down*, The Hill, Jan. 23, 2014, *at* http://thehill.com/blogs/congress-blog/energy-environment/196135-rfs-kept-gas-prices-down.

[454] *See* U.S. Dept. of Energy, Alternative Fuels Data Center, *at* http://www.afdc.energy.gov/fuels/ethanol_benefits.html (last visited July 21, 2015).

[455] *Id.*

accounts for 58% of the fuel supply growth between 2005 and 2011.[456] Without the RFS, there would be little competitive alternative to imported oil.

As in other areas, EPA merely pays lip service to its statutory obligations. It observes, "By aiming to diversify the country's fuel supply, Congress also intended to increase the Nation's energy security."[457] But, as explained above, EPA's proposal would in effect maintain current levels of production and consumption of ethanol-based renewable fuels and therefore would fail to advance the goal of ensuring the Nation's energy independence and security.

The recent increase in domestic oil production has not changed this fundamental dynamic. Despite significant increases in domestic oil production, the United States still imports more than 9 million barrels per day of foreign oil,[458] and the price of oil has also once again begun rising.[459] The only effective strategy for improving the United States' energy security is to reduce our dependence on oil by stimulating further growth in renewable fuels. But decreasing the volume requirements for domestic renewable fuels in the U.S. market, as EPA proposes, would fail to achieve this goal. In short, the RFS "set a goal to replace oil from around the world. The best way and the fastest way to do so is to expand the use of ethanol."[460]

XI. CONCLUSION

For the reasons set forth above, EPA should not grant a general waiver and should not reduce the statutory renewable fuel volume requirements further than the proposed cellulosic waiver flow-through would allow. Specifically, EPA should set the renewable fuel volume requirement to 17.08 bil for 2014, 17.90 for 2015, and 18.40 for 2016. At a minimum, though, EPA should raise its proposed renewable fuel volume requirements to account for the higher projected E10 blendwall, the correct treatment of exported ethanol, and the proper treatment of carryover RINs as supply for purposes of the general waiver authority. Unless EPA takes these actions, EPA's 2014-2016 RFS rule will fail to spur any of the growth in renewable fuel production and use that Congress sought to achieve through the RFS.

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[456] *Id.* at 9.

[457] 80 Fed. Reg. at 33,101.

[458] *See* EIA, *Weekly U.S. Imports of Crude Oil and Petroleum Products* (showing an average of 9,105,000 barrels of oil imported per day thus far in 2015), *at* http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WTTIMUS2&f=W.

[459] *See* EIA, *Weekly Cushing, OK WTI Spot Price FOB* (showing a price increase of 23 percent from January to May 2015), available at http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=W.

[460] Bush, *supra* note 450.

Growth Energy Comments on EPA's Notice of Receipt of Petitions for a Waiver of the 2019 and 2020 Renewable Fuel Standards

Docket # EPA–HQ–OAR–2020-0322

Exhibit 14

THE IMPACT OF AN RFS WAIVER ON THE ETHANOL INDUSTRY AND BROADER ECONOMY IN 2016

Edgeworth Economics

July 27, 2015

The U.S. Environmental Protection Agency's (EPA's) proposal to set the Renewable Fuel Standard (RFS) biofuel mandates below the statutory levels can be expected to cause a reduction in demand for biofuels, relative to a scenario in which the statutory mandates were maintained. Table 1 shows EPA's proposed requirements, compared to the statutory mandates. Table 1 also shows these totals if the requirement for cellulosic ethanol is excluded and the statutory requirement for biomass-based diesel (BBD) is assumed to equal EPA's proposed volumes. Under this second scenario, EPA's proposal implies a reduction in total biofuels consumption of as much as 0.81 billion gallons in 2016.[1] EPA's proposed level for advanced biofuels exceeds the statutory mandate; therefore meeting the implied "target" for conventional biofuels actually would require a larger increase in the volume of that fuel type—an additional 1.0 billion gallons in 2016.

Table 1
Comparison of Statutory and Proposed Biofuel Mandates in 2016
(billion ethanol-equivalent gallons)

	Statutory	Proposed
Cellulosic	4.25	0.206
Biomass-Based Diesel	≥1.0	1.8
Advanced (inclusive of Cellulosic and BBD)	7.25	3.4
Total	22.25	17.4
Implied Conventional (Total less Advanced)	15.0	14.0
Exclude Cellulosic and Assume Statutory Requirement for BBD Equals EPA's Proposal		
Advanced	3.0	3.19
Total	18.0	17.19
Implied Conventional (Total less Advanced)	15.0	14.0

Source: EPA NPRM, May 29, 2015.
Note: Biomass-based diesel volumes are in actual gallons.

There are presently 212 ethanol production facilities in the U.S. with total capacity in the range of 15.0 to 15.4 billion gallons annually, with another three facilities totaling 0.1 billion gallons of capacity presently under construction.[2] Since the amount of available capacity in the U.S. to produce ethanol exceeds the quantity for the implied "target" for conventional biofuels in 2016, a reduction in the requirements implies either the idling or permanent closure of presently operating facilities or the continued idling of facilities that are not producing at present, but which would be operating if requirements were increased.[3]

[1] The figure of 0.81 billion gallons is based on an assumption that compliance with higher mandate levels would be met by increases in production and consumption, as opposed to a drawdown of banked RINs.

[2] The Renewable Fuels Association (RFA) estimates operating capacity at 199 open facilities of 15.0 billion gallons and nameplate capacity at all 212 facilities of 15.4 billion gallons. *See* ethanolrfa.org/bio-refinery-locations.

[3] Again, assuming compliance is accomplished through increased production and consumption of conventional ethanol, rather than drawdown of banked RINs or additional supplies of other biofuels.

The most direct economic impact from a decline in demand for ethanol is felt at those ethanol production facilities that would be forced to idle or close. This would cause a series of adverse economic impacts to the local regions. First, these plants would lose any operating profits generated by current levels of production. In addition, the plants would be expected to lay off some or all of their workforces, cease to purchase inputs from local vendors, and reduce tax payments to local jurisdictions. Finally, additional economic activity would be lost to the host regions when the reduction in revenues causes employees and vendors to reduce their own local purchases from restaurants, retail establishments, etc. (the "multiplier" effect).

As shown in Figure 1, most U.S. ethanol capacity is located in the Midwest.[4] It would be difficult to predict which particular facilities would cease operations in response to a decrease in ethanol demand. However, we can estimate economic impacts based on a "typical" facility with the following characteristics:

- Annual production capacity/output: 75.4 million gallons.[5]
- Employment: 0.8 employees per million gallons of ethanol produced annually, or about 60 employees for an average facility.[6]
- Annual revenues from sales of ethanol and co-products: approximately $2.60 per gallon of ethanol produced or $196 million per year.[7]

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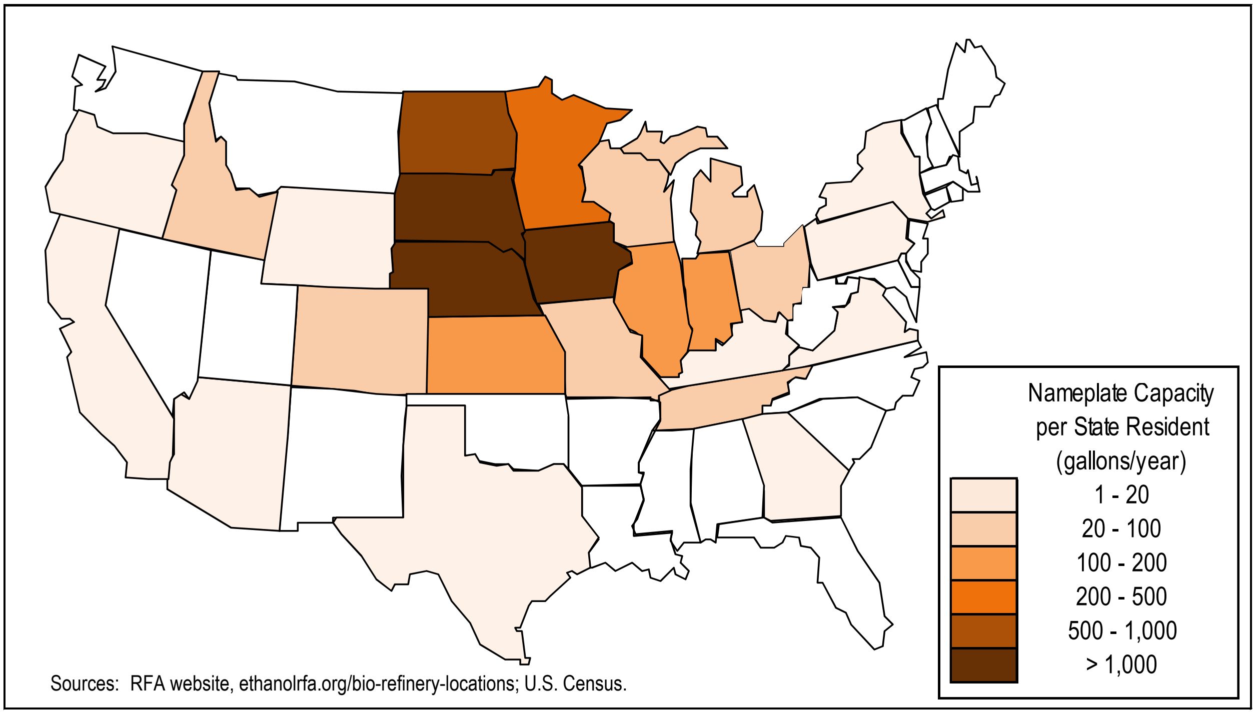
[4] 73 percent of U.S. capacity is located within Iowa, Nebraska, Illinois, Indiana, Minnesota, and South Dakota. [RFA website, ethanolrfa.org/bio-refinery-locations] In Figure 1, we show capacity on a per-capita basis to provide a more appropriate measure of the relative importance of ethanol production to the local economies.

[5] *See* www.ethanolrfa.org/pages/statistics.

[6] Based on various sources, including: John Urbanchuk, "Contribution of the Ethanol Industry to the Economy of the United States," Cardno ENTRIX, prepared for the Renewable Fuels Association, February 2, 2012; David Swenson, "Understanding Biofuels Economic Impact Claims," Iowa State University, April 2007; public SEC filings; and proprietary data provided by members of Growth Energy.

[7] Based on 2014 data from public SEC filings and proprietary information provided by members of Growth Energy.

Figure 1
U.S. Ethanol Operating Capacity, per State Resident



Based on these figures, EPA's proposal, which would cause a reduction in the statutory "target" for conventional biofuel by 1.0 billion gallons in 2016, will result in the closure or continued idling of approximately 13 ethanol plants and the loss of 800 jobs at those facilities, with reduced revenues from ethanol and co-product sales of $2.6 billion.

In addition to these direct effects, the regions that host ethanol production facilities would experience additional reductions in economic activity stemming from reduced purchases of locally-sourced inputs (the "indirect" impact) and reduced spending by facility employees and local vendors (the "induced" impact). These additional economic impacts are generated by the multiplier effect, which results from the recycling of business revenues and household income within the local region.

A number of researchers have developed estimates of the relevant multipliers for the ethanol industry. These estimates depend on a number of factors, including:[8]

- *The relevant region* – When indirect/induced economic effects are calculated for larger and/or more developed regions, the multipliers tend to be larger, since a greater fraction of local business revenues and household income will tend to be re-spent within that region.
- *Impact on local farmers* – The multiplier estimate depends on the assumptions regarding the change in crop prices in response to an ethanol plant closure. If local crop prices fall, farmers will experience a reduction in income and may alter their planting behavior.

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[8] See, for example, Susan Christopherson and Zachary Sivertsen, Cornell University, *Economic Policy Makers Beware: Estimating the Job Impact of Public Investment in Biofuel Plants* (working paper, Dec. 12, 2009); Dave Swenson, Iowa State University, *Input-Outrageous: The Economic Impacts of Modern Biofuels Production*, (June 2006).

- *Economies of scale* – Reduced spending by the ethanol industry on local utilities and the transport industry may result in additional reduced economic activity, but the total effect may not be proportional to the change in ethanol output, due to scale economies in those other industries.

Plausible estimates for the overall multiplier effect for employment applicable to the ethanol industry range from about 2 (indicating a total impact on employment equal to two times the direct employment impact) to about 7.[9] Based on our review of the literature, we conclude that a value of 4 is a reasonable figure from this range. Applying this multiplier to the direct employment impacts calculated above, we calculate that a waiver of the RFS mandate would result in a loss of approximately 3,200 jobs in ethanol producing regions, based on the 1.0 billion gallon estimate.

Finally, reduced economic activity caused by plant closures would have adverse effects on state and local government budgets due to reductions in tax collections on property, sales, and wages. Based on the previously cited research, we estimate that a waiver of the RFS mandate would result in a loss of approximately $31 million in tax revenues to the regions hosting ethanol plants.[10]

Table 2 summarizes our calculations regarding direct and overall economic impacts based on a reduction of up to 1.0 billion gallons of conventional ethanol production.

Table 2
Economic Impacts Associated with Closed Ethanol Production Facilities
Caused by a Reduction of the RFS Mandate in 2016

Decline in Ethanol Production	up to 1.0 billion gallons
Impacts based on 1.0 billion gallon reduction	
Number of Closed Facilities	13
Lost Revenues at Closed Facilities	$2.6 billion
Lost State/Local Tax Revenues	$31 million
Reduced Employment at Closed Facilities	800 jobs
Overall Reduced Employment in Ethanol Producing Regions	3,200 jobs

[9] See, for example, Urbanchuk, February 2, 2012, *op. cit.*; Swenson, April 2007, *op. cit.*; Christopherson and Sivertsen, December 12, 2009, *op. cit.*; and Swenson, June 2006, *op. cit*.

[10] Swenson [June 2006, *op. cit*.] calculates regional indirect tax revenues generated by economic activity at the ethanol plant and through the multiplier effect equal to approximately 1.2 percent of plant revenues.