Blending In

The Role of Renewable Fuel in Achieving Energy Policy Goals

PREPARED FOR

growth energy™
America's Ethanol Supporters

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Executive Summary

On July 21, 2017 the U.S. Environmental Protection Agency (EPA) published in the Federal Register the 2018 proposed mandated volumes for all categories of renewable fuels, along with the 2019 biomass-based diesel volume requirements. While EPA did not propose to exercise general waiver authority to limit overall renewable fuel, EPA did ask for comment on using general waiver authority:

> Based on a preliminary evaluation of the availability of renewable fuel in the market, regarding which we seek public comment, EPA is not proposing to use the general waiver authority to further reduce volumes for 2018. However, EPA solicits comments on whether it is appropriate to exercise the general waiver authority and will evaluate comments and updated data in considering whether such an approach is warranted. (82 FR 34213)

The EPA proposal also cited the observed increase in the imports of certain renewable fuels as motivation to request comments regarding the use of waiver authorities to counteract any perceived diminution in U.S. energy independence and security (82 FR 34212).

Examining the appropriateness of exercising waiver authority as requested by the proposed rule can 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 2018 standards roughly maintain the current contribution of renewable fuels in the nation's motor 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 current Administration's stated energy policy.

Our primary conclusions are:

- The presence of significant amounts of ethanol 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.
- Small amounts of renewable fuel imports have occurred recently primarily due to the requirements under the California Low Carbon Fuel Standard (LCFS), and not the RFS. Changing the required volumes of the RFS will not affect these import volumes, which are dwarfed by the overall domestic production of renewable fuels.
- 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 21, 2017 the U.S. Environmental Protection Agency (EPA) published in the Federal Register the proposed 2018 mandated volumes for all categories of renewable fuels, along with the proposed 2019 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 on how the EPA may ensure "energy independence and security," reflecting similar language as the preamble above.[2] Finally, the EPA proposal also cited the observed increase in the imports of certain renewable fuels as motivation to request comments regarding the use of waiver authorities again to ensure the nation's energy independence and security.[3]

Analysis of the appropriateness of exercising general waiver authority under the circumstances cited in the proposed rule focuses primarily on domestic renewable fuel supply and economic (or

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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 Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019; Proposed Rule, 82 Fed. Reg. 34,213 (July 21, 2017).

3 82 FR 34,212.

environmental) impacts, while the role of ethanol fuel production for ensuring energy security and independence raises broad issues involving energy markets, along with 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 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….[4]

Developing domestic energy resources to expand exports and create U.S. jobs has been the focus of the new Administration since the beginning of the term. While "energy dominance" tends to be primarily focused on domestically produced fossil fuels, 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.

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[4] 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

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 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 slow and imports to increase by 2016. 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.[5] 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 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.[6] Ethanol production fell (and imports rose) due to a poor corn harvest in 2012, but growth resumed and by 2016 ethanol production reached about 1 million barrels per day with about 70,000 barrels per day of exports and negligible imports.[7]

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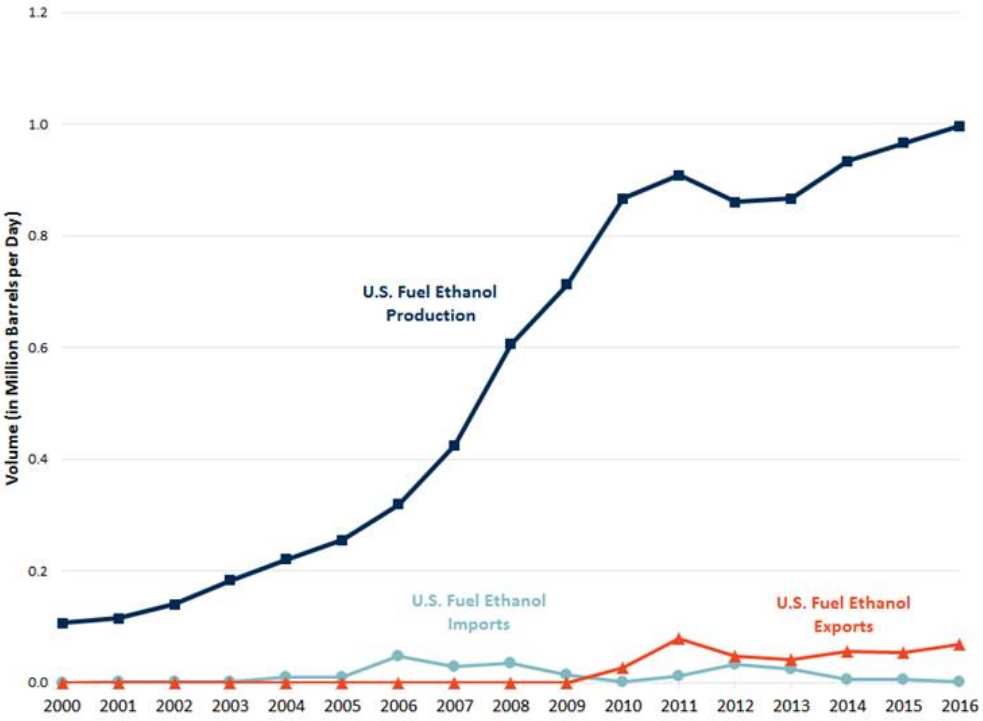
5 The proposed volume requirements in 2018 for renewable fuel are 19.24 billion gallons and the advanced biofuel requirement is 4.24 billion gallons. 82 FR 34,207.

6 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.

7 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.

Figure 1: U.S. Annual Fuel Ethanol Production, Imports, and Exports, 2000 – 2016



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

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.

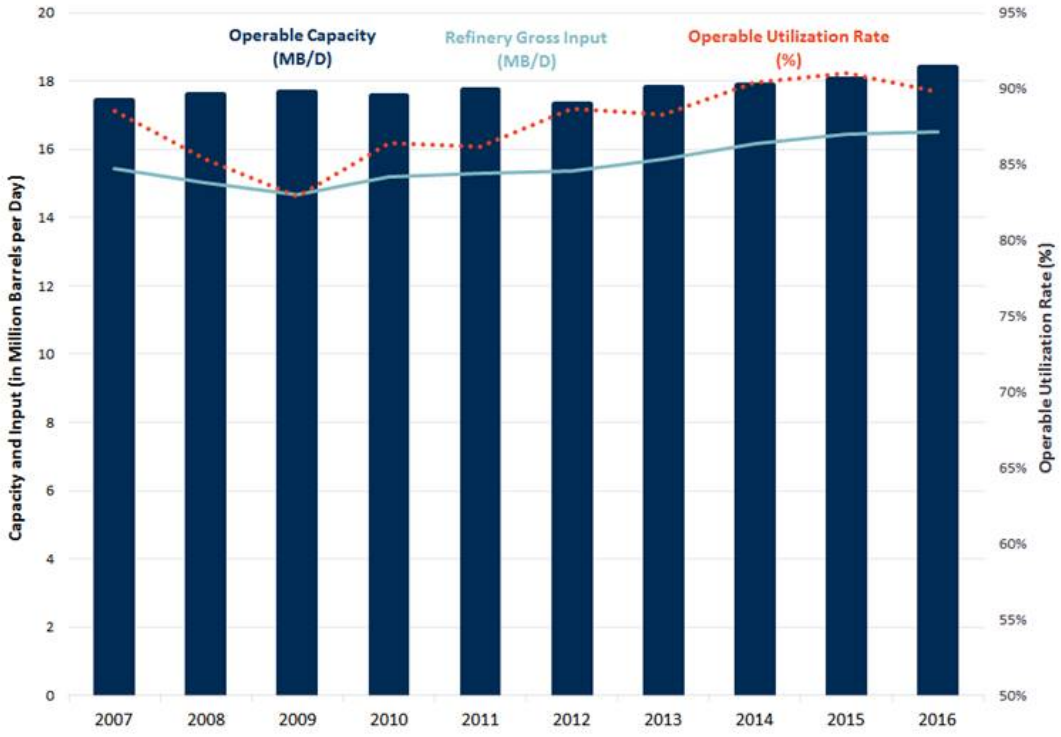
B. Domestic Oil Industry Expansion Coincided with Ethanol Growth

Next, we examine the changes in the observed volumes of refined petroleum products in general and gasoline in particular, including imports and exports. The intent is to discern how increased volumes of ethanol consumed over the past decade affected the supply and disposition of petroleum products for which the ethanol substituted.

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 2016, returning in 2014 to

pre-recession (2007) levels of approximately 90% as shown on Figure 2 below.[8] (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 almost 1.0 million barrels per day during the same period. Overall refinery processing production (as measured by volume of inputs, since changing product slates vary in volumetric terms) also rose during this time period. Neither the rising use of ethanol over the past decade, nor other factors influencing domestic 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 – 2016



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

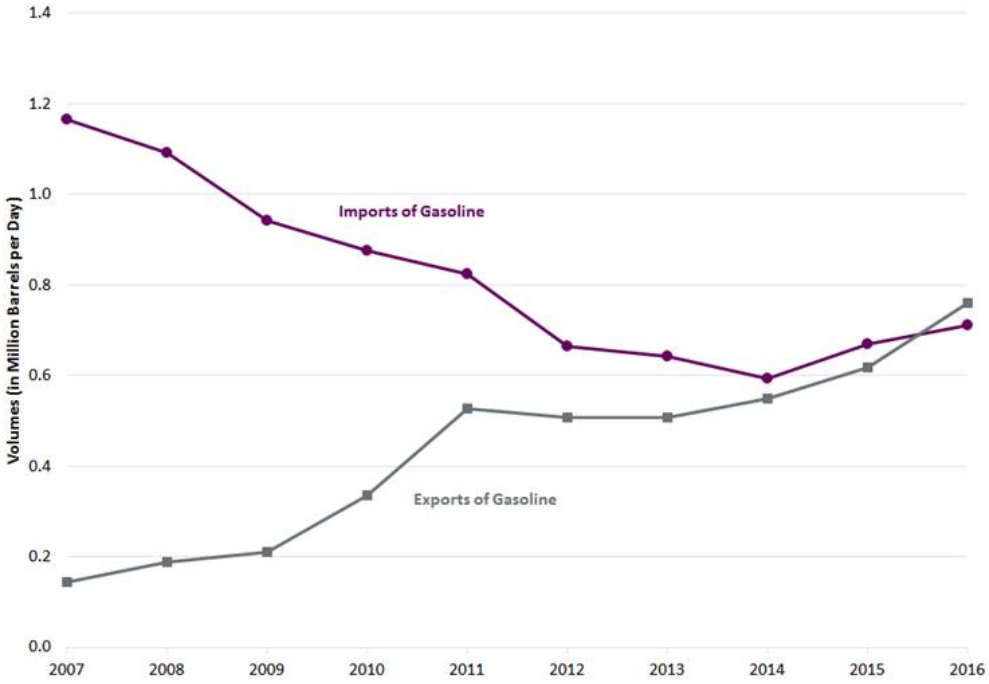
In short, refinery production does not exhibit any decline that might be associated with increased amounts of ethanol blended into gasoline sold in the U.S. Given that nationwide transportation fuel consumption has not increased commensurate with domestic production, the

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

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.

The overall trend in gasoline trade volumes since 2007 is a pronounced reduction in imports and a significant increase in exports, so that in 2016 the U.S. became a net exporter for the first time since 1961. This is shown in Figure 3.

Figure 3: U.S. Imports and Exports of Gasoline, 2007 – 2016

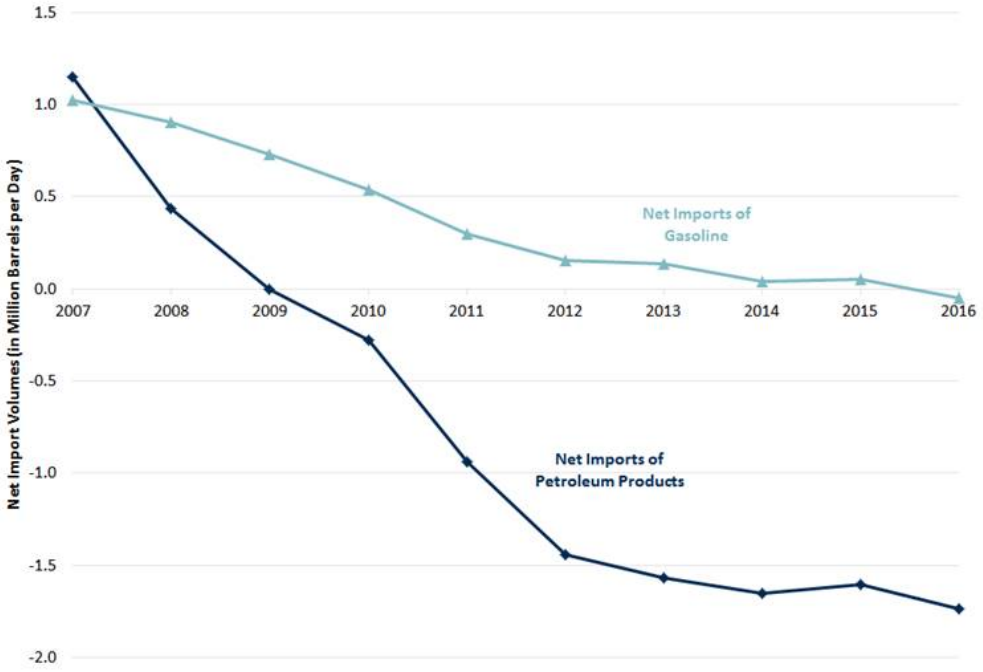


Source and notes: U.S. EIA. Gasoline import and export volumes include volumes for both finished motor gasoline and motor gasoline blending components.

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).

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 4 shows the net imports (imports minus exports) for gasoline and petroleum products between 2007 and 2016. This figure shows that net imports of gasoline fell by about one million barrels per day between 2007 and 2016, while net imports of petroleum products fell by almost three million barrels per day over the same period. Again, increased ethanol occurred during a significant expansion of U.S. gasoline and other petroleum product supplies.

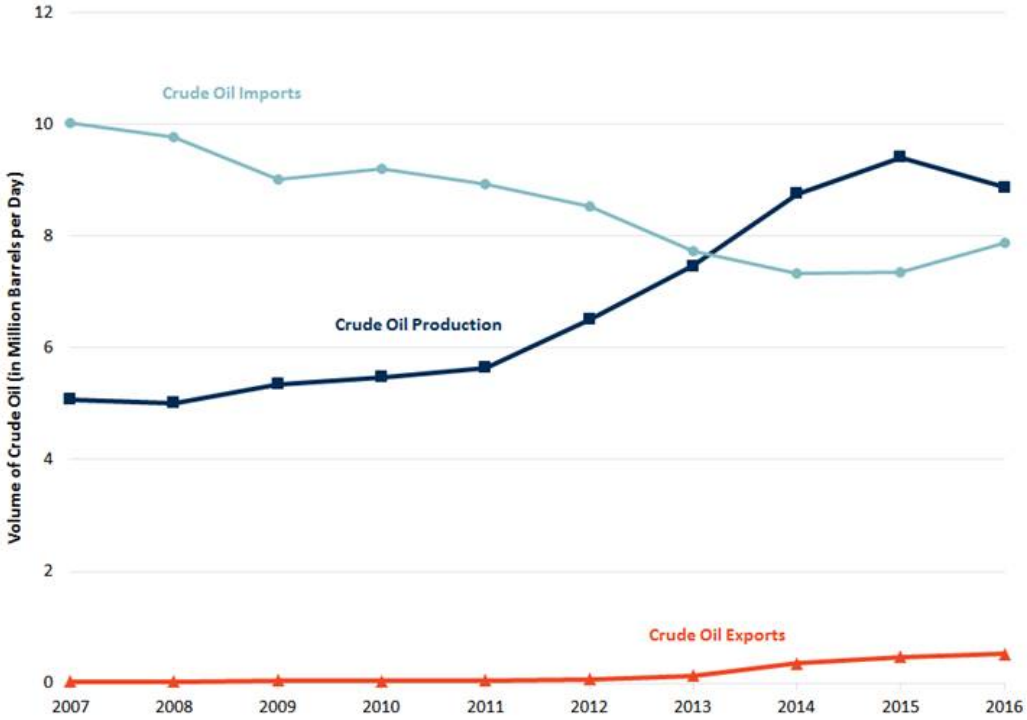
Figure 4: U.S. Net Imports of Gasoline and Petroleum Products, 2007 – 2016



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.

Much of the change in U.S. petroleum product markets reflects significant changes in domestic crude oil supply conditions. 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 5. The increased production of U.S. crude oil has also enhanced energy independence and security.

Figure 5: U.S. Crude Oil Production, Import, and Export Volumes, 2007 – 2016



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 roughly 9 million barrels per day in 2015-2016, as shown on Figure 5 above.[9] Much of the increased production is light sweet crude from the Permian Basin and the Bakken, 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 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 early 2017 exceeded one million barrels per day of crude oil, which some analysts expect to rise to two million barrels per day or more.[10] 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

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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.

10 See, for example, EIA Energy Conference Panel Session - Crude Exports, by Alan Gelder, June 2017, https://www.eia.gov/conference/2017/pdf/presentations/alan_gelder.pdf.

barrels per day in 2007 to about 8 million barrels per day in 2016.[11] The refining industry in the U.S. generally prefers to process heavy sour crude oil of the type produced in Canada, Venezuela, or Mexico, and the continuing volume of imports reflects in part the demand for sour crude by U.S. Gulf Coast refiners and in part the demand of West Coast refiners who find importing crude preferable to overcoming the geographical barrier of the Rocky Mountains.

C. Recent Increases in Biodiesel and Ethanol Imports are Negligible

In the Notice of Proposed Rulemaking, EPA put a particular focus on increasing volumes of certain renewable fuels imported from abroad:

> EISA's stated goals include moving the United States toward "greater energy independence and security [and] to increase the production of clean renewable fuels." This is not simply a general goal, but is embedded in statutory provisions, as well: for example, one of the factors EPA is directed to consider in the context of establishing the biomass-based diesel standard for 2019 under CAA section 211(o)(2)(B)(ii) is the impact of renewable fuels on the energy security of the United States.
>
> In recent years increasing volumes of renewable fuels have been imported and used by obligated parties to comply with their RFS obligations. For example, data from EPA's EMTS system show that in 2016, 46 million gallons of ethanol and 731 million gallons of advanced biodiesel and renewable diesel were imported into the United States…Due to their origin outside the United States, imported renewable fuels may not have the same impact on energy independence as those produced domestically. Industry stakeholders have observed the trend of increasing imports, too….
>
> EPA is interested in stakeholder views on this topic and on what steps EPA might take to ensure energy independence and security. Furthermore, and in light of these considerations, EPA requests comment on whether or not to reduce the biomass-based diesel required volume below the level specified in this proposed rule for 2019. Finally, we request comment on whether and to what degree these considerations 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

[11] 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.

reduction to the total renewable fuel requirement) below the level proposed for 2018.[12]

Any consideration of energy independence and security must consider the volumes transacted in relevant categories of energy products and the ability to substitute among them. The volumes cited in the notice convert into 2,740 barrels per day of ethanol and about 47,700 barrels per day of advanced biodiesel and renewable diesel. When compared to the overall fuel volumes considered above – in the millions of barrels per day range – these volumes cannot possibly have significant effects on the nation's energy independence and security. Compared to about 1,000,000 barrels per day of ethanol produced (and 70,000 barrels per day exported), 3,000 barrels per day of imports represent 0.3 percent of U.S. production. This poses no material risk of eroding energy independence or security.

For advanced biodiesel and renewable diesel, the proportion of imports is higher, which is particularly relevant to domestic biodiesel producers, who petitioned the International Trade Commission (ITC) for a countervailing duty and antidumping investigation against Argentina and Indonesia earlier this year.[13] But 47,700 barrels per day of any fuel – mandated or not – still fails to rise to the level of a genuine energy independence and security concern that warrants the EPA alternating mandates under the RFS given the scale of U.S. diesel fuel consumption. The proposed RVO incorporates an EIA projection for domestic diesel consumption in 2018 of over 9,300,000 barrels per day, which means the imported biodiesel and renewable diesel fuel accounts for about 0.5 percent of the overall projected U.S. diesel consumption.

Also, the very nature of the ITC petition renders the import volumes of biodiesel irrelevant to energy independence and security concerns, as the domestic biodiesel producers claim that they are being undercut by unfairly *low* prices, and could supply the required amounts if not for the unfair competition from foreign sources. In other words, this is an ordinary international trade dispute, not a question of our energy independence and security, which is typically focused on the potential *lack* of availability or *high* prices of foreign supply, not the opposite.

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[12] 82 FR 34,212.

[13] On August 21, 2017, the Department of Commerce issued memoranda with preliminary determinations that Argentina and Indonesia provide subsidies for biodiesel production in support of the petitioners motions before the ITC, see Investigation C-357-821 and C-560-831.

Much 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). As we explain in more detail below, the LCFS creates an incentive for obligated parties to import ethanol and renewable diesel from other countries over domestically produced products due to their relative carbon content as assessed by the California Air Resources Board (ARB).[14] Any reduction in the RVO will have absolutely no impact on this trend; in fact, a reduction in the advanced RVO will not change the demand under the LCFS but may further reduce opportunities for domestic producers to satisfy volumes elsewhere in the U.S.

The LCFS program establishes levels of carbon intensity (CI) reported as gCO_2e/MJ (grams CO_2 equivalent per megajoule). Firms producing or importing gasoline or diesel to be marketed in California must acquire credits when the fuel's CI, as determined by ARB, exceeds the increasingly stringent Required CI. In 2017, a refiner marketing a gallon of gasoline blendstock would have to obtain a fraction of a credit equivalent to 4.76 gCO2e/MJ per gallon for gasoline delivered in the state because ARB determined the CI of its gasoline to be 99.78 gCO2e/MJ per gallon while the current standard is 95.02 gCO2e/MJ per gallon.

Credits can be obtained in several ways, including

- blending ethanol with gasoline, assuming the ethanol blended has a CI below the standard set for 2017;
- purchasing credits from another petroleum marketer that has created a surplus by blending a sufficient amount of ethanol; or
- buying credits from marketers of alternative transportation fuels, such as natural gas, that have CIs below the ARB threshold.

Ethanol is the most obvious choice for petroleum product refiners and marketers. The current RFS requires refiners and marketers to blend renewable fuels such as ethanol into gasoline or purchase Renewable Identification Numbers (RINs) to achieve compliance.

California presents unique problems because ethanol CIs vary depending on the source. The state has published one hundred and eighty-one different ethanol "pathways." The CIs of these pathways range from a high of 95.6 per gallon for ethanol produced in Texas to a low of 7.18 per

[14] We note that other assessments have reached different conclusions regarding the relative CIs of corn and foreign ethanol.

gallon for ethanol produced in California.[15] The method of electricity generation used to produce ethanol is a key determinant of its CI. The largest sources of ethanol with low CIs is Brazil and other Latin American countries, where ethanol producers obtain low CI scores because the electricity is generated using renewable fuels (*e.g.*, hydropower) and the ethanol feedstock is mostly a byproduct of sugarcane processing.

West Coast (PADD V) imports of ethanol in 2014 accounted for about 20 percent of U.S. total imports.[16] By 2016, the West Coast accounted for almost all of the fuel ethanol imports.[17] The increase in low-carbon ethanol use over time occurred as a result of the increasingly stringent LCFS and its impacts on gasoline distributors. The standard of 95.02 gCO2e/MJ per gallon in 2017 will fall to 88.6202 gCO2e/MJ per gallon in 2020, creating additional demand for ethanol with very lower CI scores, primarily obtained from abroad. This will tend to increase ethanol imports regardless of the RVO for total renewable fuel.

The same conclusion applies to the increase in imports of renewable diesel fuel. The EPA notes that imports of advanced biodiesel and renewable diesel totaled 731 million gallons in 2016, comprised of 561 million gallons of biodiesel and 170 million gallons of renewable diesel.

As with ethanol, foreign producers have an advantage in producing renewable diesel, with producers in Singapore dominating the list of low-CI suppliers, and PADD V (almost certainly California) has been a large importer of renewable diesel. According to data published by the ARB and EIA, 89.7 percent of the renewable diesel was imported to PADD V in 2016, suggesting that the LCFS program accounted for most of the imports.[18]

These imports will almost certainly continue because the CI of conventional diesel is 102.41 according to the ARB while the target is 98.44 in 2017 and falls to 91.81 by 2020. Thus, a firm

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15 See figures at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

16 PADD stands for Petroleum Administration District for Defense. PADD V includes the West Coast states of California, Oregon, and Washington, as well as Nevada, Hawaii, and Alaska. Most of the ethanol imports into PADD V are thought to go to California.

17 U.S. EIA, Fuel Ethanol Imports by Area of Entry, https://www.eia.gov/dnav/pet/pet_move_imp_a_epooxe_IM0_mbbl_a.htm.

18 U.S. EIA, Other Renewable Diesel Fuel Imports by Area of Entry, https://www.eia.gov/dnav/pet/pet_move_imp_a_epoordo_im0_mbbl_a.htm.

marketing conventional diesel must purchase credits or, alternatively, blend biodiesel or renewable diesel before selling the product. As the price of carbon credits rises, obligated parties will intensify their efforts to obtain and blend renewable fuels having very low CIs. Imports will rise because the supplies with the lowest CIs are generally found abroad.

Thus, the recent increase in imports of renewable diesel fuels is primarily driven by the economics of the California LCFS. Any exercise of general waiver authority to reduce the required volumes of advanced renewable fuels would have limited impact on imports of renewable diesel fuels, but could undercut domestic producers, which would be contrary to the objectives of the RFS.

III. The Effects of Increased Ethanol Production on U.S. Agriculture and Economic Development

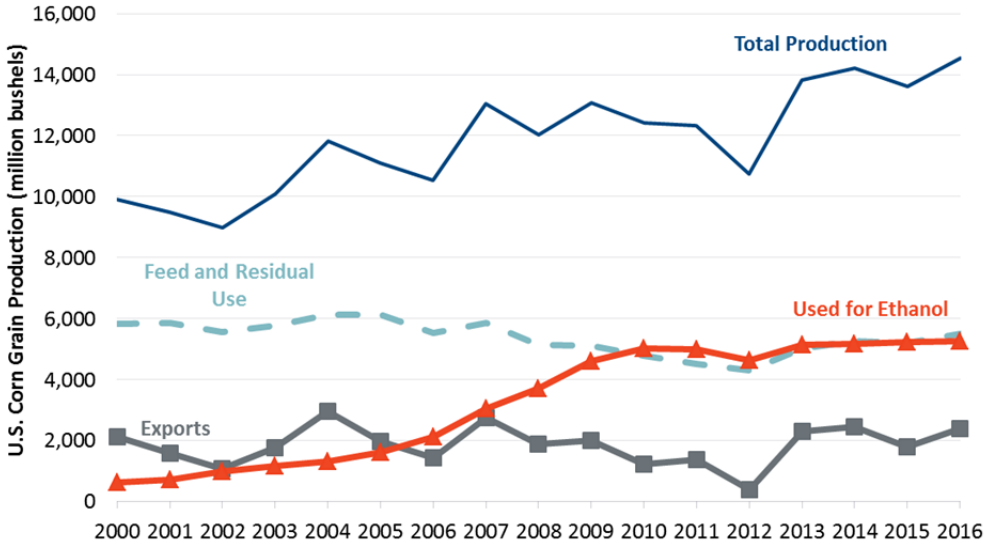
The increased volumes of ethanol produced in the U.S. represent the development and maturation of an energy industry based on a domestically grown resource. This industry provides a significant and steady source of income and jobs to the middle portion of the country that is dependent on sometimes variable 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 6 below shows total U.S. corn grain production and sources of demand since 2000.[19] This figure demonstrates two important points. First, between the early 2000s (2000 – 2002) and the three most recently reported years (2014 – 2016), the average annual U.S. annual corn grain production increased by 4,657 million bushels, primarily due to increased ethanol-related demand. In fact, ethanol demand represented 95% of the increase in corn production during this period. Second, the figure below shows that over 40% of the domestic demand for U.S. corn production arises from fuel ethanol production.

[19] 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/.

Figure 6: U.S. Corn Grain Production by Consumption Type, 2000 – 2016



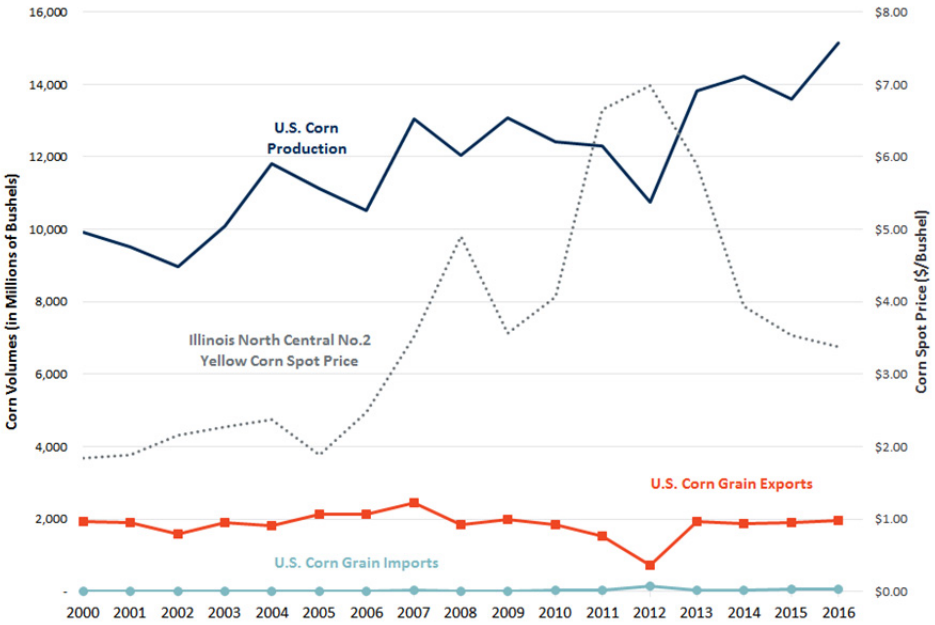
Sources and notes: U.S. DOE Alternative Fuels Data Center. An additional 1,400 million bushels per year are classified as "produced for other uses." This production level has remained steady throughout this time period.

Increased demand for corn production has not resulted in increased imports or reduced corn exports. Figure 7 below shows that during the period in which corn production increased due to ethanol demand U.S. corn exports remained fairly steady around 2,000 million bushels per year (except for the poor harvest year of 2012).[20] In other words, U.S. corn production has increased to meet rising U.S. corn demand from expanded ethanol production.

[20] For production, see: U.S. Department of Agriculture (USDA) Economic Research Service, Feed Grains Database, https://data.ers.usda.gov/FEED-GRAINS-custom-query.aspx.

For imports and exports, see: USDA Economic Research Service, Feed Grains Yearbook Tables 18 and 20, https://www.ers.usda.gov/data-products/feed-grains-database/feed-grains-yearbook-tables/.

Figure 7: U.S. Corn Grain Production, Imports, and Exports, 2000 – 2016



Sources and notes: USDA Economic Research Service, Feed Grains Database and Feed Grains Yearbook Tables. Bloomberg, Illinois NC No.2 Yellow Corn Spot Price Index. For trade volumes, corn grain includes white, yellow, seed, and relief.

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 $2/bushel in 2005 and reached $7/bushel in as a result of the poor harvest of 2012, but have since reverted to $3.37/bushel in 2016.[21] 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."[22] Corn used for ethanol production in 2016 accounted for $18 billion in income for corn growers.[23]

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[21] We used the Illinois North Central No. 2 Yellow Corn spot prices listed in Bloomberg as a representative corn price.

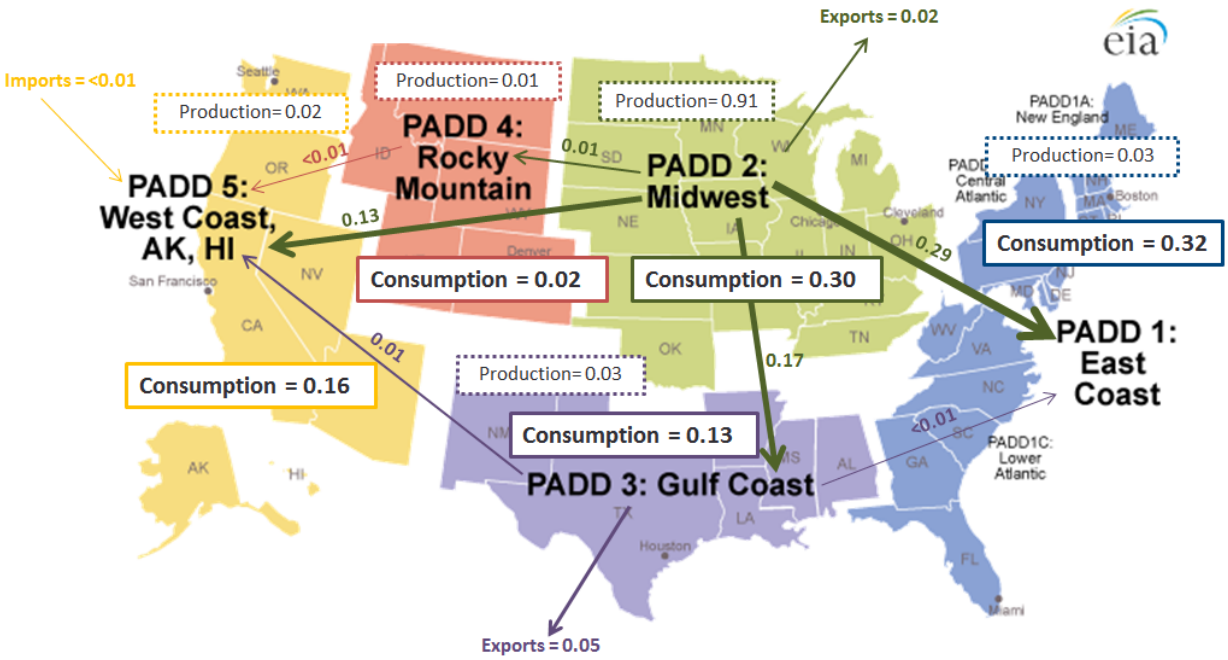
[22] Wendong Zhang, "Four Reasons Why We Aren't Likely to See a Replay of the 1980s Farm Crisis," *Agricultural Policy Review*, ISU CARD, Spring 2017.

[23] The DOE reports that 5,275 million bushels of corn were used for ethanol in 2016, as shown in Figure 6 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 2016 of $3.37/bushel.

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.

Figure 8: Regional Fuel Ethanol Production, Consumption, and Trade, 2016 (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 2017 DOE U.S. Energy and Employment Report, the biofuels industry currently employs over 105,000 workers, with the almost 29,000 of those jobs in the corn ethanol fuels sector, as shown in Figure 9 below. About 80% of corn ethanol employment is in agriculture or wholesale trade.[24]

[24] U.S. DOE, U.S. Energy and Employment Report, January 2017, p. 47. Available at: https://energy.gov/downloads/2017-us-energy-and-employment-report.

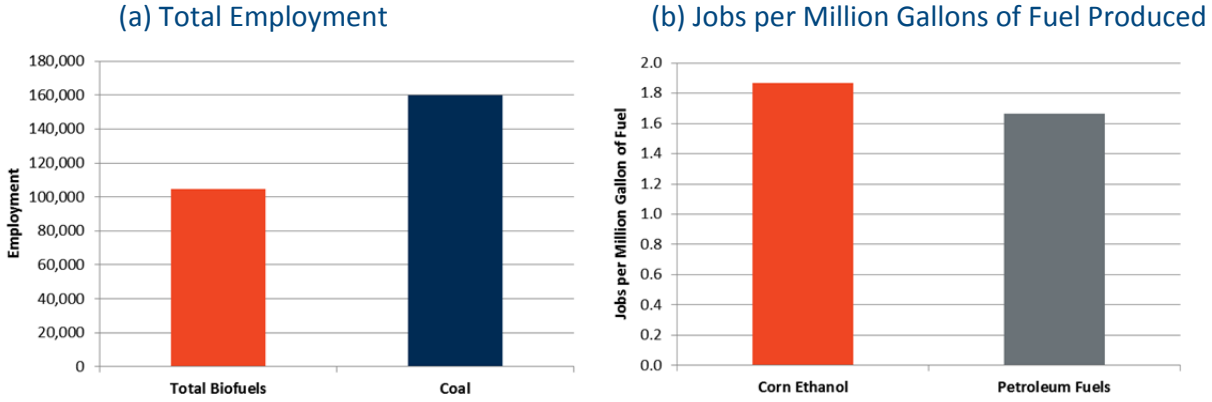
Figure 9: Biofuel Employment Statistics

Sector	Jobs
Corn Ethanol	28,613
Cellulosic Biofuels	30,458
Biodiesel	23,088
Other Biofuels	22,504
Total	**104,663**

Source: U.S. DOE.

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 (105,000 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 (1.9 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. DOE.

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.[25] 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.[26]

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.[27] 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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[25] John Pender, *et al.*, Rural Wealth Creation: Concepts, Strategies, and Measures, Economic Research Report No. 131, March 2012, p. 12.

[26] Jason Brown, *et al.*, Emerging Energy Industries and Rural Growth, Economic Research Report No. 159, November 2013.

[27] 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.[28] In that market, ethanol use had an outsized impact on moderating the world crude oil price along the steep global supply curve.

[28] Philip K. Verleger, Jr., The Renewable Fuel Standard: How Markets Knock Down Walls, January 2014.

In the past three years, crude prices fell dramatically from nearly $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.[29] As a result, the price-moderating effect of U.S. ethanol use in current petroleum markets estimated by Verleger in 2014 has fallen as the global supply curve has pushed out and become less steep. In this current low oil price environment, the effects of ethanol on motorists are more subtle but still significant and beneficial.

As described above, the 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.[30] Such flexibility can allow more 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.

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29 U.S. EIA, Europe Brent Spot Price FOB, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=M.

30 See Marc Chupka, *et al.*, Peeking Over the Blendwall: An Analysis of the Proposed 2017 Renewable Volume Obligations, July 11, 2016. Available at: 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

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 added to 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."

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