THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

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July 11, 2016

RE: International Council on Clean Transportation comments on "Renewable Fuel Standard Program: Standards for 2017 and Biomass-Based Diesel Volume for 2018" Notice of Proposed Rulemaking (EPA–HQ–OAR–2016–0004; FRL–9946–90– OAR)

These comments are submitted by the International Council on Clean Transportation (ICCT). The ICCT is an independent nonprofit organization founded to provide unbiased research and technical analysis to environmental regulators. Our mission is to improve the environmental performance and energy efficiency of road, marine, and air transportation, in order to benefit public health and mitigate climate change. We promote best practices and comprehensive solutions to increase vehicle efficiency, increase the sustainability of alternative fuels, reduce pollution from the in-use fleet, and curtail emissions of local air pollutants and greenhouse gases (GHG) from international goods movement.

The ICCT welcomes the opportunity to provide comments on the U.S. EPA Renewable Fuel Standard (RFS) program. We commend the agency for its continuing efforts to promote a cleaner, lower-carbon transportation sector that uses less petroleum-based fuels. As we have commented before, the RFS program has set strong standards with thorough, comprehensive scientific analyses and rigorous life-cycle emission accounting. This proposed rule builds upon the impressive steps EPA has undertaken to promote low-carbon biofuels. The comments below offer a number of technical observations and recommendations for EPA to consider in its continued efforts to strengthen the program and maximize the program's benefits in mitigating the risks of climate change and reducing petroleum use.

We would be glad to clarify or elaborate on any points made in the below comments. If there are any questions, EPA staff can feel free to contact Dr. Stephanie Searle (stephanie@theicct.org).

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Chief Program Officer

International Council on Clean Transportation

ICCT comments on docket no. EPA–HQ–OAR–2016–0004

Summary of comments

EPA has proposed increasing the biomass-based diesel (BBD) volume from 2.0 billion gallons in 2017 to 2.1 billion gallons in 2018. EPA expects additional BBD to be used to meet the proposed advanced biofuel and total renewable fuel volumes in 2017. These comments focus primarily on the volumes of BBD incentivized under these three categories in 2017 and 2018.

EPA is required by statute to consider an analysis of the supply of agricultural commodities in setting volume standards for BBD under the RFS. ICCT has recently completed such an analysis in order to inform EPA's rulemaking on 2017-2018 RFS volumes. Our assessment finds that, based on projected changes in the production of major BBD feedstocks and their consumption in other sectors, the availability of these feedstocks for BBD production has been increasing. We expect growth in feedstock availability of 42 million biodiesel-equivalent gallons in 2018 compared to 2017, and an average annual increase in availability of 31 million gallons over the period 2016-2022.

However, this rate of increase is far lower than the growth in BBD production needed to meet the proposed RFS standards for 2017 and 2018. EPA has already established the BBD volume for 2017 at 2 billion gallons, representing an increase of 100 million gallons compared to 2016. In the present proposed rulemaking, EPA expects a further increase of 100 million gallons of BBD would be necessary to meet the advanced biofuel volume. Altogether, this proposal would require an increase of 200 million gallons of BBD over 2016, which is much higher than the expected growth in feedstock availability. EPA is also now proposing the 2018 BBD volume, which would require a further increase of 100 million gallons in the BBD category compared to 2017.

Increasing demand for BBD above the level of available feedstock by such a substantial amount will very likely lead to price increases of these commodities and increased imports of both BBD and feedstocks. These effects will likely lead to negative indirect impacts such as feedstock switching in non-BBD industries (for example the soap industry switching from tallow to palm oil) both in the U.S. and abroad.

In order to avoid negative indirect impacts on the U.S. economy and on global greenhouse gas emissions, ICCT suggests that the proposed RFS volumes be adjusted in order to account for growth in BBD feedstock availability. Our suggestion for revised volumes is shown in Table 1. As the 2017 BBD volume has been finalized and already requires a higher increase in BBD than can be supported by growth in feedstock availability, ICCT recommends that the advanced biofuel and renewable fuel mandates are set at levels that do not require additional increases in BBD compared to 2016 levels. We also suggest setting the 2018 BBD volume at a level that reflects our projection in BBD feedstock availability. We recommend that EPA follow this approach for the 2018 proposal for advanced biofuel and renewable fuel volumes, and in all future years of the RFS program.

ICCT comments on docket no. EPA–HQ–OAR–2016–0004

Table 1: ICCT suggestion for RFS volumes in 2017 and 2018 (and EPA proposal) in million gallons

	2017	2018
Biomass-based diesel*		2,042 (2,100)
Advanced biofuel	3,850 (4,000)	
Renewable fuel	18,650 (18,800)	

*In biodiesel equivalent gallons. Advanced and renewable fuel in ethanol equivalent gallons.

Comments on biomass-based diesel volumes for 2017 and 2018

EPA has proposed renewable fuel and advanced biofuel volumes for 2017 that would very likely require biomass-based diesel (BBD) in addition to the 2.0 billion gallons required within the BBD category due to pressure from the ethanol blend wall. Around 2.7 billion gallons of BBD, including advanced BBD and grandfathered renewable BBD, are expected to be used to meet the proposed renewable fuel and advanced biofuel requirements (Table II.E-1 in the proposed rule). Overall, it is likely that an increase of 200 million gallons BBD will be required to meet the proposed 2017 volumes compared to the 2016 RFS mandate; of this, 100 million gallons represents the increase in the BBD volume, and 100 million gallons represents an increase in additional BBD used to meet the overall advanced biofuel mandate.

EPA has also proposed a BBD volume of 2.1 billion gallons for 2018. This represents a further increase of 100 million gallons compared to the required BBD volume of 2.0 billion gallons in 2017. If EPA takes the same approach in setting 2018 volumes for renewable fuel and advanced biofuel as for 2017, the overall volumes for 2018 could require 2.8 billion gallons or more of BBD.

EPA is required by statute to set BBD volumes "based on … an analysis of … the impact of the use of renewable fuels on … job creation, the price and supply of agricultural commodities, rural economic development, and food prices."[1]

ICCT recently updated an analysis of the supply of agricultural commodities used to produce BBD in the U.S. in order to inform EPA's rulemaking (attached as an Appendix).[2] This study builds on a previous analysis by Prof. Wade Brorsen (2015)[3] that assessed the current production of major BBD feedstocks and projected the likely growth in availability of these resources. The updated study performs a more in-depth assessment of other uses of BBD feedstocks and of market trends in both production and consumption of these commodities. As a result, this study provides a more refined understanding of what level of these resources will be available for BBD production in 2017-2022.

Increasing the demand for BBD above domestic feedstock availability will very likely increase the prices of these commodities and result in negative indirect effects, including:

a) Bidding feedstocks away from other uses; these other uses would replace this feedstock with another. As an example, if tallow is diverted from soaps and other industrial projects to BBD production, soaps and other products will turn to a low cost alternative, likely to be palm oil or petroleum-based oils.
b) Increased imports of feedstock or BBD from other countries. Increased feedstock exports or BBD production in those countries would very likely have the same effect as above, diverting fats, oils and greases from other uses and leading to feedstock switching.

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[1] Energy Independence and Security Act of 2007, Section 202, Paragraph (a)(2)(B)(ii); https://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf
[2] http://www.theicct.org/projected-US-biodiesel-availability
[3] http://www.ucsusa.org/sites/default/files/attach/2015/07/Brorsen-RFS-Biodiesel-Feedstock-Analysis.pdf

None of these effects would meet the goals of the RFS program in greenhouse gas (GHG) reduction and supporting the domestic economy. In particular, previous research has demonstrated a substitution effect between U.S. soy oil and imported palm oil, indicating that when soy prices rise as a result of increased demand, palm oil imports to the U.S. increase.[4] In addition, setting the renewable fuel volume at a level that incentivizes further BBD drives imports of grandfathered renewable BBD that does not meet the 20% GHG reduction threshold. In a previous assessment, we have found that a significant fraction of grandfathered BBD used to meet the renewable fuel mandate of the RFS is likely imported palm biodiesel and renewable diesel.[5] As EPA and others have assessed, expansion in the palm oil industry is associated with very high GHG emissions.[6] ICCT therefore recommends that growth in mandated BBD volumes under the RFS not exceed growth in the domestic supply of BBD feedstocks.

In our updated assessment, we find that the production of several major BBD feedstocks is likely to increase over the next several years; this includes vegetable oils (soy, canola, corn) due to yield improvements, as well as animal fats (tallow, poultry fat, etc) due to an expectation of growing livestock production in the U.S. Consumption of these resources in food products, livestock feed, and some industrial uses is expected to increase as well, reducing the net growth in BBD feedstock availability. We do not expect production of inedible corn oil, a by-product of corn ethanol processing, to increase substantially, but the expected increase in edible corn oil production will offset some of the increase in demand for vegetable oils in food. While used cooking oil has become a prominent BBD feedstock, we do not find any indication that collection of used cooking oil in the U.S. is likely to increase, and so no additional availability can be expected from this feedstock.

Overall, we find a growing availability of BBD feedstocks in the U.S. that will not be needed in other industries. **We project an increase of 42 million biodiesel-equivalent gallons in 2018 over 2017, and an average annual increase in feedstock availability of 31 million gallons over the period 2016-2022**.

While this represents a substantial increase in feedstock availability, it is far lower than the increase in BBD production that is implied by the 2017 mandate. The total feedstock availability is compared to 2015 BBD production and imports and the proposed 2017 and 2018 volumes in Figure 1. We note that EPA has not yet proposed volumes for the renewable fuel and advanced biofuel categories for 2018; for the purposes of illustration, this figure assumes the same amount of additional BBD would be required in 2018 as in 2017.

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[4] http://gradworks.umi.com/15/54/1554542.html

[5] http://www.theicct.org/blogs/staff/unexpected-tax-bill-for-imported-palm-oil-biodiesel

[6] https://www.gpo.gov/fdsys/pkg/FR-2012-01-27/pdf/2012-1784.pdf; http://www.theicct.org/review-peat-surface-greenhouse-gas-emissions-oil-palm-plantations-southeast-asia; http://www.theicct.org/historical-analysis-and-projection-oil-palm-plantation-expansion-peatland-southeast-asia

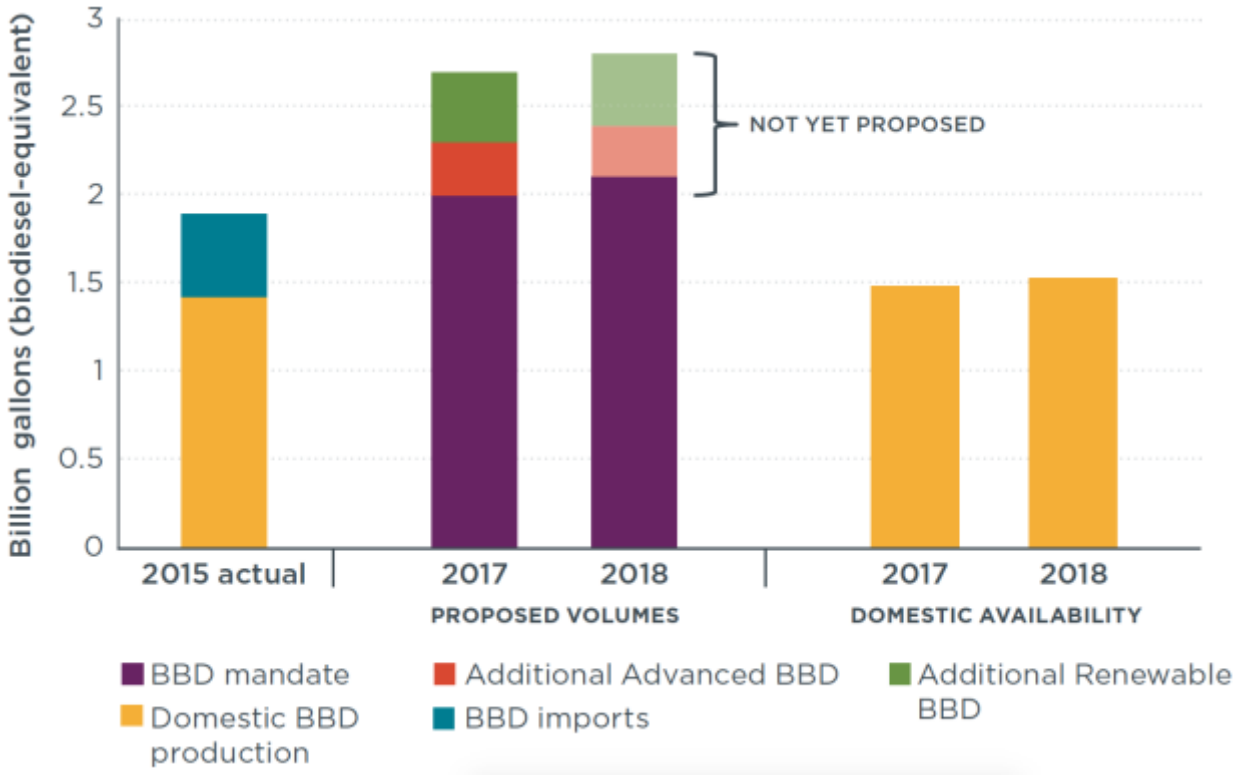

Figure 1: Domestic availability of BBD feedstocks compared to 2015 production and imports and 2017 and 2018 proposed RFS volumes

ICCT recommends that EPA revise the proposed 2017 volumes for advanced biofuel and renewable fuel downward in order to account for limitations in BBD feedstock availability. The 2017 BBD volume is already finalized at 2.0 billion gallons and requires an increase of 100 million gallons compared to the 2016 standard; this is already greater than the increase in BBD feedstock availability according to our assessment. ICCT thus recommends setting the 2017 advanced biofuel and renewable fuel volumes at levels that do not require additional BBD compared to the 2016 volumes. ICCT recommends setting the 2018 BBD volume at 2.042 billion gallons, reflecting the expected increase in feedstock availability. The suggested volume revisions are shown in Table 1. Although EPA is not currently requesting comment on 2018 volumes for the advanced biofuel and renewable fuel categories, ICCT suggests that EPA use this same approach when proposing those volumes next year, and generally follow this approach of setting RFS volumes according to feedstock availability in all future years of the program.

Table 1: ICCT suggestion for RFS volumes in 2017 and 2018 (and EPA proposal) in million gallons

	2017	2018
Biomass-based diesel*		2,042 (2,100)
Advanced biofuel	3,850 (4,000)	
Renewable fuel	18,650 (18,800)	

*In biodiesel equivalent gallons. Advanced and renewable fuel in ethanol equivalent gallons.

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Projected availability of fats, oils, and greases in the U.S.

Authors: Brett Nelson and Stephanie Searle
Date: 7 July 2016
Keywords: Renewable Fuel Standard (RFS), biofuel, biodiesel, renewable diesel, feedstock availability

Summary

Environmental Protection Agency's (EPA) latest proposed volume mandates for the Renewable Fuel Standard (RFS) would require an increase in biomass-based diesel (BBD, including biodiesel and renewable diesel) production in 2018 of at least 100 million gallons over 2017 depending on how the advanced biofuel mandate is set. In setting annual volume requirements, the EPA is required by statute to consider factors including the impact of the RFS on the price and supply of agricultural commodities and food prices. Thus, the volume requirements set by the EPA should take into account demand for biofuel feedstocks from other sectors and determine an amount that will be available without disrupting other industries or increasing price volatility of feedstocks.

In this study, we assessed trends in the production of potential BBD feedstocks in the United States and the consumption of these commodities in all sectors. We used projections made by the United States Department of Agriculture (USDA), supplemented by projections based on linear historical trends when others were not available. There are five key trends affecting the availability of fats, oils, and greases (FOG) for BBD: (1) increasing domestic production of vegetable oils, (2) increasing livestock production, (3) increasing consumption of fats and oils in food, corresponding with population growth, (4) increasing consumption of biobased lubricants and oils, and (5) constant production of yellow grease. Soybean, canola, and edible corn oil production are all projected to increase, largely as a result of yield improvements. We expect inedible corn oil production to remain roughly constant as demand for corn ethanol under the RFS is unlikely to grow significantly after 2016, and improvements in corn oil extraction have leveled off. A projected increase in livestock will affect both the supply and demand of animal fats; livestock produce fats such as tallow, but also consume some oils and fats in feed. Overall, an increase in livestock production results in a net increase in FOG availability. The trend of increased demand for biodegradable products in the lubricants and oils industry will reduce the availability of tallow. We expect FOG consumption in food to increase with population growth, following a long-term historical trend of increasing consumption. Overall, these trends will result in increased availability of animal fats for biofuels as the increased production outweighs increased demand from non-fuel sectors. The production of yellow grease is projected to remain constant. Yellow grease production historically has remained flat, and collection from restaurants and hotels is already a mature industry, while collection from households is unlikely without specific programs in place.

Based on this assessment, the United States can support an average annual increase of about 31.5 million biodiesel-equivalent gallons of BBD per year through 2022. At the current proposed BBD volume for 2018 (2.1 billion gallons), a deficit of 574 million gallons is expected in the amount of BBD that can be produced from domestically available resources. An even greater deficit will be triggered if the advanced and renewable volumes are set at a level that requires additional BBD consumption. The amounts of BBD expected in the proposed 2017 and 2018 volumes are compared to availability and 2015 production and imports in Figure 2. In the proposal for 2017, additional demand from the advanced and renewable categories results in a total expectation for 2.7 billion gallons BBD (EPA, 2016a). The EPA expects that 700 million gallons (in addition to the 2 billion gallons required for the BBD category) will be needed to meet the advanced and renewable volume proposals. Compared to domestic feedstock availability of 1.526 billion biodiesel-equivalent gallons, this proposed mandate would require a doubling of BBD imports over 2015 volumes, and would likely lead to increased prices for these BBD feedstocks and pressure on other sectors that use these resources.

Introduction

Each year, the EPA sets required volumes for each of the four categories of biofuel in the RFS: renewable fuel, advanced biofuel, BBD, and cellulosic biofuel. These categories are nested: BBD and cellulosic biofuel are both subsets of advanced biofuel, and advanced biofuel is a subset of renewable fuel.[1] Recently the EPA released its 2017 proposed requirements for renewable fuel, advanced biofuel, and cellulosic biofuel, as well as the 2018 requirement for BBD (EPA, 2016a). The EPA has proposed BBD increases of at least 100 million gallons, although increases will likely be even higher depending on how the advanced biofuel mandate is set (Table 1). As a result of ethanol blend wall pressure, the amount of BBD used for RFS compliance will likely exceed the volume requirement for the BBD category in order to satisfy the overall advanced and renewable biofuel mandates; for example, in its calculations for 2017 EPA expects 150 million ethanol-equivalent gallons out of 158 million gallons of required growth over 2016 in "other advanced" volume (advanced biofuel that is not used to fulfill the BBD or cellulosic biofuel mandates) to be filled with additional BBD (ICCT, 2016).

The EPA is required by law through the Energy Independence and Security Act of 2007 to consider a number of factors in setting annual volumes in the RFS program, including feedstock availability and the price of commodities (USGPO, 2007). All major feedstocks used for the production of RFS-eligible BBD have other uses as food, livestock feed, or as an input to industrial processes such as soap or paint production. The demand for FOG in these sectors must be considered in assessing BBD feedstock availability. Increasing demand for FOG above available levels will tend to raise prices and have negative economic impacts on non-fuel sectors. Furthermore, setting BBD mandates conservatively could avoid price volatility in the event of a supply shock (i.e. drought conditions) due to the nature of the inelastic demand for agricultural commodities.

To determine an appropriate level of BBD growth for future years of the RFS program, this study aimed to estimate the availability of BBD feedstocks. Availability was calculated by subtracting total non-fuel consumption of feedstocks from total production of feedstocks. Consumption of FOG in livestock feed, edible products, soap, fatty acids, paint and varnish, resins and plastics, lubricants and oils, other inedible products, biodiesel and changes in trade balance (exports—imports) were considered. We focused on the major feedstocks used in domestic biodiesel production, the historical use of which is shown in Figure 2. We note that we did not include palm oil in our assessment, as this pathway is not eligible under the RFS at present.

This study aimed to build on a recent, similar study (Brorsen, 2015). This study provides a more detailed assessment of market trends for each BBD feedstock.

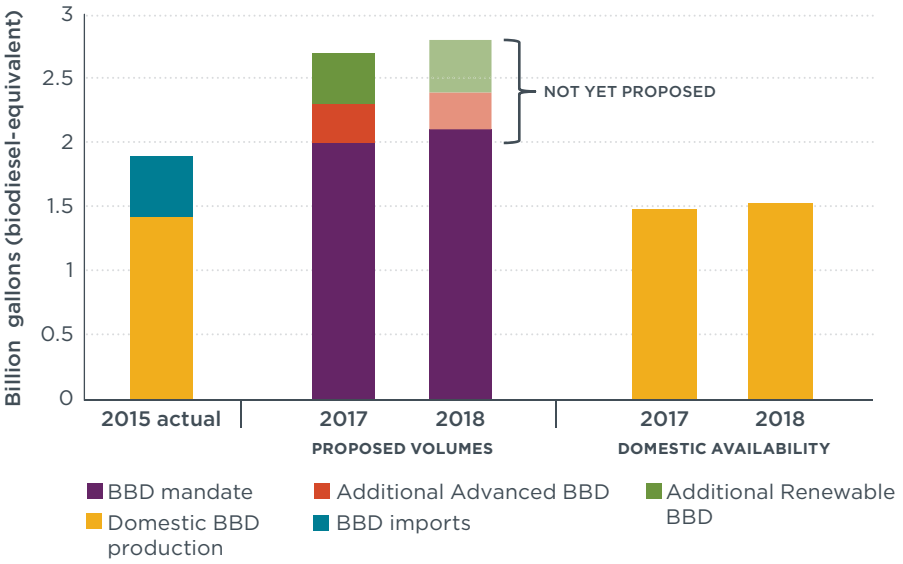

Figure 1. BBD under proposed 2017 and 2018 RFS volumes compared to domestic feedstock availability and 2015 production

Table 1. Renewable fuel volumes requirements for 2014-2018 (M Gal)

	2014	2015	2016	2017	2018
Cellulosic biofuel	33	123	230	312*	n/a
Biomass-based diesel**	1,630	1,730	1,900	2,000	2.1*
Advanced biofuel	2,670	2,880	3,610	4,000*	n/a
Renewable fuel	16,280	16,930	18,110	18,800*	n/a

Source: EPA, (2016b)
** Proposed Volume Requirements*
*** Biomass-based diesel volumes are shown in biodiesel-equivalent gallons. All other volumes are given in ethanol-equivalent gallons. One gallon of biodiesel is equivalent in energy to 1.5 gallons of ethanol.*

1 For an overview of the RFS program and of the 2017-2018 volumes proposal, see http://www.theicct.org/sites/default/files/publications/ICCTBriefing_RFS2_20140211.pdf; http://www.theicct.org/sites/default/files/publications/ICCT_RFS-2017-volumes_policyupdate_201606.pdf

Methodology

AVAILABILITY

Availability of feedstocks was determined by subtracting the projected trade balance (exports—imports) and consumption in non-fuel industries from projected production. Trade balance is treated as consumption when exports are greater than imports and production when imports are greater than exports. Relatively complete information on the total production and consumption of feedstocks in livestock feed, edible products, industrial products, trade balance, and ending balance (ending stocks—beginning stocks) were used to determine if any production or consumption had not been considered. A remainder term of approximately 900 million pounds was consumed that had not been assigned to a specific consumption category (this is equivalent to approximately 2.4% of total production of FOG in this analysis). We deemed this the "other consumption" category and held it constant through the projection period.

Biofuel Consumption

Biodiesel consumption data was retrieved from the Energy Information Agency (EIA, 2012, 2014, 2016a) and can be found in Figure 2. EIA data reflects only feedstock use in biodiesel and does not include information about renewable diesel feedstocks. Renewable diesel from domestic feedstocks was calculated by subtracting total biodiesel produced in the United States (EIA, 2016a) from total domestically produced BBD used for RFS compliance (EPA, 2016a).

PRODUCTION AND CONSUMPTION OF OILS AND FATS

Vegetable Oils

Historical data on the production, trade balance, and change in stocks of vegetable oils was retrieved from the USDA oil crops yearbook (USDA-ERS, 2016a, b, c). Future production of soybean oil was retrieved from the most recent USDA ten-year projections (Wescott & Hansen, 2016). Future production of canola oil was projected out based on a historical linear trend. Future production of inedible corn oil was projected to remain flat at 2015 levels. Inedible corn oil used as a BBD feedstock is mainly extracted from distillers grains after the production of corn ethanol. Corn ethanol production in the United States is unlikely to increase substantially as its support under the RFS is limited. The non-advanced renewable fuel volume is capped at 15 billion gallons from 2015 onward (EPA, 2010a), and the proposed non-advanced renewable fuel mandate is set at 14.8 billion gallons for 2017 (EPA, 2016a). Furthermore, corn oil extraction yields have leveled off and fractionation technology has already been incorporated into most ethanol plants (Jessen, 2013). Edible corn oil production, however, is expected to increase proportionally with corn production increases projected by the USDA. A detailed breakdown of vegetable oil consumption in food, livestock feed, and industrial uses (US Census, 2004, 2005, 2007, 2009, 2011) and biodiesel inputs (EIA, 2012, 2014, 2016a) were used to develop a baseline consumption breakdown. We then projected the use of vegetable oils in food to increase in proportion to population growth, using population projections from the USDA ten-year projections. Since 1980, the total consumption of FOG in edible products has increased substantially according to USDA data (USDA-ERS, 2016d). We projected the use of vegetable oils in livestock feed to increase proportionally to increased livestock production (projected by the USDA). And finally, we projected the use of vegetable oils in industrial products to be constant at 2015 levels based on the preferred use of tallow in industrial products when available (McGlashan, 2006, Cahoon et al., 2009).

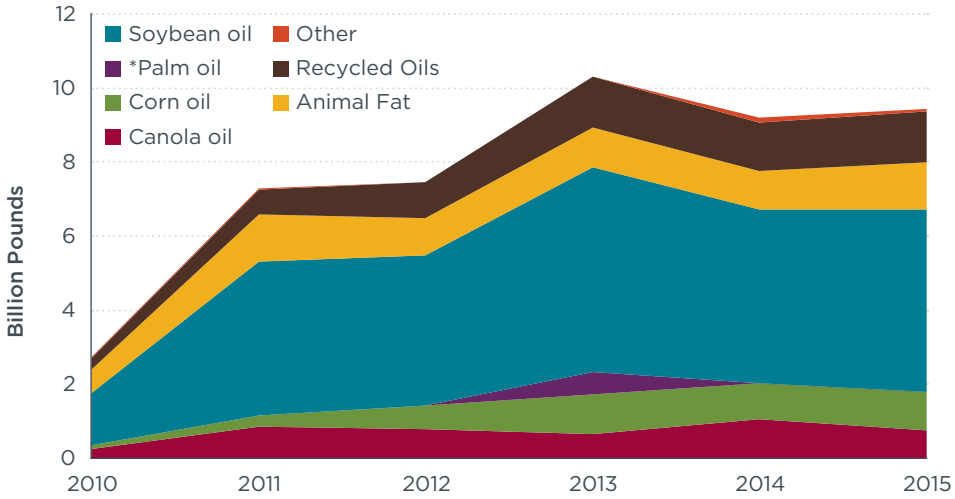

Figure 2. U.S. inputs to biodiesel production
Source: (EIA, 2012, 2014, 2016a)
**Notes—Renewable diesel feedstocks are not shown. Palm oil is not currently RFS eligible.*

Animal Fats

A ratio of meat to animal fat production was calculated based on meat (USDA-ERS, 2016e) and animal fat production (US Census, 2004, 2005, 2007, 2009, 2011) data from 2003-2010. We then applied this ratio to the historical and projected meat production (USDA) for 2011 onward to estimate the amount of fat produced. Detailed consumption of animal fats in industrial

uses in the U.S. Census reports and trade balance data retrieved from the National Renders Association 2015 Market Report (Swisher, 2016) were used as a baseline for future consumption projections. The projections on future meat production and population growth (Wescott & Hansen, 2016) were used to extrapolate future consumption of animal fats in livestock feed and edible products. Consumption of animal fats in industrial products was assumed to remain constant for fatty acids, resins and plastics, paint and varnish, and soap following historical trends (or future projections in the case of soap) (USDA-ERS, 2016f) and to increase at a rate of 6.6% for lubricants (Grand View Research, 2016; BusinessWire, 2016).

Yellow Grease

Historical data for the production of yellow grease from 2003-2010 was available in the U.S. Census reports. Due to a lack of a statistical trend and assumed maturity of the yellow grease market in the United States (Lane, 2016, Schwab et al., 2016, Brorsen, 2015), we made an overall assumption that the production of yellow grease has been and will continue to be constant from 2011 onward. Consumption data for yellow grease was estimated based on historical trade balance and consumption data available in the U.S. Census reports. We predicted that constant production of yellow grease will result in no change in yellow grease consumption in livestock feed. Increased FOG consumption in livestock feed is expected to come from other sources.

Trade Balance

Exports and imports of all goods are highly dependent on policies of other countries. Because there is no accurate way to predict the future effect of policies in other countries, the projected trade balance (export-import) of all FOG was held constant at 2015 levels.

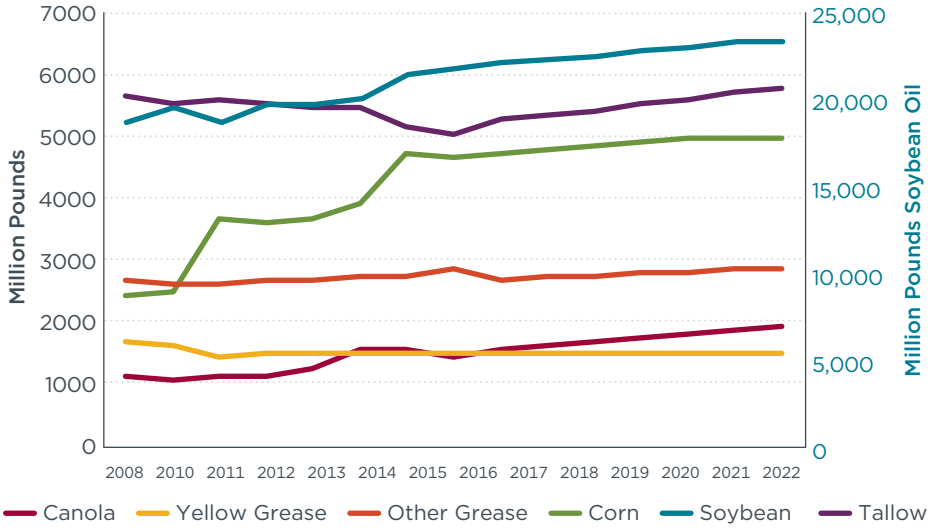

Figure 3. Historical and projected future production of fats, oils and greases (soybean oil on right axis)
Source: USDA Economic Research Service, http://www.ers.usda.gov/data-products/oil-crops-yearbook.aspx for 2008–2015. Years 2016–2022 are projected.

Results and Discussion

OVERALL TRENDS IN PRODUCTION AND CONSUMPTION

Trends of vegetable oil, animal fats, and yellow grease production are shown in Figure 3. Vegetable oil is generally expected to increase as a result of increased yield (Westcott & Hansen, 2016). We also predict that animal fat production will increase in line with increased meat production projected by the USDA. This is a departure from the current market trend in which meat consumption had significantly decreased from 2008–2014. Changing lifestyle has had a part in the decreased consumption of meat; however, it is believed that the recent economic recession is the main cause for the decline over this period. According to the USDA, this trend is expected to revert back to positive as lower production costs of meat and thus lower prices will increase demand for meat in the United States. Livestock production costs are expected to decrease as a result of falling energy prices, which will reduce fuel and fertilizer expenses for producers. Unlike vegetable oil and animal fats, yellow grease production is assumed to remain constant over the projected period. This assumption was based on relatively flat yellow grease production from 2003–2010 (US Census, 2004, 2005, 2007, 2009, 2011), and the maturity of the yellow grease market (Lane, 2016, Schwab et al., 2016, Brorsen, 2015).

Consumption of FOG in edible products, livestock feed, and industrial uses is shown in Figure 4. We assumed that the consumption of FOG in edible products will increase as a result of increased population, in line with a long-term trend of increasing FOG consumption in food. We also predicted that consumption of fats in livestock feed will increase with increased meat production. Livestock animals are able to produce more fat than they consume in feed. Thus, the amount of fats produced from livestock will be greater than that used in livestock feed.

Consumption of FOG in industrial products will also increase throughout the production period. We predicted that soybean oil, corn oil, and tallow will be used in industrial products based on their low price and availability. Increased use in industrial products is a direct result of increased demand for biodegradable

lubricants and oils. This industry is expected to increase at a rate of at least 6.6% year over year (Grand View Research, 2016; BusinessWire, 2016). We expect tallow consumption to increase proportionally based on its prominent use in lubricants and industrial products generally (McGlashan, 2006, Flinn, 2011; Sallmon et al., 2010). All other industrial uses of FOG are expected to remain flat. Other industrial uses of FOG include soap, fatty acids, paint and varnish, resins and plastics, and other inedible products. Historically FOG usage in soap has dramatically decreased since the production of petroleum based soaps and detergents began in the 1950s (Swisher, 2006). Over the last five years, however, FOG usage has maintained a flat trend. Projections differ for the future of FOG usage in soaps: usage could increase as environmental concerns increase demand for naturally based products or it could decrease as petroleum based detergents continue to get cheaper and better formulations decrease the risk to the environment. Therefore, we took an average of the relatively flat soap production over the last five years and projected a continued trend of constant production. The remaining industrial uses (fatty acids, paint and varnish, resins and plastics, and other inedible products) were averaged over the 30-year period of available data (1980–2010) and assumed to remain constant as we were not able to identify any trends for these categories (USDA-ERS, 2016f).

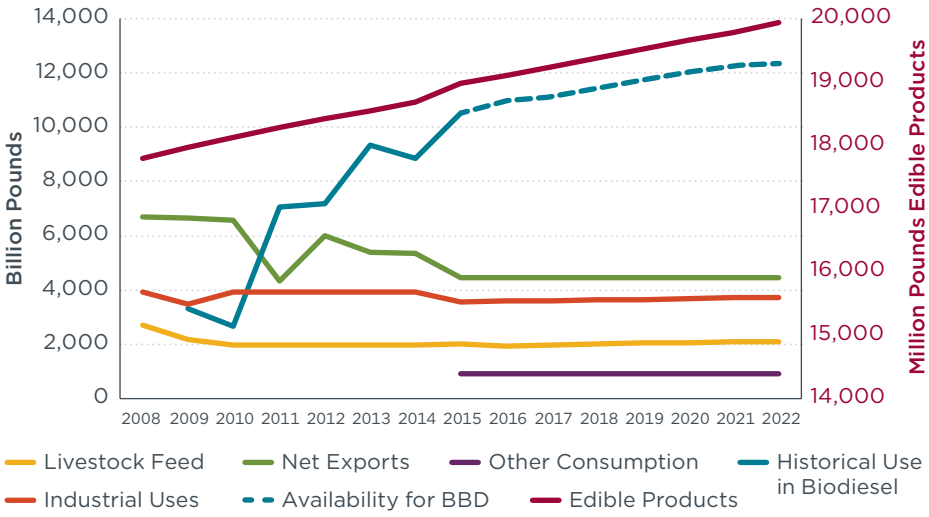

Figure 4. Historical and projected future consumption of fats, oils, and greases by end use (edible products on right axis)
Availability displayed as year over year change.

AVAILABILITY OF VEGETABLE OILS

Soybean Oil

Over the past five years soybean oil has been the most utilized biodiesel feedstock (Figure 2; EIA, 2016a). This is mainly due to low prices and abundance of soybean oil, as a result of its standard use as a rotation crop for corn. Increased corn yields, reduced nitrogen expenses, and reduced rootworm management costs are a few advantages to planting soybean in rotation with corn that have led to soybean being the second most planted of any crop in the United States (Morrison, 2013). Soybeans have relatively low oil yield; the bulk of the value of soybeans is in the protein-rich soy meal (Cromwell, 2012). However, soybean oil is still by far the highest produced vegetable oil in the U.S. (USDA—ERS, 2016f).

Soybean oil production has been relatively constant over the past 10 years with a slight upward trend (Figure 3). According to the USDA soybean oil production is expected to continue increasing slightly due to minor improvements in oil yield. Soybean oil production is expected to increase non-linearly, with the greatest increases occurring during 2018–2020. We predict that consumption will also increase based on increased use in edible products and livestock feed. Currently, the major use of soybean oil is in the production of edible products and we expect such usage will grow with increased food demand resulting from population growth. We also predict that livestock feed, although accounting for a minor portion of total soybean oil consumption, will increase corresponding to USDA projected increases in livestock production.

We project soybean oil availability to increase by 175 million pounds or 23.5 million gallons of biodiesel equivalent from 2017 to 2018. This is a roughly 2.61 % increase over the 2017 soybean availability, an underwhelming volume that will fulfill only 23.5% of the proposed increase in BBD requirements from 2017 to 2018. Soybean oil availability is projected to increase by an average of about 111 million pounds or 15 million gallons of biodiesel equivalent per year during the projection period from 2016 to 2022.

Canola Oil

Canola oil production has risen slightly over the last decade while domestic use has soared. Imports have risen to satisfy the increased demand (roughly 70% of total supply) (USDA-ERS. 2016b). Canola oil contributes less towards biodiesel production compared with other FOG because of growing preference for canola oil in edible products and increasing use and availability of less expensive feedstocks (i.e. greases and inedible corn oil) (Schwab et al., 2016). Canola oil is believed to consist of relatively healthy fats compared with other

edible oils (Global Industry Analysts, 2016). In turn, use of edible canola oil has more than tripled from 2002 to 2015 (USDA-ERS, 2016g). Despite this, canola oil was the fourth largest contributor to biodiesel production in 2015 (EIA, 2016a).

Similarly to soy, future domestic canola oil production is projected to increase only slightly. Domestic use is projected to continue to increase. Also similarly to soy, canola oil consumption in livestock feed is projected to increase proportionally with increased livestock production, (with minimal effect on overall availability). Total growth in the availability of canola oil is projected at an average of about 50 million pounds or 6.5 million gallons of biodiesel equivalent per year during the projection period.

Corn Oil

Corn oil production has shown tremendous growth over the past 10 years. Corn oil production has increased largely as a result of an increase in corn oil fractionation in the corn ethanol industry. Corn oil can be fractioned out at different stages of the corn ethanol process to produce edible or inedible corn oil. Separation of the corn germ from the kernel prior to ethanol fermentation produces edible corn oil. This process involves a more expensive extraction and refining process (Rajendran et al., 2012; CRA, 2006). Increased supply of edible corn oil would not directly increase biofuel feedstock supply because of its use exclusively in edible products; however, it would indirectly increase supply as the oil could offset some FOG demand growth in edible products. We predicted edible corn oil production to increase proportionally with increased corn production projected by the USDA. Corn oil can also be fractioned out of corn mash during the corn ethanol process to produce inedible corn oil (Lincolnway Energy, 2015). Inedible corn oil consumption was previously dominated by use in livestock feed but has been used increasingly as a biofuel feedstock over the past five years. However, inedible corn oil production has been relatively flat since the end of 2013 and is expected to remain flat as extraction yield improvements and the number of producers fractioning out corn oil have leveled off (Jessen, 2013). Additionally, the RFS mandate for non-advanced renewable fuel is leveling off and is not expected to increase substantially from now through 2022. In the statute, non-advanced renewable fuel is capped at 15 billion gallons and the proposed 2017 volumes are at 14.8 billion gallons. It is thus not likely that corn ethanol production, and thus inedible corn oil production, will increase substantially in future years. As a result the amount of inedible corn oil available for biodiesel production was projected to remain constant at 2015 levels.

Other Vegetable Oils

Despite having approved RFS pathways, neither sunflower oil nor cottonseed oil is currently used for biodiesel due to price premiums (USDA-ERS, 2016h). Both sunflower and cottonseed oil could displace some of the demand for biodiesel in edible products if production is greater than increases in population growth. However, the USDA does not offer long-term projections for sunflower and cottonseed oil production and historical trends do not suggest significantly increasing production (USDA-ERS, 2016i, j). Thus, we expect both oils to remain irrelevant to the biofuel feedstock supply.

Camelina oil for biodiesel also qualifies as an advanced biofuel feedstock; however, it has not been produced at a significant scale in the United States due to limited profitability (AgMRC, 2015).

AVAILABILITY OF RENDERED PRODUCTS

Animal Fat

Animal fat availability is dependent on the domestic consumption of meat and the amount of animal products prepared for export. As mentioned previously, the USDA ten-year projections estimate an increase in total livestock production in the United States.

Animal fat mainly consists of tallow, white grease, and poultry fat. Tallow is animal fat from ruminant animals: cattle, lamb, and sheep. Tallow production has decreased proportionally with red meat production over the last seven years but is expected to rebound with increased production. Increased meat production will also have the effect of increased tallow consumption in livestock feed. In addition, increased consumption of lubricants, one of several industrial uses of FOG, will increase the consumption of tallow. Overall, increased production is expected to outweigh increased consumption resulting in about 53.5 million pounds or 7 million gallons of biodiesel equivalent growth in availability per year.

Based on the reporting of FOG in the U.S. Census, white grease and poultry fat were grouped into the category “other grease”. White grease and poultry fat production were estimated using a relationship between meat production and corresponding animal fat production. In contrast to total meat production, pork and poultry production have increased since 2010. As a result, production and consumption have increased each year. This trend is expected to continue in future years. Domestic use of other grease in livestock feed and edible products is projected to rise slightly as well. Ultimately, we expect total “other grease” availability for biodiesel production to increase by about 23 million pounds or 3 million gallons of biodiesel equivalent per year.

Yellow Grease

Yellow grease is a biodiesel input manufactured through the filtration of used baking and frying oils. Yellow grease collection from restaurants and hotels is a well-established and highly competitive industry, thus it is unlikely that collection rates will improve. Additionally, decreases in baking and frying fat consumption per capita (USDA-ERS, 2016k) should cancel out any expected increase in production resulting from population growth. The amount of yellow grease used in biodiesel has steadily increased over the past five years and was the second largest input for biodiesel production in 2015 (Figure 2). However, this trend is likely a result of bidding yellow grease stocks away from formerly prominent uses in livestock feed and export. We predict that yellow grease consumption in livestock feed will remain constant as a result of constant production, and that other FOG will be used increasingly in livestock feed. We also expect that yellow grease exports will have dropped to zero by 2016 and will remain at this level. Thus, total consumption and total availability for BBD are expected to remain constant throughout the projection period.

Brown Grease

Almost no information about total United States brown grease generation has been collected. A 2011 study performed in the general Raleigh, North Carolina area estimated that approximately 18.65 gallons brown grease/person/year is generated and of this 2% is usable brown grease that could be converted into biodiesel (Austic, 2010). Using the 2016 population, an approximate 121 million gallons of usable brown grease could be collected for biodiesel production. Such a significant impact however, has yet to be realized, as the high water and free fatty acid content, cold flow issues, and other issues associated with brown grease require costly treatment (Haas et al., 2016). Brown grease conversion to biodiesel has had support in the past but interest has dwindled because cost-efficient conversion to biodiesel is very challenging. Brown grease is still collected intermittently in order to prevent clogging of pipes and is used in anaerobic digesters, composters, electricity producing boilers, or disposed of through land application (Austic, 2010). It is unlikely that brown grease will significantly contribute to the production of BBD in the United States in the foreseeable future.

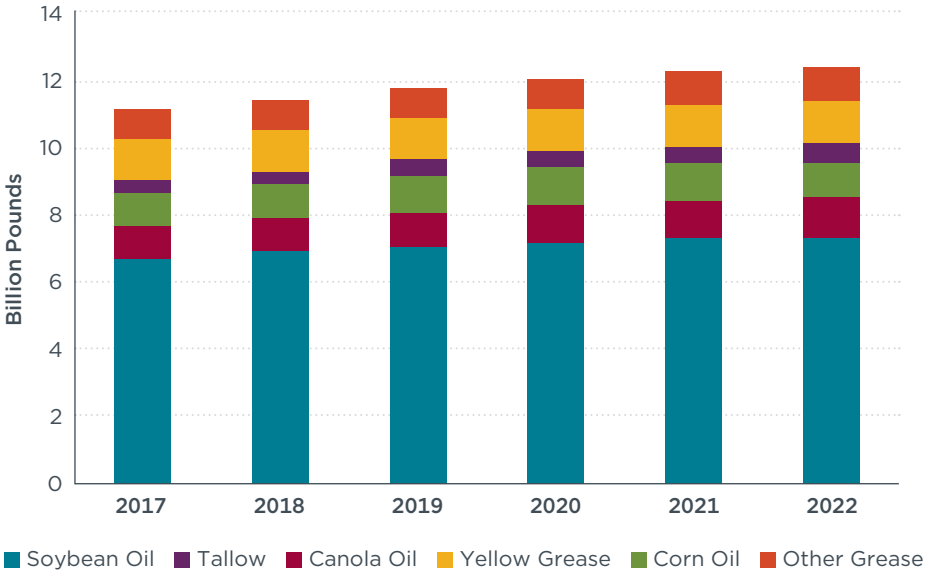

Figure 5. Projected total availability of BBD feedstocks
Availability is equal to the projected total supply minus all consumption in non-BBD sectors.

Other

Algae have potential as a biodiesel feedstock and research into cost improvement has been highly funded over the past seven years. Unfortunately, progress is very slow. Several issues including limited algae growing season/geography, high-cost fertilizer and energy inputs, and algal yield are still significant barriers to cost-efficient algal biofuel production (Lane, 2014). Many are still optimistic about the future of algal biofuels, however, a number of large algal producers have shifted their focus from away from biofuels towards other products in the cosmetic and nutrition industries (Ghose, 2012). Such a shift implies that algal biofuels may be far from commercially viability. Algae could one day contribute significantly to biodiesel production but due to great uncertainty it has been left out of this study.

Other sources of FOG contributed about 91 million gallons of biodiesel in 2015 according to EIA (2016a). However, due to the undifferentiated nature of the "other" category no projections about availability can be made.

BBD imports

Imports necessary to meet the RFS mandate are expected to increase year over year as the deficit between available feedstock and required volumes increases. In 2015, the United States imported roughly 334 million gallons of biodiesel and 204 million gallons of renewable diesel (EIA, 2016b, c).

TOTAL AVAILABILITY OF FATS, OILS AND GREASES FOR BBD PRODUCTION

Availability of each feedstock through the projection period is displayed in Figure 5. Soybean oil continues to account for the majority of biodiesel feedstock availability. Annual changes in availability of feedstocks

are reported in Table 2. Non-linear production of animal fats is a result of USDA projected increases in energy and meat prices, and thus, a decrease in livestock producer returns. Decreased producer returns ultimately slow the growth of livestock production through the projection period. Additionally, non-linear increases in soybean oil production projected by the USDA are based on non-linear decreases in planted acreage.

Looking towards 2018, we project a total domestic FOG availability of 1.526 billion biodiesel-equivalent gallons (Table 2). Compared to the proposed BBD mandate of 2.1 billion gallons for 2018, this will result in a deficit of 574 million gallons that can only be met by importing biodiesel or feedstock from other countries. A continued RFS BBD requirement increase of 100 million gallons per year compared with an average of 31.5 million gallons of increased FOG availability per year will result in exceedingly larger deficits over the projection period. An even greater deficit would be triggered if the advanced and renewable volumes are set at a level that requires additional BBD consumption. Based on a continued 700 million gallon gap between the BBD mandated volume and BBD needed to fulfill the total advanced and renewable mandate (EPA, 2016a), we expect a deficit of 1.274 billion gallons in 2018 that must be imported; an amount more than double the 2015 BBD import levels. Increased BBD requirements greater than increases in domestic feedstock production will put pressure on feedstock commodity markets and negatively affect other domestic sectors that depend on these resources.

One gallon of biodiesel is assumed to require 7.5 pounds of oil (EPA, 2010b).

Table 2. Summary of domestic BBD feedstock availability (million gallons biodiesel equivalent)

		2017	2018	2019	2020	2021	2022
Total Availability	Soy Oil	893	916	938	960	971	975
	Canola Oil	126	132	139	145	152	159
	Corn Oil	141	141	141	141	141	141
	Tallow	44	53	64	70	76	81
	Yellow Grease	167	167	167	167	167	167
	Other Grease	113	117	120	123	125	127
	Total	**1,484**	**1,526**	**1,568**	**1,606**	**1,632**	**1,649**
Annual Growth in Availability	Soy Oil	6	23	22	21	11	4
	Canola Oil	7	7	7	7	7	7
	Corn Oil	0	0	0	0	0	0
	Tallow	6	9	11	7	6	4
	Yellow Grease	0	0	0	0	0	0
	Other Grease	4	3	3	3	2	2
	Total	**23**	**42**	**42**	**38**	**26**	**17**

Availability is equal to the projected total supply minus all consumption other than BBD.

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