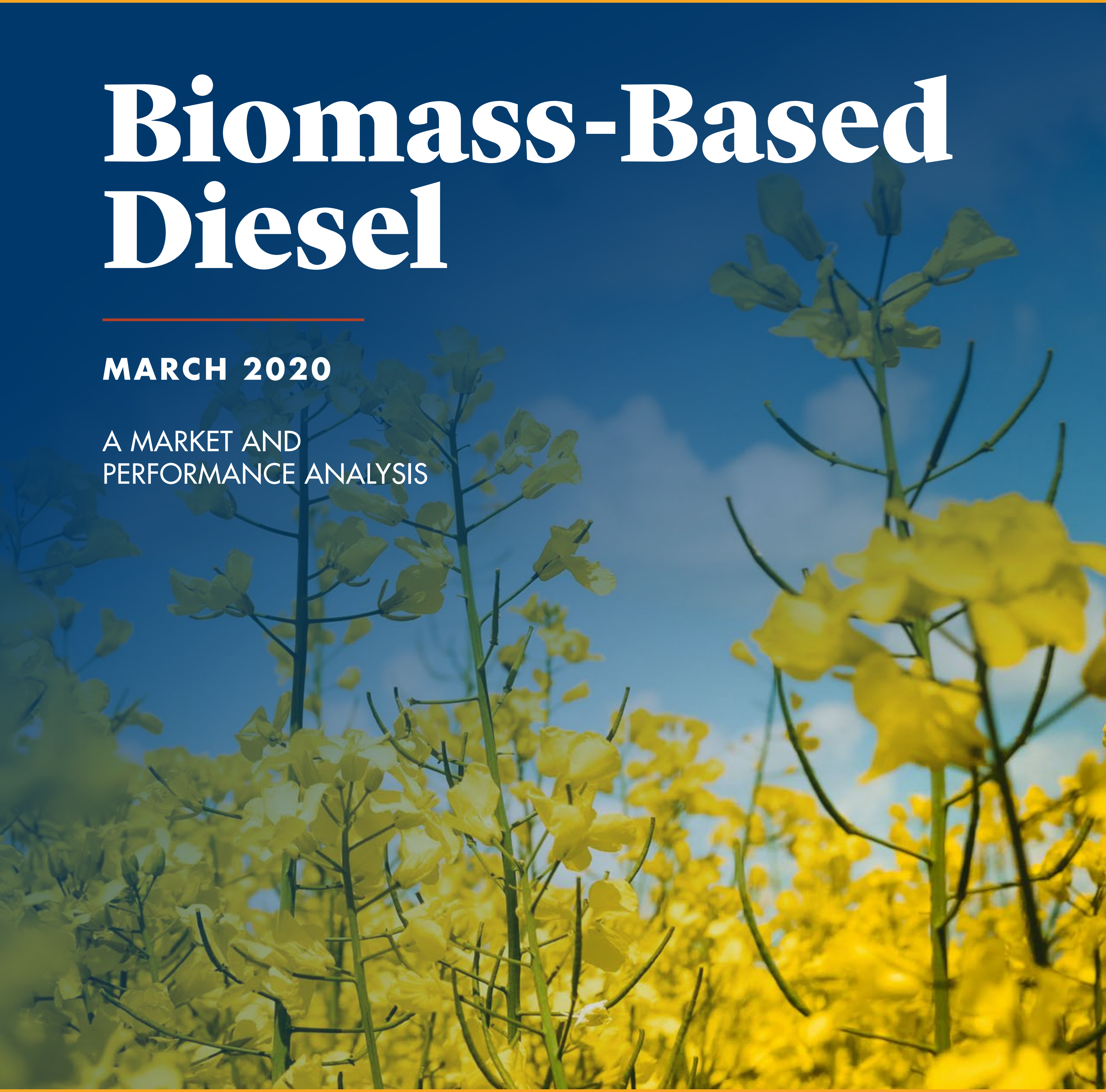
Fuels Institute

EXECUTIVE SUMMARY

Biomass-Based Diesel

MARCH 2020

A MARKET AND
PERFORMANCE ANALYSIS



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Contents

Introduction

This report provides a comprehensive overview of U.S. biomass-based diesel (BBD) markets and performance. BBD is defined here as biodiesel (fatty acid methyl esters, or FAME) and renewable diesel (hydrocarbons) that are derived from lipid feedstocks.

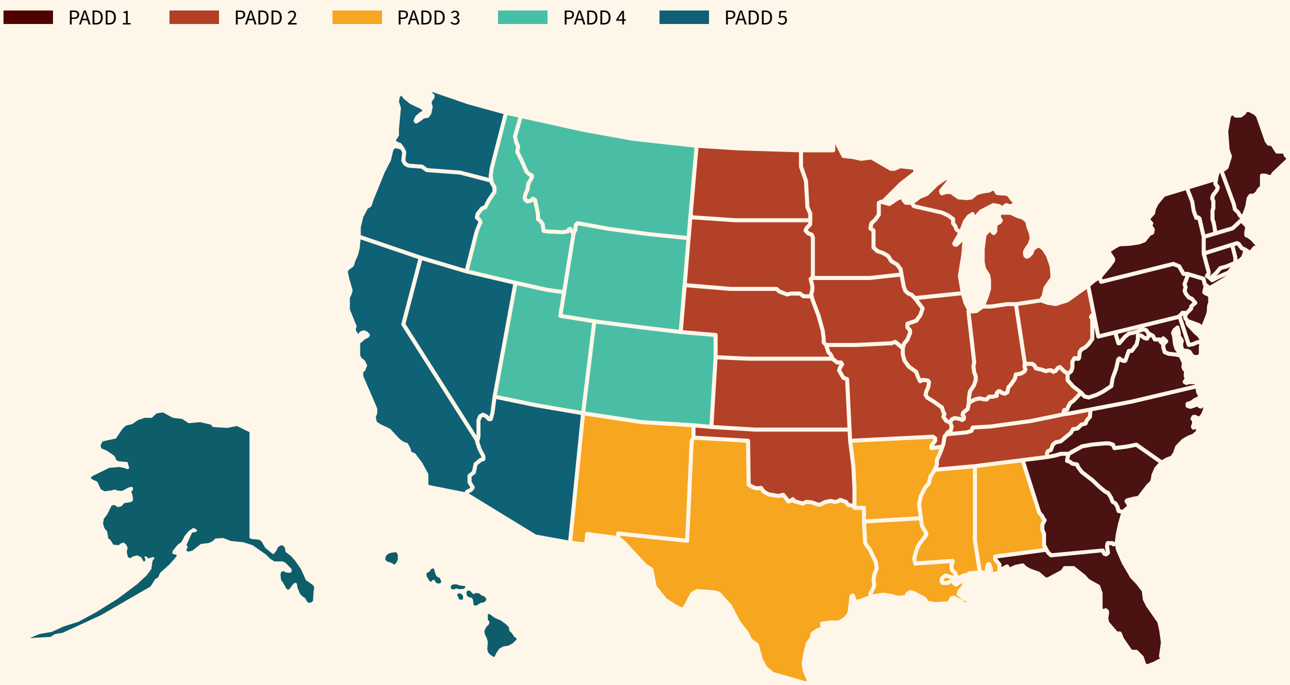
This report's primary purpose is to summarize and evaluate the major attributes of the U.S. BBD sector at every stage of the supply chain, including production, transportation, distribution, and consumption. It is divided into four sections that focus on the following topics:

1. **Section 1.** BBD supply and demand and their drivers;
2. **Section 2.** Variations in BBD blending patterns and their contributing factors;
3. **Section 3.** The technical and environmental performance characteristics of BBD fuels and BBD blends; and
4. **Section 4.** BBD production and demand economics, both in the presence and absence of government subsidies and other types incentive programs.

The motivation behind this report is the large increase in BBD production and consumption that has occurred over the last decade in the U.S. The diesel fuel that is used by motor vehicles in the country contained an average BBD content of approximately 5% by volume (vol%) in 2018 compared to 0.5 vol% in 2010. That number is on track to increase to 10 vol% as early as 2022 as new capacity in the form of renewable diesel facilities comes online, making BBD one of the country's most widespread alternative fuels.

The full report reviews and analyzes the available data on each covered BBD subject in detail. This executive summary presents the major findings of each of the full report's sections and briefly discusses their implications. The full report's subsections (e.g., Section 1.1, Section 1.2, etc.) are cited within the executive summary to permit easy reference to the relevant data and analysis. Citations are not included in this executive summary for readability purposes but can be found in the corresponding sections of the full report. Units are presented in the executive summary and full report present data according to SI system, but with two main exceptions for the purpose of readability: volumes are presented in gallons and temperatures are presented in degrees Fahrenheit. Finally, both the executive summary and the full report frequently refer to the U.S. Petroleum Administration for Defense Districts (PADD) as a geographical representation. The PADD regions largely align with the major U.S. geographic regions (i.e., the Eastern seaboard; Midwest; Gulf Coast, Mountain West, and Western seaboard). Figure ES-1 presents the PADD region boundaries. Appendix I and Appendix II present PADD-level BBD supply and demand data, respectively. Appendix III reconciles the different nomenclatures that are employed in the data sources that this report frequently references.

FIGURE ES-1: U.S. PADD REGIONS



SECTION 1.

Overview of Biomass-Based Diesel Supply in the U.S.

1.1 BIODIESEL SUPPLY

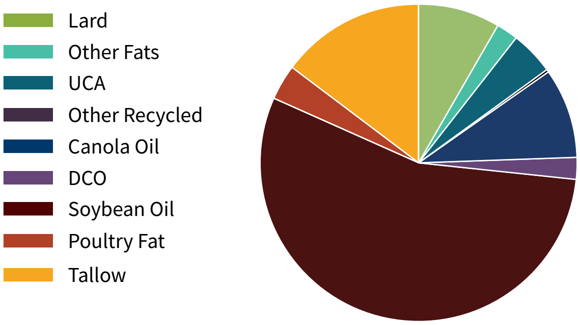
Biodiesel is the primary form of BBD production in the U.S. Unlike petroleum-derived diesel fuel (“petrodiesel”), biodiesel contains oxygen and is therefore not a hydrocarbon fuel. This oxygen content reduces the energy content of one gallon of biodiesel by up to 7% relative to one gallon of ultra-low sulfur petrodiesel (ULSD). It also is indirectly responsible for some of the performance advantages and many of the infrastructure constraints that are covered in Section 3. Most biodiesel is produced via the transesterification pathway, by which lipid feedstock is reacted with an alcohol, such as methanol or ethanol, to yield biodiesel and the lower-value coproduct glycerol. Methanol is used to produce almost all U.S. biodiesel due to its cost advantage relative to ethanol, the latter of which is commonly used as a renewable fuel in the form of fuel ethanol.

The lipid feedstocks that are used to produce U.S. biodiesel (and BBD more generally) fall into one of two categories: fats and oils. While fats and oils contain both saturated and unsaturated fatty acids, fats have a higher saturated fatty acid content that makes them solid at room temperature, whereas oils are characterized by a higher unsaturated fatty acid content and are liquid at room temperature. Fats are usually, but not always, obtained from animal sources while oils are usually, but not always, obtained from vegetable sources. The saturation level of lipid feedstocks has important implications on BBD technical performance that are covered in Section 3. Both types of lipids are further categorized according to how they are produced, as this aspect has important environmental performance implications that are also discussed in Section 3. Agricultural lipids are those feedstocks such as canola oil, soybean oil, and other oilseed crops that are produced via conventional agricultural practices. Residue and waste lipids are those feedstocks such as distillers’ corn oil (DCO), tallow, and used cooking oil (UCO) that are produced as either coproducts of other renewable fuel production pathways (DCO) or as waste products from unrelated activities (tallow and UCO).

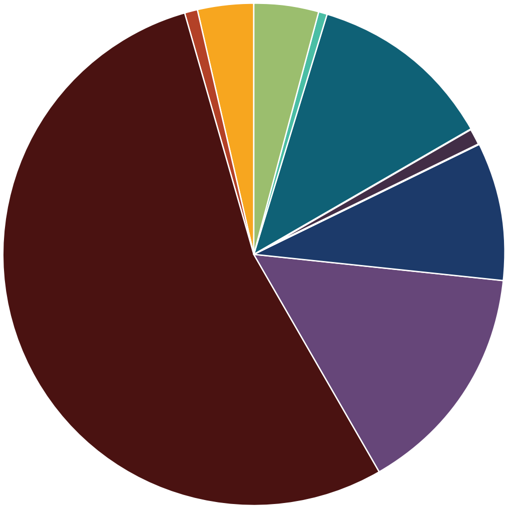
BBD feedstocks have different characteristics that necessitate production pathways of varying complexities. Free fatty acid (FFA) content varies widely across feedstocks. Feedstocks with low FFA contents can be used in low-complexity biodiesel production facilities but incur a cost premium. Feedstocks with high FFA contents require additional processing steps but are often available at a discount to low-FFA feedstocks. As a rule, agricultural lipids have low FFA contents and residue/waste feedstocks have high FFA contents. Moisture and sulfur content are also important feedstock characteristics since both must be managed by BBD production facilities if either is present in large quantities in the utilized feedstock(s).

BBD feedstock availability has repeatedly been presented as an imminent constraint on BBD production over the last decade. These forecasts have inevitably been discarded as the amount of lipid feedstock that is consumed annually by U.S. biodiesel producers has increased from 1.6 million megagrams (Mg) in 2009 to 6.4 million Mg in 2018 (see Figure ES-2). Feedstock prices have broadly declined over the last decade despite this rising demand as the supplies of new feedstocks such as DCO and UCO and existing feedstocks such as soybean oil have increased by still more. The fact that feedstock prices are currently at or below decade lows suggests that biodiesel producers will

FIGURE ES-2: U.S. BIODIESEL FEEDSTOCK MIX, 2009 AND 2018

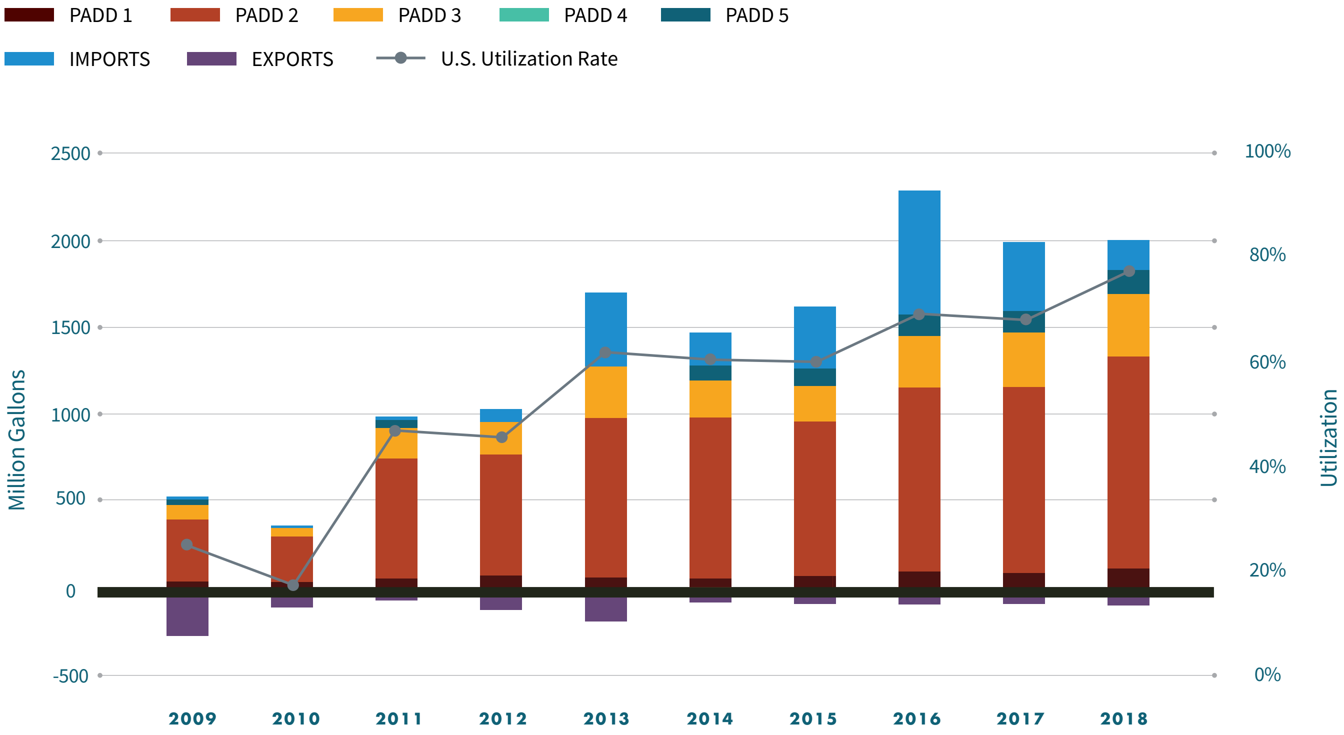


2009 = 1.6 MILLION Mg



2018 = 6.4 MILLION Mg

FIGURE ES-3: SOURCES OF U.S. BIODIESEL SUPPLY AND U.S. UTILIZATION RATE, 2009-2018



have little difficulty sourcing adequate lipid volumes in the near future. The large amount of new BBD capacity that is scheduled to become operational by 2022 makes it possible that feedstock availability could become a constraint in the new decade, however.

The majority of U.S. biodiesel supply is sourced from within the U.S., although imports had provided substantial volumes in past years before being reduced by the imposition of countervailing duties on biodiesel from Argentina and Indonesia (see Figure ES-3). The PADD 2 region is the source of both the majority of U.S. biodiesel production and biodiesel supply due to its large number of relatively large biodiesel production facilities and abundant supply of oilseed feedstocks. The PADD 3 region is a small but growing source of U.S. biodiesel production. The PADD 1, 4, and 5 regions, by contrast, are only marginal producers of biodiesel.

Biodiesel capacity remained relatively stable over the last decade even as total U.S. production increased from 516 million gallons in 2009 to 1,855 million gallons in 2018. The rising production volumes were made possible by increased utilization of existing capacity. In 2018 the U.S. hosted 2,400 million gallons of biodiesel capacity across 96 operational facilities that were registered with the U.S. Environmental Protection Agency (EPA). The average operational and registered U.S. biodiesel facility has a capacity of 25.1 million gallons per year (MMGY), although this varies by PADD region: the PADD 1 region has the smallest biodiesel facilities on average while the PADD 3 region has the largest.

Just over 50% of U.S. biodiesel production is derived from soybean oil due to the large volume of production capacity that is present in the soybean-producing PADD 2 region, and this ratio has largely remained unchanged over the last decade even as the domestic production volume has increased nearly four-fold. The residue and waste feedstocks DCO and UCO contribute another 25% of U.S. biodiesel production. The remaining 25% is derived from a combination of other oilseed (e.g., canola) and residue/waste (e.g., animal processing residues) feedstocks. Most large biodiesel production facilities utilize multiple feedstocks so as to ensure sufficient feedstock supply and the ability to utilize whichever cost-advantaged feedstocks are available at a given time. Smaller facilities such as those in the PADD 1 and PADD 2 regions, by contrast, often utilize just a single feedstock (e.g., UCO for PADD 1 facilities, soybean oil for PADD 2 facilities).

Imported biodiesel is also derived from a variety of feedstocks. One of the largest sources of imports by the U.S. historically, Argentina, has utilized a single feedstock (soybean oil) for most of its biodiesel production. Reduced import volumes from Argentina, as well as Indonesia, since 2017 have caused other countries such as Canada and South Korea to become increasingly important sources of foreign biodiesel, expanding U.S. exposure to other feedstocks such as canola oil and UCO as a result. Each U.S. PADD region has a unique set of foreign biodiesel trade partners, however, and the feedstock mix of each region's biodiesel imports is a function of the feedstock mix in those countries.

Over 70% of U.S. biodiesel production is moved near the end consumer by truck. Trucks are the most cost-effective means of moving biodiesel when the total movement distance is ~150 miles or less. Rail, water, and pipelines are utilized to move biodiesel over longer distances, as has become necessary as the PADD 1 and PADD 5 regions have increased their biodiesel supply over the last decade without corresponding increases to their production volumes. Imports only comprise a small share of the biodiesel that is consumed in the these two regions despite their own lack of production capacity and abundant deepwater port infrastructure. They instead source most of their biodiesel supply from the PADD 2 and PADD 3 regions. Biodiesel is regularly moved from the PADD 2 and PADD 3 regions to the PADD 1 and PADD 5 regions as a result. These longer-distance movements, which comprise 28% of U.S. biodiesel production, primarily occur via rail and, to a lesser extent, water, although both options have unique constraints.

Small volumes were also moved via pipeline in 2009 and 2010 during initial trials of biodiesel movements through refined products pipelines. Pipeline movement has not become widespread, although it has restarted in recent years following further study of the technical implications covered in Section 3. The utilization of the country's plentiful refined products infrastructure would make biodiesel more competitive in the existing petrodiesel market by reducing its costs of transportation and/or increasing its ability to access higher-margin markets. In the meantime, most biodiesel movements will continue to be completed via truck.

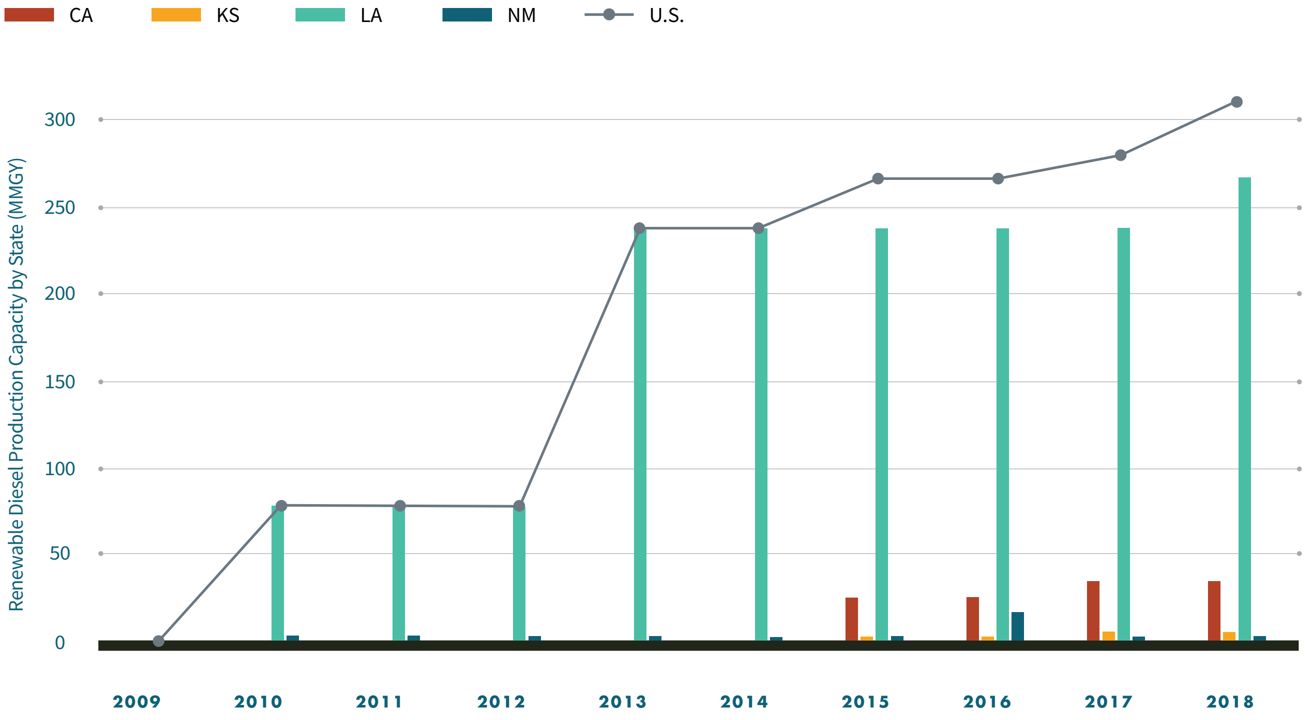
1.2 RENEWABLE DIESEL SUPPLY

Renewable diesel is similar to biodiesel in that both BBD fuels are produced from lipid feedstocks and are blended with petrodiesel for use in diesel engines. They are very different fuels in terms of chemical composition, however. Renewable diesel is produced via lipid hydroprocessing and isomerization instead of transesterification. Rather than react the lipid feedstocks with methanol to yield FAME, as transesterification does, the hydroprocessing pathway reacts the feedstocks with hydrogen. This hydrogen binds with the feedstock's oxygen content to form water that is separated and removed, leaving only hydrogen and carbon behind. The resulting fuel is, like petrodiesel, composed of hydrocarbons, and the two fuels are interchangeable under certain conditions as a result. The renewable diesel that is supplied to the U.S. market is a fully paraffinic fuel, which causes it to have a lower density and therefore energy content (approximately 4% lower per gallon) than petrodiesel. Renewable diesel offers some performance advantages that are covered in Section 3.1, but its fully paraffinic nature also presents open questions about other performance properties such as lubricity and elastomer compatibility. The hydroprocessing and isomerization pathway yields two coproducts: propane (rather than glycerol) and naphtha, the latter of which is used as a renewable gasoline blendstock.

Renewable diesel can be produced from any feedstock that is capable of being utilized as a biodiesel feedstock. Renewable diesel producers often prefer to utilize saturated feedstocks, however, for two reasons. First, the hydroprocessing pathway saturates the feedstocks with hydrogen and the amount of saturation that needs to occur is a function of the feedstock's beginning saturation level. Second, saturated feedstocks yield biodiesel that has a higher cloud point (e.g., the temperature at which biodiesel begins to freeze and experience degraded engine performance) than biodiesel derived from unsaturated feedstocks, making the former less desirable for biodiesel (see Section 3.1). Conversely, renewable diesel's cloud point does not depend on a feedstock's saturation level. Although hydrotreated fats and oils have extremely high melting points (often >90 °F), with sufficient isomerization renewable diesel can have a cloud point comparable to that of petrodiesel. Renewable diesel facilities are frequently very large and, like large biodiesel facilities, often utilize multiple feedstock types in order to ensure sufficient feedstock availability throughout the year.

The U.S. renewable diesel sector is substantially less developed than the U.S. biodiesel sector. The country's first commercial-scale renewable diesel production facility did not become operational until 2010. Only five such facilities were operational at the end of 2018. Many of these facilities are large relative to biodiesel facilities, though, and U.S. renewable

FIGURE ES-4: U.S. RENEWABLE DIESEL PRODUCTION CAPACITY BY STATE, 2009-2018



diesel production capacity increased from 78 MMGY to 397 MMGY between 2010 and 2018 (see Figure ES-4). The large majority of this production occurs in Louisiana, making the PADD 3 region the country's primary domestic source of renewable diesel. U.S. capacity is expected to increase to almost 3,000 MMGY by 2022 as new facilities and expansions of existing facilities become operational. The additional capacity will be spread across every PADD region except the PADD 1 region, and the PADD 5 region is expected to have a plurality of U.S. renewable diesel production capacity by 2022.

U.S. RENEWABLE DIESEL PRODUCTION INCREASED FROM 16 MILLION GALLONS IN 2010 TO 329 MILLION GALLONS IN 2018. U.S. RENEWABLE DIESEL IMPORTS HAVE ALSO INCREASED RAPIDLY AND CONTRIBUTED AN ADDITIONAL 173 MILLION GALLONS TO U.S. SUPPLY IN 2018.

The PADD 3 and PADD 5 regions account for most U.S. renewable diesel supply. The PADD 3 region's supply is primarily sourced from internal production, although it has imported small volumes over the last decade. The PADD 5 region's supply is primarily sourced from a combination of imports and shipments from the PADD 3 region, although internal production has contributed additional volumes since 2016. The PADD 1, 2, and 4 regions have very limited supplies of renewable diesel due to the absence of production capacity, such as the PADD 3 region has, or valuable renewable diesel supply incentives, such as the PADD 5 region has in the form of California's Low Carbon Fuel Standard (LCFS).

U.S. imports of both renewable diesel and biodiesel (BBD) are mostly sourced from residue and waste feedstocks due to the major role that California's LCFS plays in incentivizing exports to the U.S. The LCFS provides participating low-carbon fuels with a subsidy that is valued as a function of the fuel's unique carbon intensity (CI), and the subsidy increases in value as the CI decreases. Residue and waste feedstocks yield BBD with a lower CI than that derived from agricultural crops, encouraging the addition of the former to the state's supply. The LCFS also imposes a high CI on BBD that is derived from palm oil, effectively preventing that feedstock, which is a common BBD in Southeast Asia, from participating in the LCFS. U.S. renewable diesel production utilizes a variety of feedstocks, of which animal processing residue is one of the most important due to the technical characteristics discussed above and the location of Louisiana's renewable diesel production capacity near animal processing facilities.

Renewable diesel does not encounter as many movement constraints as biodiesel due to its status as a hydrocarbon fuel, although the economics of movements by the different transportation modes are the same for both fuels. The primary difference is that renewable diesel can be moved via refined products pipelines without causing the contamination issues that exist in some situations for biodiesel. It does not appear that substantial volumes of renewable diesel are being moved via pipeline at this time, however, likely due to the fact that most U.S. renewable diesel production capacity is located near the pipelines that move products to the PADD 1 region but not the PADD 5 region, yet renewable diesel supply is much greater in the PADD 5 region due to California's LCFS.

1.3 BBD SUPPLY INCENTIVES

BBD supply is incentivized via a combination of policies that exist at the national and state levels. The most impactful of these is the U.S. Renewable Fuel Standard (RFS), which mandates the blending with petrodiesel prior to retail of specific volumes of BBD that gradually increase every year (see Figure ES-5). The RFS ensures that a minimum volume of BBD is supplied to the U.S. transportation fuel sector. The RFS utilizes sustainability criteria by requiring participating BBD fuels to have been produced from lipid feedstocks and possess a life cycle CI that is at least 50% lower than that of petrodiesel.

FIGURE ES-5: ADVANCED BIOFUEL AND BBD MANDATED BLENDING VOLUMES UNDER THE U.S. RFS

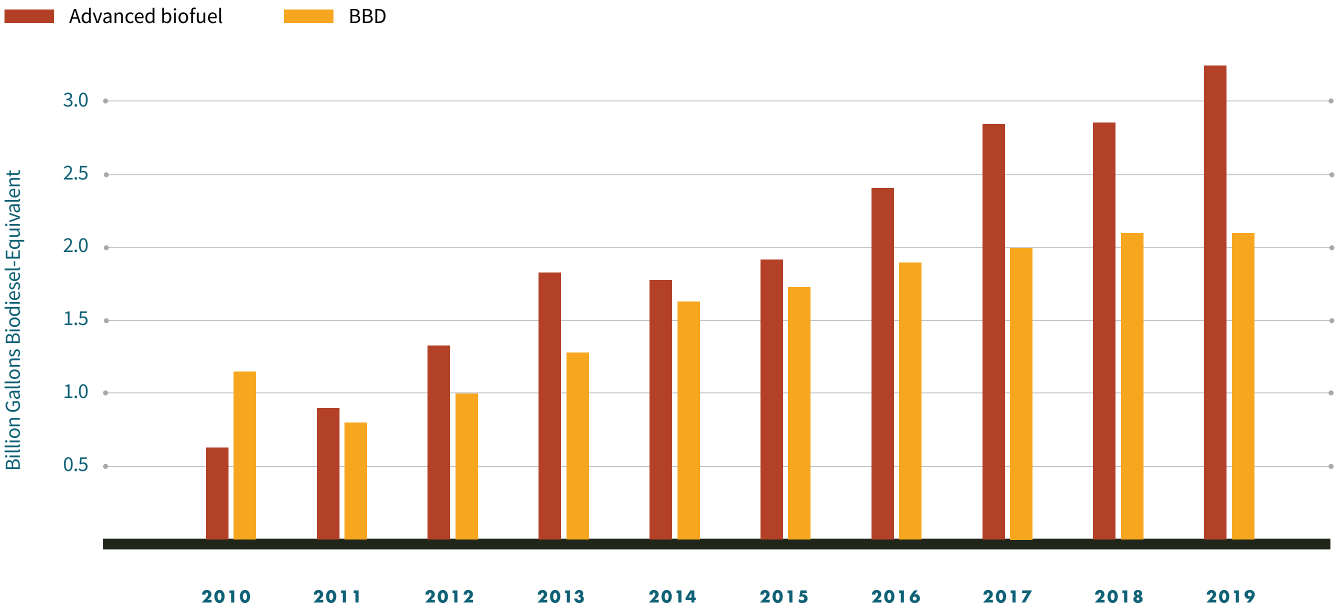
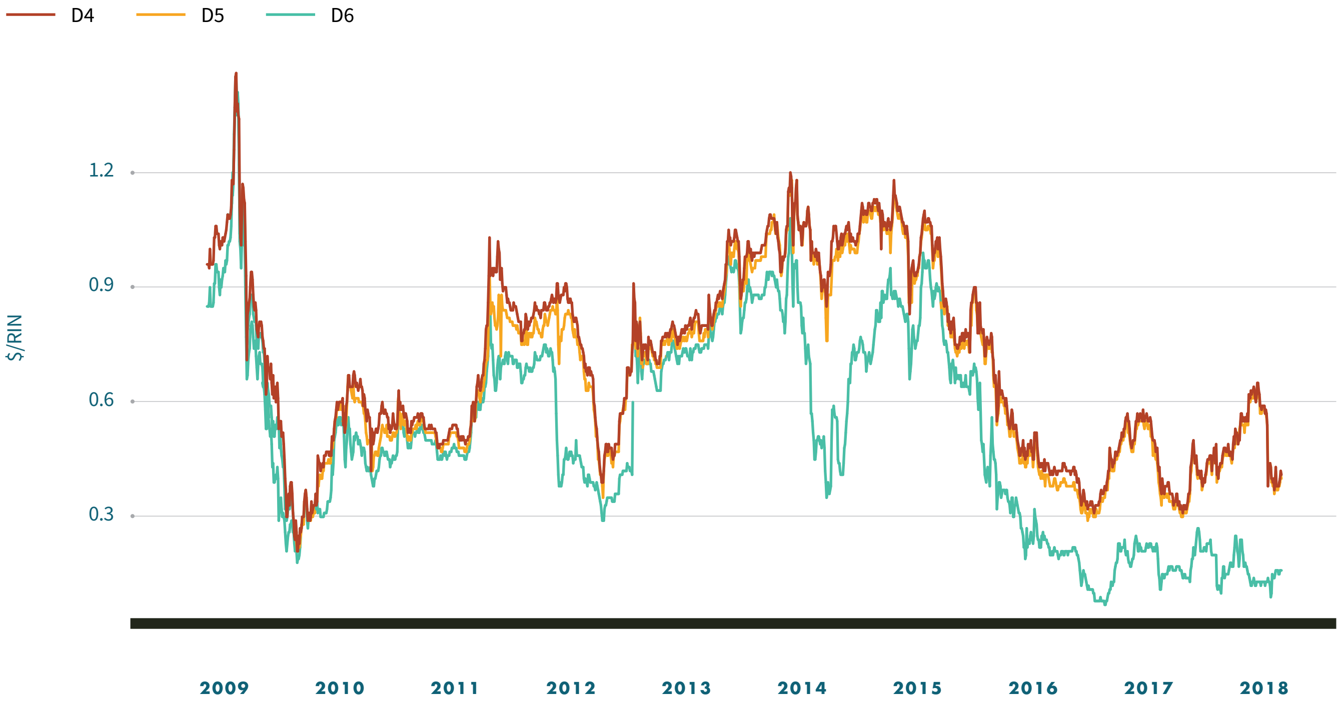


FIGURE ES-6. D4, D5, AND D6 RIN PRICES UNDER THE RFS, 2013-2018



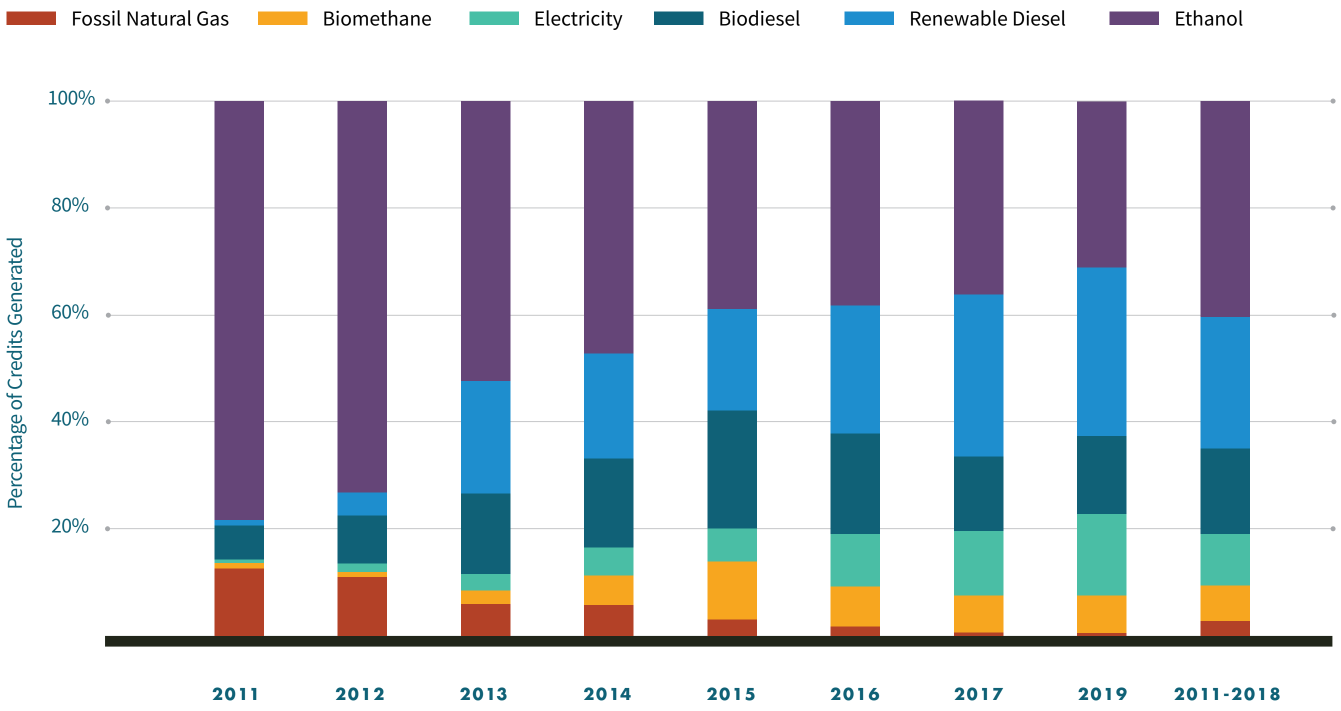
RFS compliance is maintained via tradeable credits called Renewable Identification Numbers (RIN). Each RIN corresponds to a gallon of BBD (based on an ethanol energy-equivalent basis, so one gallon of biodiesel receives 1.5 RINs and one gallon of renewable diesel receives up to 1.7 RINs) that has been blended with petrodiesel or sold for retail. Refiners are required to submit a certain number of RINs to the EPA annually to demonstrate their compliance with the mandate. Refiners obtain RINs by either blending sufficient volumes of BBD or purchasing RINs from other parties. RIN prices have declined sharply over the last two years as the EPA has taken steps to reduce RIN demand via the widespread allocation of small refinery exemption waivers to refineries (see Figure ES-6).

The U.S. has historically provided a refundable tax credit popularly known as the biomass-based diesel blenders' credit, or BTC (see Section 1.3). This tax credit is currently worth $1 for every gallon of pure BBD that is blended with petrodiesel for consumption. As a refundable tax credit this subsidy is paid by the IRS to the taxpayer after the taxpayer's tax liability had been offset. The BTC has been allowed by Congress to expire on multiple occasions over the last decade, most recently at the end of 2017, before ultimately being retroactively reinstated and sometimes also extended. Its latest absence had a notably negative effect on U.S. BBD supply given that it was concurrent with the EPA's weakening of the RFS mandate.

A state policy that has had an outsized impact on U.S. BBD supply is California's LCFS. The LCFS establishes annual CI reduction targets, reaching 20% by 2030, for the transportation fuels that are sold within the state. Each year's target is met via the blending of fuels with individual CIs that are lower than those of the corresponding petroleum-derived fuels (e.g. gasoline and diesel fuel). The supply of low-carbon fuels is incentivized via their ability to generate credits that are currently valued at $195 for every Mg of CO2 that is reduced. BBD in the form of biodiesel and renewable diesel has been the largest source of these credits since the LCFS was implemented in 2011 (see Figure ES-7). BBD fuels have been major contributors of credits due to their ability to achieve CI reductions of up to 90% relative to petrodiesel. In 2018 BBD fuels received credits equal to an average of approximately $1.32 per gallon of BBD, and that value has increased further in 2019 to date.

Eight states besides California have implemented explicit BBD blending mandates in their transportation sectors, although two of these have subsequently been temporarily or permanently suspended; these state-level policies are described in detail in Section 2.4. The most ambitious state mandate is that of Minnesota, which requires that all No. 2 diesel fuel sold in the state between April and September contain 20 vol% biodiesel (a 5 vol% blend mandate is in effect during the rest of the year). Several states in the Northeast have also implemented “bioheat” mandates that require the blending of BBD with heating oil, although New York State is the only state with an active bioheat mandate due to strict prerequisites in the other states. 30 states provide tax incentives for BBD production, blending, and sales, often in the form of income tax and fuel excise tax credits. Competitive grants and loan guarantees for BBD infrastructure investments are two additional incentive mechanisms that have been utilized over the last decade at the federal and state levels of government.

FIGURE ES-7 PERCENTAGE OF TOTAL CREDITS GENERATED BY DIFFERENT ALTERNATIVE FUELS ON AN ENERGY-EQUIVALENT BASIS UNDER THE LCFS



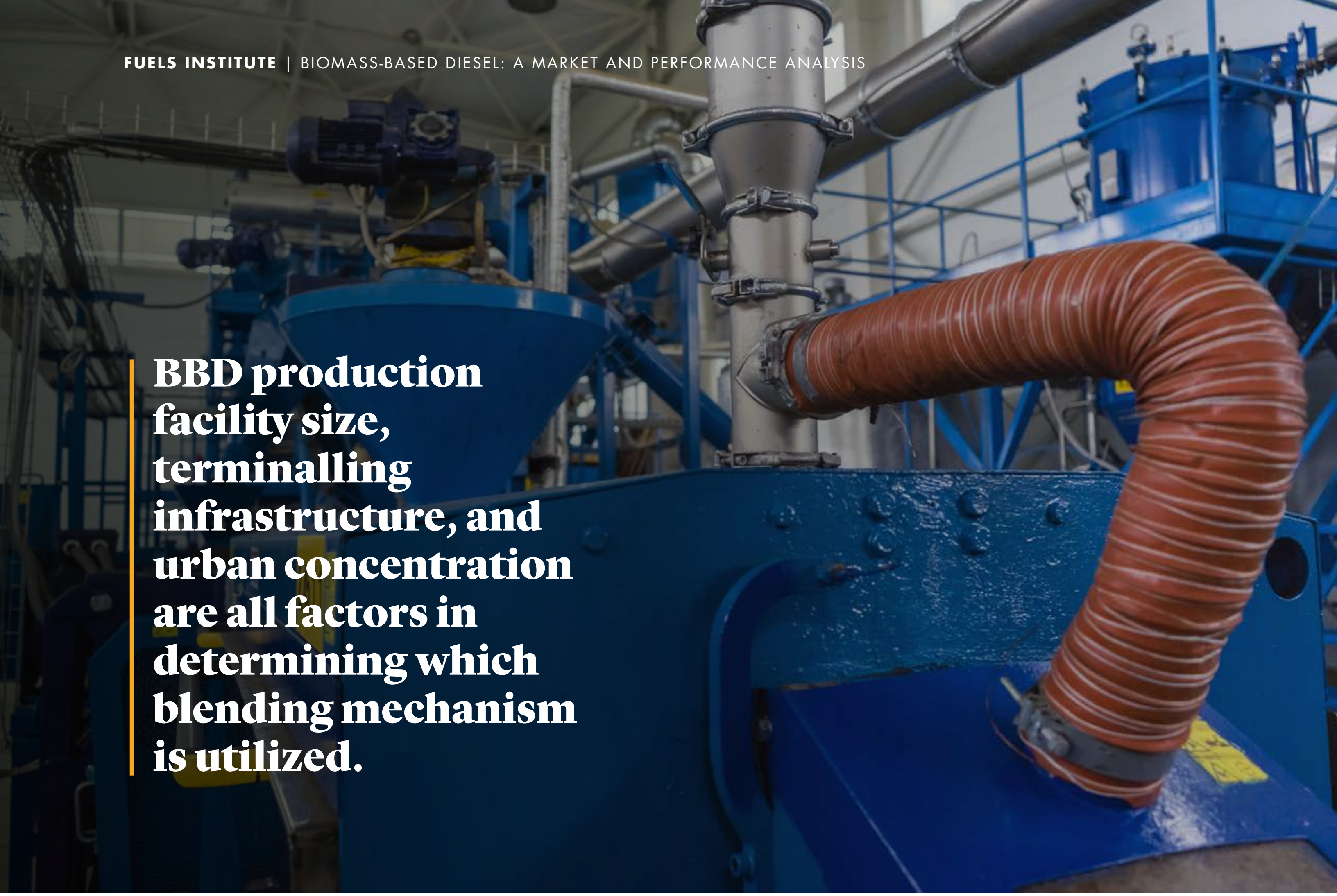
SECTION 2.

Overview of U.S. Biomass-Based Diesel Distribution, Blending, and Demand

2.1. BBD DISTRIBUTION

BBD utilizes a different distribution network than refined fuels do. Petrodiesel is commonly moved from refineries via refined products pipelines to large bulk terminals. It is then offloaded, or "racked" to trucks for transportation to retailers for final sale to consumers. A lack of pipeline utilization by the BBD sector (see Section 1.1) means that most biodiesel and renewable diesel volumes skip the refinery and pipeline infrastructure altogether. BBD is instead distributed via a variety of routes that differ across PADD regions. Historically much BBD has been sold directly by production facilities to so-called "fuel jobbers", which use tanker trucks that are filled with straight BBD at the BBD production facility or with a combination of petrodiesel and BBD via separate filling activities, often occurring at separate facilities. This latter process is known as "splash blending." The volume of each fuel in the tank determines the blend rate. The jobber then drives to the retailer to sell the blended fuel, relying on the pumping process and natural agitation during the trip to combine the two fuels into a homogenous blend. Fuel jobbers have been an important source of blending in the PADD 2, PADD 3, and PADD 5 regions.

Improved blending techniques have become more common at bulk fuel terminals, fueling stations, and local "bulk plants" in recent years as U.S. BBD supply has increased. BBD is moved from the production facility to a bulk terminal via truck, rail, or barge where it is blended via either a manifold or rack blending system. Manifold blending is less expensive but only allows a terminal to dispense a single blend. Rack blending is more expensive but allows the blend rate to be changed to meet a customer's specific needs. Both types of terminal blending systems can achieve more accurate BBD blend rates and more homogenous BBD blends than are achieved via splash blending. Bulk fuel terminals are the largest source of blending in the PADD 1 region.

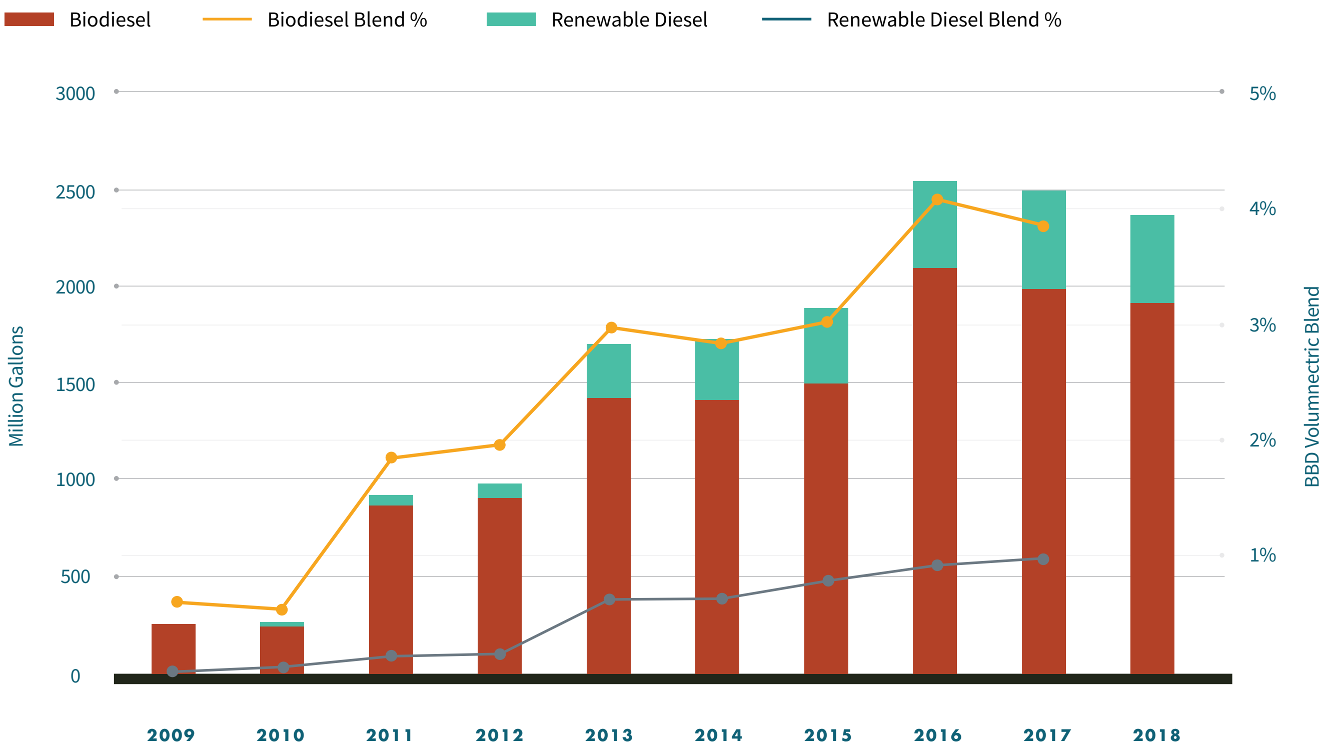


BBD production facility size, terminalling infrastructure, and urban concentration are all factors in determining which blending mechanism is utilized.

Small volumes of BBD have been moved from BBD production facilities to refineries in recent years, blended onsite, and then moved through pipelines to terminals as ≤5 vol% blends. Such refinery blending allows for the BBD blend to be cost-effectively moved over long distances, increasing its market reach. This process has created conflicts with terminal operators, however, since the specific BBD blend rate is not always known for ≤5 vol% blends (see Section 3.1). Terminal operators can inadvertently violate especially strict BBD blend labeling requirements in some states when the petrodiesel coming off of the pipeline already contains some BBD. These disparate labeling laws could become a potential constraint on BBD distribution through pipelines if refinery blending becomes widespread. Refineries are the largest source of blending in the PADD 4 region, although it is very likely that this blending is done at onsite truck racks or refinery-owned terminals, and that the BBD blends only rarely move through pipelines in that region.

The blending mechanism that is utilized is determined by multiple factors, including BBD production facility size, the presence of terminalling infrastructure, and a region's urban concentration. BBD from smaller production facilities is often blended by fuel jobbers whereas that from large facilities, especially those with multimodal transportation systems, is more likely to be blended at terminals. BBD from production facilities that are located close to retail stations is also frequently blended by jobbers, although some large retail chains have set up their own blending operations. Some BBD producers even operate their own terminals for blending purposes as well.

FIGURE ES-8: U.S. ANNUAL BBD CONSUMPTION VOLUMES (2009-2018) AND AVERAGE BLEND RATES AS PERCENTAGE OF MVNRLM DIESEL FUEL CONSUMPTION



2.2. U.S. DEMAND AND BLENDING

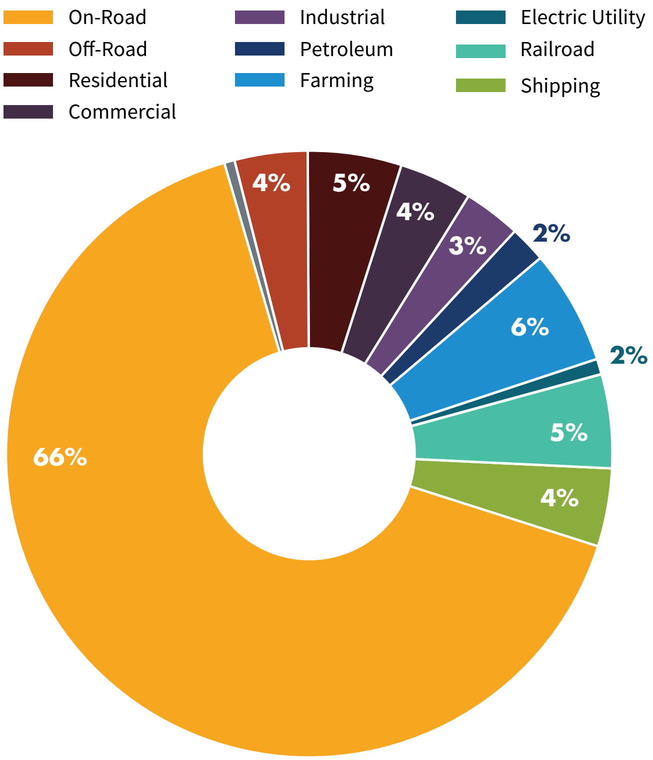
U.S. BBD consumption matches U.S. BBD supply due to the cost-competitiveness of BBD blends with pure petrodiesel at retail stations (see Section 4.2). Biodiesel is the primary form of BBD consumption, although renewable diesel's share of the total has increased over the last decade (see Figure ES-8). The average annual blend rates of both BBD fuels increased steadily from 2010 to 2016, although biodiesel consumption has declined (both in absolute terms and relative to petrodiesel consumption) as reduced BBD imports in 2017 and 2018 were not fully offset by increased domestic production. U.S. motor vehicle, non-road, locomotive, and marine (MVNRLM) diesel fuel contained an average BBD blend of approximately 5 vol% in 2017, the most recent year for which data is available.

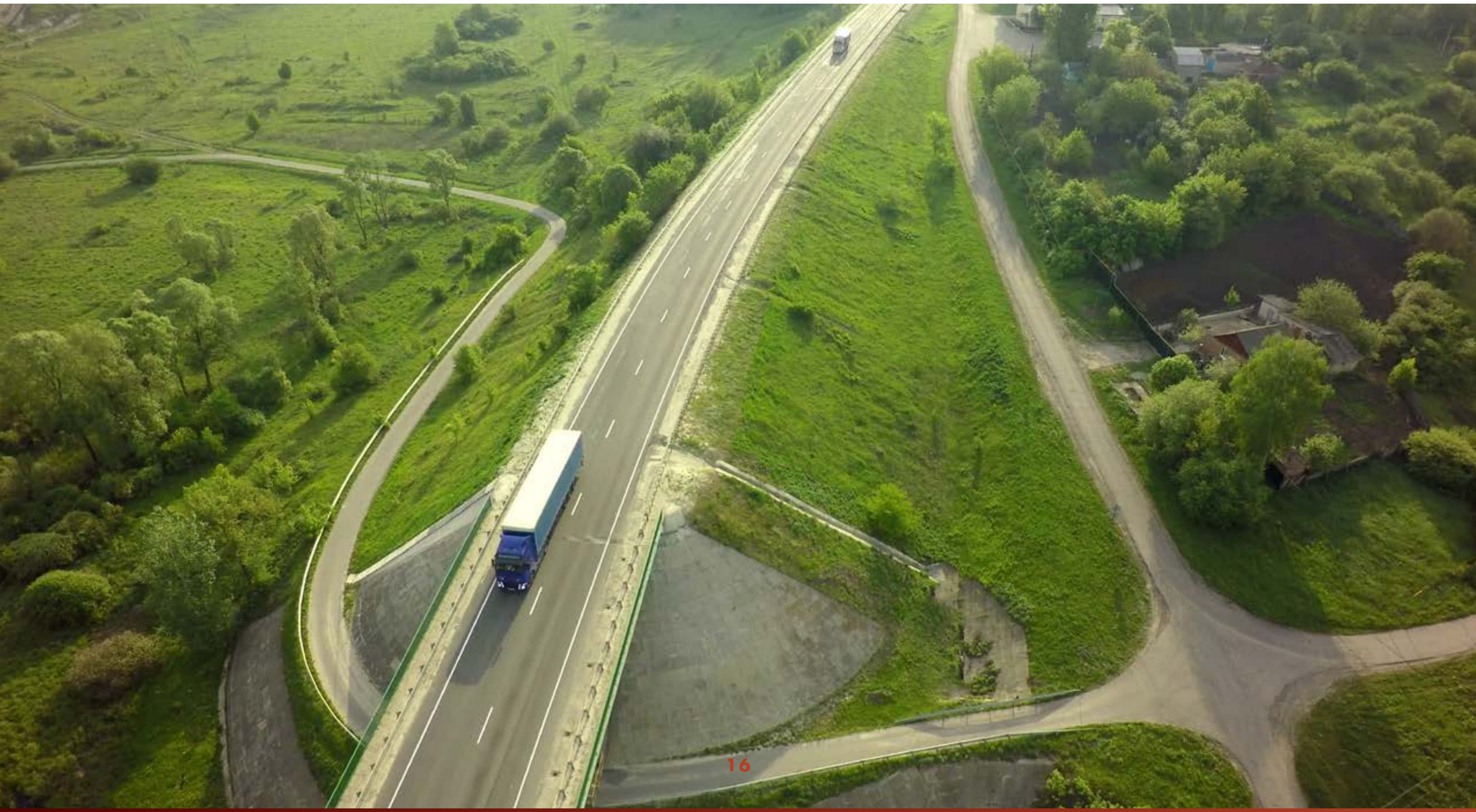
Biodiesel has been broadly approved under U.S. on-road diesel engine warranties for use in blends of up to 20 vol% with petrodiesel. It is also approved for use as blends of up to 5 vol% in most other diesel fuel applications. Renewable diesel that meets the ASTM D975 specification can be used in blends of up to 100 vol% in almost all diesel fuel applications. While data on BBD demand in each sector of the diesel fuel market is not available, it is possible to estimate maximum U.S. BBD consumption based on these blend usage constraints and sector-based distillate fuel oil (i.e., diesel fuel and heating oil) consumption (see Figure ES-9). U.S. biodiesel and renewable diesel consumption can increase by 7,200 million gallons and 60,000 million gallons, respectively, relative to their 2017 levels before encountering blend usage constraints.

Sector-based BBD demand in the U.S. is mainly determined by a combination of infrastructure and policy. The widespread ability to consume biodiesel blends of up to 20 vol% in on-road diesel engines has caused biodiesel distribution networks to focus on that sector. This is especially true for fuel jobbers that operate on limited distribution networks and manifold blending terminals that only offer one biodiesel blend at a time. The presence of RFS incentivizes this focus by basing the number of RINs that a blender earns on the number of gallons that are blended: a fuel jobber or manifold blending terminal operator generates 4x as many RINs by producing a 20 vol% blend than by producing a 5 vol% blend. Other things being equal, these types of blenders will most likely continue to focus on the on-road sector so long as the average annual blend rate remains substantially below 20 vol%. That said, growing efforts to reduce various types of emissions (e.g., sulfur oxides, particulate matter, CO2) will cause the use of biodiesel blends in other sectors such as residential (space heating) and off-road/farming (machinery) to increase moving forward.

FIGURE ES-9: U.S. DISTILLATE FUEL OIL (EXCLUDING KEROSENE) CONSUMPTION BY SECTOR IN 2017

Percentages are rounded to nearest whole digit



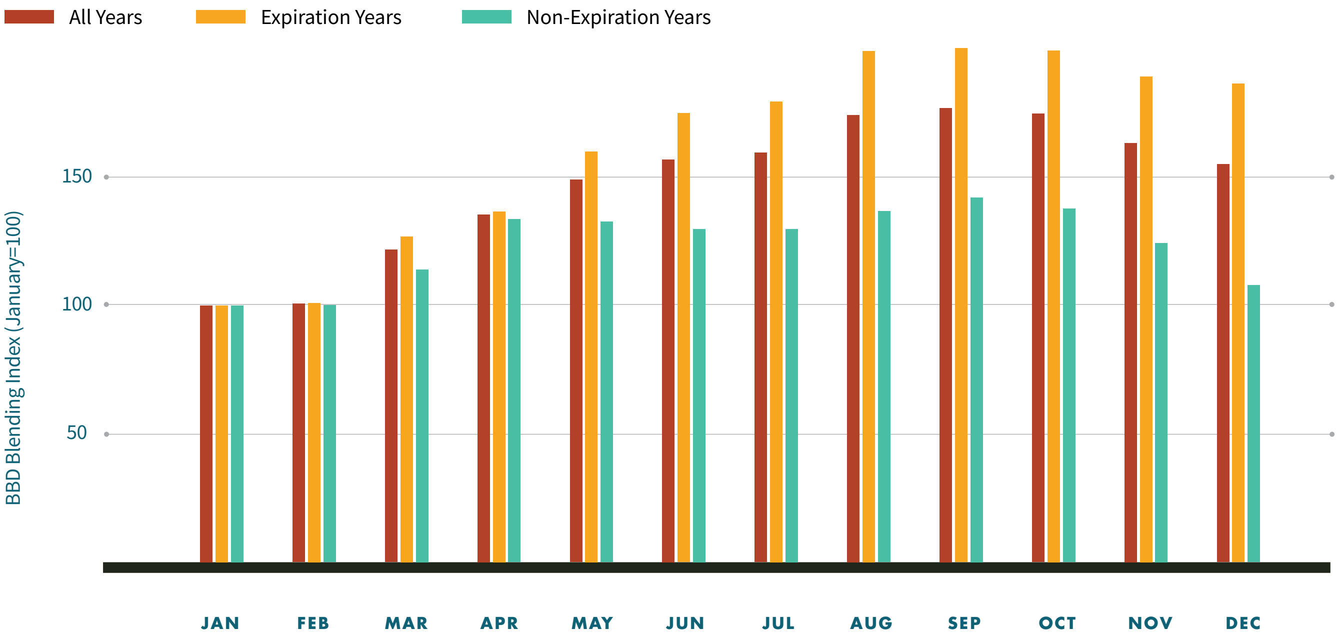


Average blend rates do not remain steady throughout the year but instead increase from March to August/September before declining through the end of the year (see Figure ES-10). This annual pattern exists due to a combination of seasonal and policy factors. Biodiesel prices operate in part as a function of petrodiesel prices (see Section 4.1), and petrodiesel prices normally increase during the warmer months of the year due to higher seasonal demand for the fuel. Seasonal factors have an even stronger effect on biodiesel demand: in addition to higher general fuel demand during the warmer months of the year, biodiesel consumption in the winter is hindered by its high cloud point relative to petrodiesel (see Section 3.1). Minnesota's biodiesel blend mandate declines to 5 vol% during the coldest half of the year due to concerns about the effect of biodiesel's cloud point on its winter performance, for example. Biodiesel production also declines in the winter as producers perform important facility maintenance while demand is low.

The BTC's expirations have also affected seasonal demand for BBD. The BTC has historically expired on December 31 and blenders have responded to its expected expiration by blending more BBD in the later months of the year than they have in non-expiration years (see Figure ES-10). This does not necessarily mean that the BTC's expiration in past years has resulted in more BBD blending than would have otherwise been the case. Rather, blenders most likely moved their purchases of BBD up by a few months in order to achieve maximum blending volumes while the BTC was still in effect, and these increases may have been offset by reduced blending volumes in the early months of the subsequent years.

It is possible to quantify annual and monthly average blend rates at the national level based on data that is published by the U.S. Energy Information Administration (EIA). This data only represents the average values as a function of BBD consumption volumes relative to petrodiesel consumption

FIGURE ES-10: INDEX OF MONTHLY U.S. BBD BLENDING VOLUMES BY REFINERS AND BULK TERMINAL OPERATORS, 2013 compared to average of other years in which the BTC either expired or almost expired



volumes, however, and is not disaggregated according to different blend rates (e.g., 5 vol% biodiesel, 20 vol% biodiesel, etc.). These results can give the impression that all U.S. BBD consumption occurs at a uniform blend rate: 5 vol% BBD for the U.S. in 2017, for example (see Figure ES-8). The limited data on consumption according to actual blend rates that is available shows that this is not always true, however. Iowa's published data shows that 82% of biodiesel sales in that state in 2018 were in blends of 11 vol% or higher. While Iowa's biodiesel supply profile cannot be assumed to be applicable to the PADD 2 region's profile, let alone the profiles of other PADD regions, it does support other data showing the widespread availability of 20 vol% biodiesel blends at retail stations across the U.S.

The quantification of consumption in the form of <6 vol% biodiesel blends is particularly challenging in regions that do not specifically collect data on consumption volumes according to BBD blend. This is due to the ASTM D975 specification for diesel fuel that allows a FAME content of up to 5 vol%. A 95 vol% petrodiesel/5 vol% biodiesel blend meets the same specification as pure petrodiesel as a result. Under federal law fuel dispensers do not need to provide labels for BBD blends of ≤5 vol% that meet the D975 specification. Some states do require fuel dispensers to carry labels showing the specific BBD content in the fuels dispensed, but these labeling requirements vary widely across the U.S. (see Section 3.1).

2.3. REGIONAL DEMAND AND BLENDING

BBD consumption varies widely across the PADD regions in accordance with differences in supply volumes (see Section 1.1). This is reflected in the large differences in average annual blend rates between each region. The PADD 4 region has the lowest quantity of BBD consumption in terms of both absolute volumes and average annual blend rates (0.7 vol% in 2017). The neighboring PADD 5 region, on the other hand, has the country's highest average annual blend rate at 8.5 vol% in 2017, although both the PADD 2 and PADD 3 regions consumed a larger volume of BBD in the same year (see Table ES-1).

TABLE ES-1: BBD DEMAND AND AVERAGE BLEND RATE PER PADD REGION, 2017

REGION	DEMAND VOLUME IN 2018 (MILLION GALLONS)	AVERAGE ANNUAL BLEND RATE IN 2017
PADD 1	480	3.5%
PADD 2	731	4.2%
PADD 3	781	7.0%
PADD 4	18	0.7%
PADD 5	614	8.5%

The sector-based distillate oil demand profiles of each region exhibit some important differences. The PADD 1 region is characterized by a particularly large residential demand share due to the continued use of heating oil in the Northeast. This trait makes bioheat an option in the PADD 1 region that is not available to the same extent in the other PADD regions that instead utilize natural gas for space heating. The PADD 2 region is characterized by a large combined MVNRLM sector due its large on-road, farm, and rail sectors, making blend mandates in the region an effective means of displacing overall petrodiesel consumption. The PADD 5 region has been characterized by rapid demand growth in its on-road sector relative to the other demand sectors even as California's LCFS has caused the region's total diesel fuel supply, which includes BBD, to increase strongly over the last decade.

All five PADD regions are affected by seasonal trends and the expirations of the BTC, as is the case at the U.S. level. Blending volumes are lowest in the winter and highest in the summer for every PADD region, although the magnitude of the seasonal shifts is greater in those regions that are characterized by colder winter temperatures. All of the PADD regions experienced higher-than-normal BBD consumption in the months leading up to an expected expiration of the BTC, although the amount of the late-year increase also varied by region. The PADD 2 region showed only limited sensitivity to the BTC expiration periods, for example, likely due to the presence of a large number of state mandates and other demand incentives that ensured a higher demand baseline.

2.4. BBD DEMAND INCENTIVES

Demand incentives, which differ from supply incentives in that the former encourage BBD availability whereas the latter encourage, and often explicitly mandate, BBD consumption, are utilized in a variety of forms at the federal and state levels of government. One of the earliest such policies is the federal requirement under the U.S. Energy Policy Act (EPAct) of 1992 that state government and alternative fuel provider fleets ensure that 75% of their light duty vehicle (LDV) acquisitions be alternative fuel vehicles. LDVs that run on BBD blends have proven to be popular with such fleets, especially as automaker warranties have been expanded to cover biodiesel blends of up to 20 vol%. Several states have implemented their own government fleet requirements in addition to those of the EPAct by explicitly requiring the use of biodiesel blends when specific availability and price requirements are satisfied. Such additional requirements are especially common in the PADD 1, PADD 2, and PADD 5 regions.

SECTION 3.

BBD Performance

3.1. BBD TECHNICAL PERFORMANCE

Biodiesel's technical performance is comparable to that of petrodiesel in commercial applications. Pure biodiesel's energy content is lower than that of petrodiesel due to the former's oxygen content. However, the effect of this on engine power is largely offset by biodiesel's higher fuel density and the prevalence of biodiesel blends that are ≤20 vol%. Biodiesel's primary technical disadvantage is its high cloud point, which is the temperature at which the fuel begins to freeze, relative to petrodiesel. Biodiesel's cloud point is a function of its feedstock's saturation level, with higher saturation levels resulting in higher cloud points (see Table ES-2). Fleet operations have demonstrated that biodiesel's cloud point in ≤20 vol% blends is only an issue in the regions of the U.S. that experience colder winter temperatures, however, and that it can be managed via reduced biodiesel blend rates, the use of anti-gelling additives, or blending with No. 1 ultra-low sulfur diesel (ULSD).

Biodiesel blends do offer some performance advantages over ULSD in the form of higher cetane numbers, improved lubricity, and more complete combustion. The cetane number is a measure of ignition delay, and higher cetane numbers reflect a faster combustion speed and, by extension, quality. Saturated feedstocks yield biodiesel with higher cetane numbers than do unsaturated feedstocks, but in general all biodiesel feedstocks result in higher cetane numbers than are possible from ULSD. ULSD also suffers from low lubricity, to the point that ULSD use can cause excessive wear in diesel engines. The addition of as little as 1-2 vol% biodiesel to ULSD eliminates this issue due to the former's high lubricity.

Pure renewable diesel offers different advantages over petrodiesel than biodiesel does. Renewable diesel is a hydrocarbon and, as such, creates few concerns about blending constraints. It is a paraffinic fuel and provides approximately 4% less energy per gallon than petrodiesel.

TABLE ES-2. CLOUD POINTS OF PURE BIODIESEL DERIVED FROM COMMON FEEDSTOCKS

FEEDSTOCK	CLOUD POINT (°F)
Canola	26
DCO	27
Lard	53
Soybean oil	34
Tallow	61
UCO	36

It has very little intrinsic lubricity but offers a higher cetane number than either petrodiesel or biodiesel. Renewable diesel that is produced via hydroprocessing and isomerization has a cold point that is equal to or below that of No. 2 ULSD. It can even be reduced to the No. 1 ULSD range (approximately -40 °F) via more intensive isomerization, although doing so reduces the diesel fuel yield and increases the naphtha and gaseous product yields.

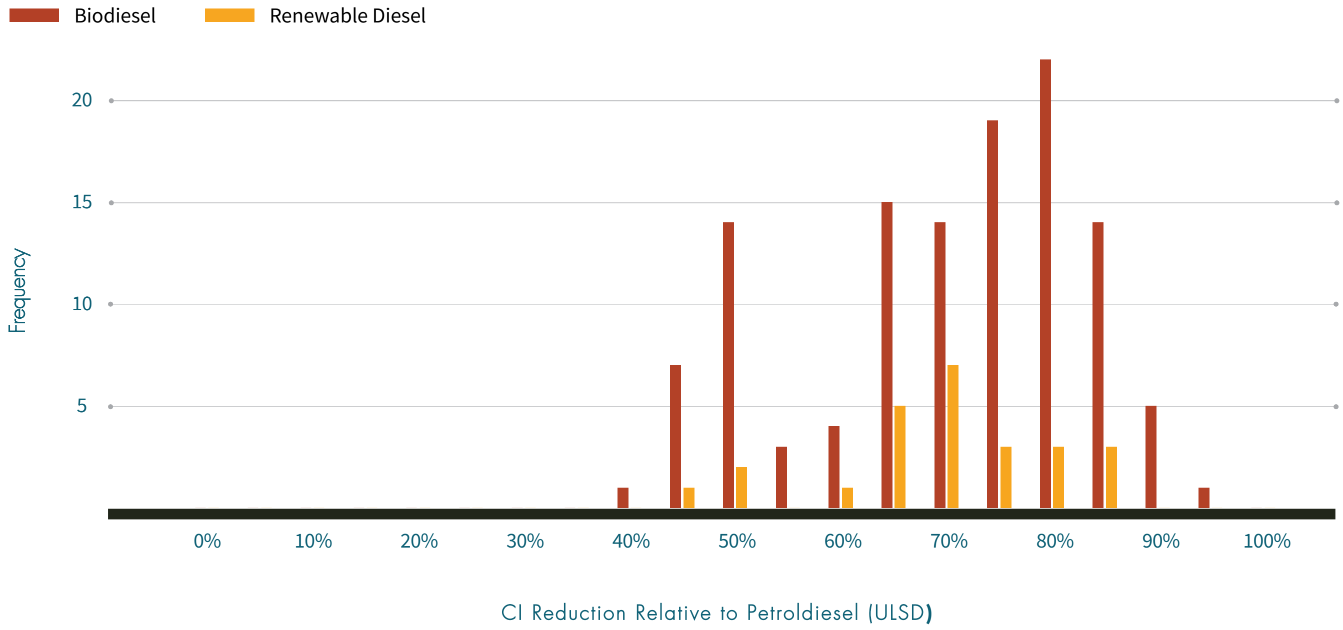
Federal law allows for biodiesel blends of ≤5 vol% that meet the ASTM D975 specification to be sold as diesel fuel, meaning that fuel dispensers are not required to label such blends as containing biodiesel. Some states have more stringent fuel dispenser labeling requirements for ≤5 vol% BBD blends, however, that require labels to show that the blends contain BBD, show the type of BBD (biodiesel or renewable diesel) that the blend contains or, in some cases, even show the specific blend percentage. This lack of uniformity makes it important that market participants be familiar with the specific labeling requirements for the jurisdiction in which they are operating. Differences between federal and state labeling requirements also have the potential to create conflicts between pipeline operators and blenders when the former move ≤5 vol% BBD blends through pipelines: whereas such blends can be accurately categorized by the pipeline operator as meeting the ASTM D975 specification, blenders in states with strict labeling requirements need to know the actual BBD content of the blends that they receive. This issue is likely to become commonplace as the volume of BBD that moves through pipelines increases in the future.

> **Biodiesel blends offer some performance advantages over ULSD in the form of higher cetane numbers, improved lubricity, and more complete combustion.**

3.2. BBD ENVIRONMENTAL PERFORMANCE

BBD consumption results in lower life cycle greenhouse gas (GHG) emissions than petrodiesel. The amount of the reduction is a function of the specific BBD production pathway employed, but BBD that is derived from residue and waste feedstocks achieves larger reductions (up to 80-90%) relative to petrodiesel than does BBD that is derived from agricultural crops. Evidence from California's LCFS shows that biodiesel and renewable diesel achieve a range of CI reductions relative to petrodiesel due to differences in feedstocks and production processes (see Figure ES-11), but also that most of the pathways that contribute to the LCFS for both fuels achieve CI reductions of between 50% and 85%. The low CIs of BBD fuels is how biodiesel and renewable diesel have been the largest combined source of carbon credits under the LCFS despite not being the largest combined form of low-carbon fuel volumes (see Section 1.3). Renewable diesel's CI reduction is greatly diminished when a more intensive isomerization process is used to reduce its cloud point. Renewable diesel generally has a CI that is higher than that of biodiesel (but still much lower than that of petrodiesel), even in the No. 2 diesel cloud point range.

FIGURE ES-11. CI REDUCTIONS OF BIODIESEL AND RENEWABLE DIESEL RELATIVE TO PETRODIESEL UNDER THE LCFS



SECTION 4.

BBD Economics

4.1. BBD PRODUCTION ECONOMICS

Biodiesel production economics operate as a function of input costs, of which feedstock cost is the most important factor, and the price of biodiesel that is paid to producers by blenders. The price of biodiesel is in turn very sensitive to the wholesale price of distillate fuel oil. The wholesale biodiesel price is also determined by the presence of government incentives such as the RFS, the BTC, and the LCFS, all of which increase the price that blenders are willing to pay for biodiesel by an amount up to the value of the incentive offered by each policy. Production economics are favorable when the margin between the combined values of wholesale biodiesel and coproduct prices exceed the combined values of the production pathway's input costs.

BIODIESEL PRODUCTION MARGINS, AS MEASURED BY THE PATHWAY'S RETURN OVER OPERATING COSTS, HAVE BEEN POSITIVE FOR MOST OF THE LAST DECADE, ALTHOUGH THEY HAVE NOT ALWAYS EXCEEDED PRODUCERS' COSTS OF CAPITAL.

Biodiesel production economics are not uniform across the entire biodiesel sector due to the impacts of factors such as facility size, region, seasonality, and state-level policies such as blending mandates. Feedstock costs vary across the U.S.; in addition to different prices for different feedstock types, prices for individual feedstocks such as soybean oil exhibit substantial variation within regions and even states. Distillate fuel oil prices and, by extension, biodiesel prices also vary by location (see Figure ES-12).

Larger biodiesel production facilities, especially those with well-developed multimodal and multi-feedstock logistics networks, benefit from economies of scale that reduce their unit production costs. Finally, biodiesel production margins have historically risen during the summer months as demand and production volumes both increase. That said, seasonal effects can be difficult to discern due to the increased demand for biodiesel that has occurred late in those years in which the BTC either expired or almost expired.

Blenders have historically paid a premium for wholesale biodiesel relative to wholesale distillate fuel oil due to the demand for biodiesel that federal and state policies have created. Biodiesel is the more expensive of the two fuels to produce, however. This is evident when comparing biodiesel's breakeven price, which is the price that biodiesel producers must receive to cover their production costs, to the No. 2 distillate wholesale price (see Figure ES-13). Biodiesel's breakeven price for a "typical" Iowa biodiesel production facility has ranged from $3/gallon to more than $5/gallon over the last decade, but during that time it has always exceeded the state's average wholesale No. 2 distillate price by at least $0.69/gallon.

FIGURE ES-12. NO. 2 ULSD REGIONAL SPOT PRICES RELATIVE TO AVERAGE OF ALL THREE, 2009-2018

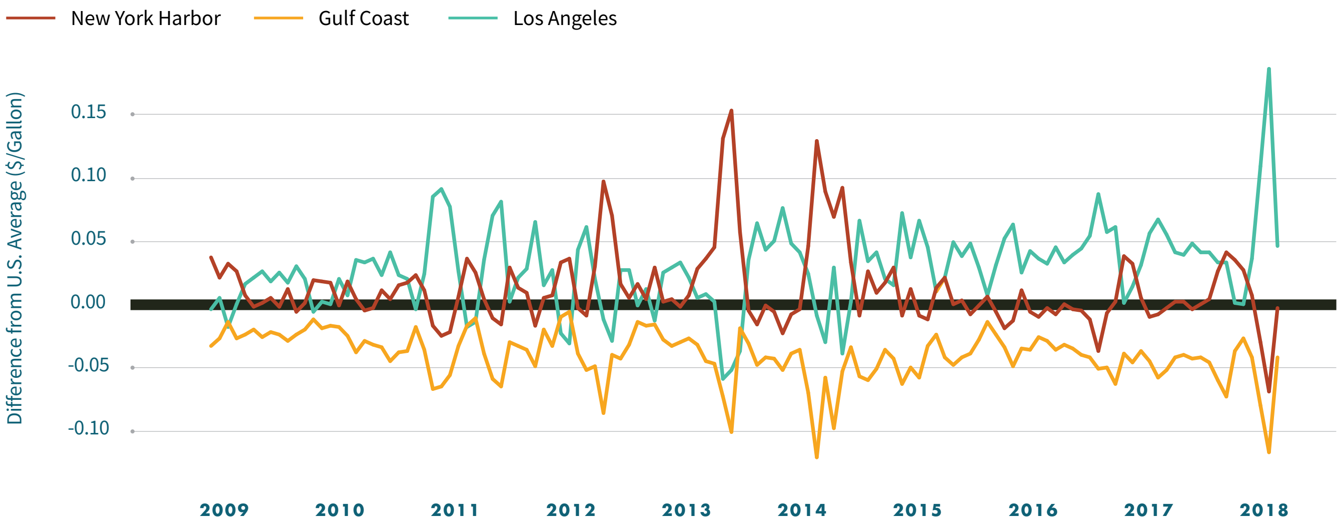
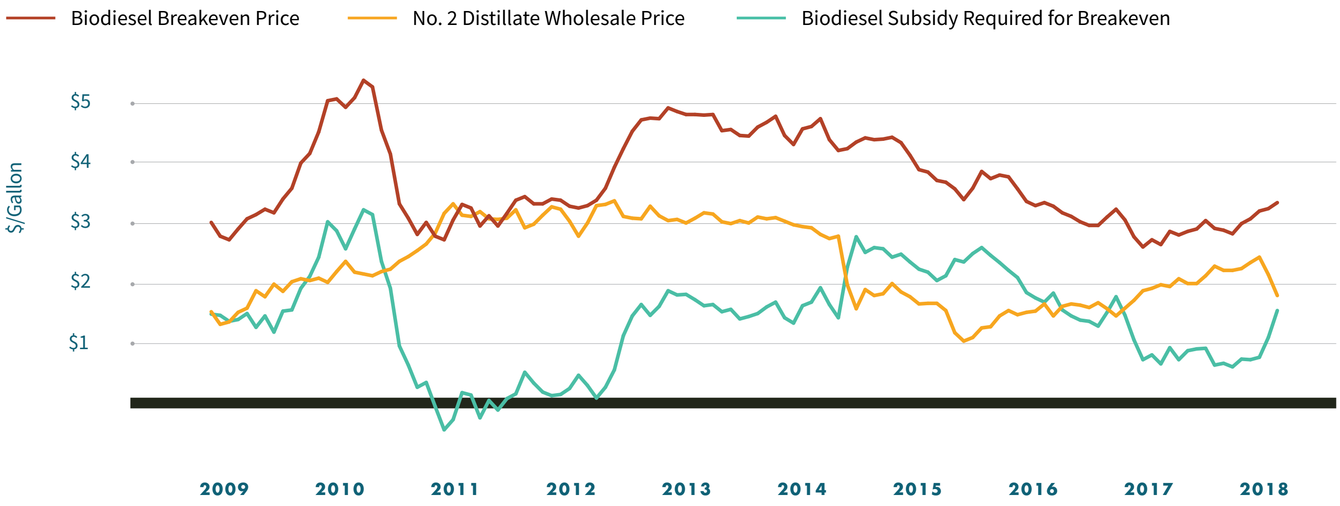


FIGURE ES-13: DIFFERENCE BETWEEN BIODIESEL BREAKEVEN PRICE AND NO. 2 DISTILLATE WHOLESALE PRICE IN IOWA, 2009-2018



THE PRIMARY REASON FOR BIODIESEL’S HIGH PRODUCTION COST RELATIVE TO THAT OF PETRODIESEL IS THE FEEDSTOCK COSTS THAT PRODUCERS OF THE FORMER INCUR. THE PRICE OF SOYBEAN OIL HAS EXPLAINED MOST OF THE VARIATION IN THE BIODIESEL BREAKEVEN PRICE OVER THE LAST DECADE.

Moderate-sized (30 MMGY) soybean oil-derived biodiesel production facilities require WTI crude prices in excess of $100/bbl to be competitive with petrodiesel on an unsubsidized basis, and the required WTI crude price escalates rapidly as the cost of soybean oil increases (see Table ES-3).

Blenders have been willing to pay the premium for biodiesel that has been necessary for producers to be economically feasible due to the effects of the policies described in Section 1.3. While the mechanisms behind policies such as the RFS and LCFS are different, they both operate to internalize the positive environmental externalities* that biodiesel contributes in the form of reduced GHG emissions, especially of CO2, relative to petrodiesel. The express linkage between the incentive that the LCFS provides to biodiesel and the value of its environmental externality in the form of a unique CI reduction value relative to the prevailing carbon credit price is one form of such externality internalization. As Figure ES-13 shows, the value that biodiesel producers have needed to receive from this process in order to make GHG emission reductions possible via biodiesel production has declined over the last decade as feedstock costs have declined.

The renewable diesel pathway’s production economics have not been as well-studied as those of biodiesel due to the former’s comparative lack of development. Both pathways have similar production economics in that they utilize similar feedstocks (lipid feedstock prices have historically been correlated, whether from agricultural crops or residues and wastes) and inputs (methanol and hydrogen are both produced mainly from natural gas) to yield similar products. Seasonal effects should not be as large for renewable diesel as for biodiesel due to the latter’s superior cold weather performance, although both fuels are affected by the presence of larger production margins in the summer months due to increased ULSD demand. Likewise, renewable diesel’s production economics are also affected by regional differences in feedstock costs and wholesale distillate fuel oil prices.

Renewable diesel’s production costs are higher than those of biodiesel, but the former also has a higher market value due to its superior energy content and technical performance. The limited data that is available for renewable diesel suggests that its production margins have been substantially more favorable than those of biodiesel over the last five years. That said, it is not possible to disentangle the effects of different factors such as LCFS credits and economies of scale, as the only available data is for the largest U.S. renewable diesel production facility.

TABLE ES-3: RELATIONSHIP BETWEEN SOYBEAN OIL AND BIODIESEL BREAKEVEN PRICES, AND THE WTI CRUDE PRICE NEEDED FOR BIODIESEL TO BE COMPETITIVE WITH PETRODIESEL, 2009-2018.
Author’s calculations

SOYBEAN OIL PRICE THRESHOLD ($/LB)	BIODIESEL BREAKEVEN PRICE ($/GALLON)	WTI CRUDE PRICE ($/BBL)
>$0.60	>$5.70	>$181
>$0.50	>$5.90	>$154
>$0.40	>$3.87	>$127
>$0.30	>$3.10	>$100
>$0.20	>$2.29	>$74

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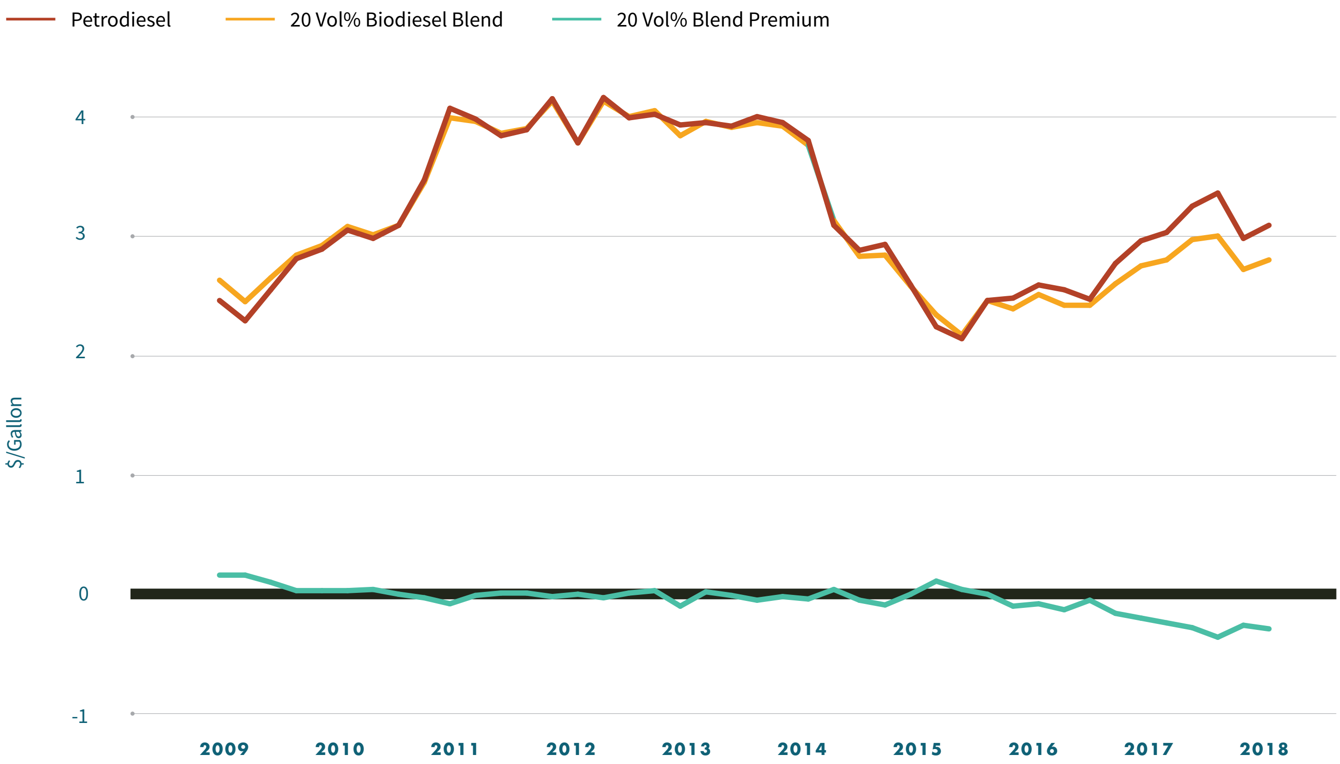
* It is important to mention that the Energy Reform established several changes on electric markets. Nevertheless, these changes won’t be discussed in this report.

FIGURE ES-14: COMPARISON OF U.S. AVERAGE PETRODIESEL AND 20 VOL% BIODIESEL BLEND RETAIL PRICES, 2009-2018



4.2. BBD DEMAND ECONOMICS

BBD demand economics differ from BBD production economics due to the presence of various supply and demand policies (see Section 1.3 and Section 2.4). As discussed in Section 4.1, policies such as the RFS, BTC, and LCFS occur at the point of blending rather than the point of production or retail (although both producers and fuel retailers do conduct limited blending operations). Blenders are therefore willing to pay a premium to BBD producers up to the amount of any incentives that they receive through their blending operations, in addition to the BBD's energy value, since the incentives cannot be earned if the BBD is not first purchased. While the RFS, BTC, and LCFS have all utilized different mechanisms over the last decade, the end result of a BBD premium that is paid to BBD producers has been the same.

The existence of the BBD premium does not mean that BBD blends have a correspondingly more expensive retail price. The average retail price of the blend for which data is available, 20 vol% biodiesel, was 9% higher than that of petrodiesel on an energy-equivalent basis over the last decade (see Figure ES-14). BBD has been cost-competitive with biodiesel because the value of the incentives generated by blenders has offset the higher production cost of biodiesel relative to petrodiesel (see Section 4.1). The 20 vol% biodiesel blend retail price premium turned negative in 2018 and 2019 as the BTC's expiration and subsequent renewal uncertainty caused biodiesel producers to accept lower prices from blenders than in the past (and also as biodiesel production costs have declined); presumably this reduction was passed on to retailers in turn.

TABLE ES-4. PETRODIESEL PRICE DISCOUNT RELATIVE TO 20 VOL% BIODIESEL BLEND PRICE, RETAIL BASIS, APRIL 2019

REGION	20 VOL% BIODIESEL BLEND PRICES ($/GALLON)	PETRODIESEL FUEL PRICES ($/GALLON)	PETRODIESEL DISCOUNT ($/GALLON)
PADD 1A	$2.89	$3.22	-$0.33
PADD 1B	$2.56	$3.16	-$0.60
PADD 1C	$2.65	$2.95	-$0.30
PADD 2	$2.99	$2.97	$0.02
PADD 3	$2.91	$2.72	$0.19
PADD 4	$3.24	$2.96	$0.28
PADD 5	$3.12	$3.83	-$0.71
U.S. average	$2.88	$3.09	-$0.21

The difference between the retail prices of petrodiesel and 20 vol% biodiesel blends* varies widely across PADD regions (see Table ES-4). This variation is due to regional differences in biodiesel production costs, petrodiesel retail prices, and the presence of a large number of different state-level fuel excise tax credits for biodiesel blends that petrodiesel is not eligible for (see Section 1.3). The average state fuel excise tax amount is $0.304/gallon, so even a partial excise tax credit can result in substantially lower retail prices for qualifying biodiesel blends. The effect of California's LCFS, which simultaneously increases the price of petrodiesel while subsidizing BBD blends, can be seen in the large average retail price discount for the latter in the PADD 5 region.

THE RELATIONSHIP BETWEEN THE RETAIL PRICES OF PETRODIESEL AND 20 VOL% BIODIESEL BLENDS IS ALSO INFLUENCED BY WHETHER THE RETAILER SELLS TO THE GENERAL PUBLIC OR ONLY TO PRIVATE/GOVERNMENT FLEETS.

20 vol% biodiesel blends sold by non-public retailers have historically been priced well below petrodiesel compared to the retail prices at public retailers. This result is notable given that private and government fleets are inelastic BBD consumers due to the presence of government mandates and corporate sustainability requirements. The general public, by contrast, has been found to be willing to quickly change from biodiesel blends to petrodiesel, and vice versa, in response to price fluctuations.

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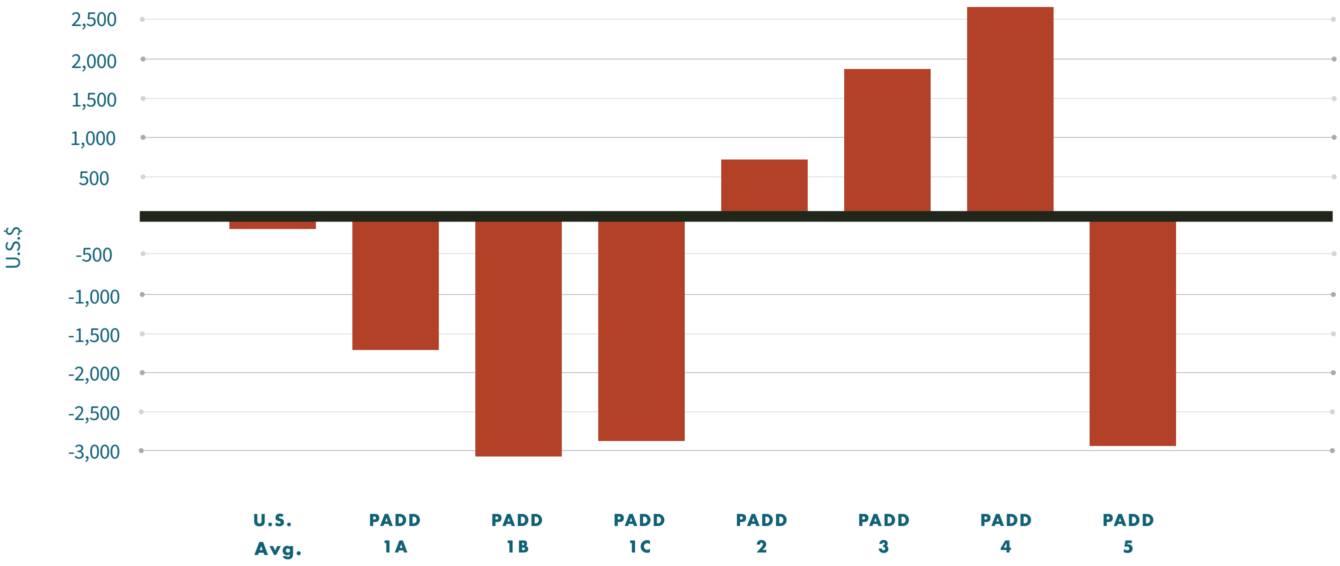
* Retail price data for the less common 2 vol%, 5 vol%, and 10 vol% biodiesel blends is limited due to a lack of survey responses from retailers of the blends, in contrast to 20 vol% biodiesel blends. This in part reflects the fact that ≤5 vol% biodiesel blends meet the ASTM D975 specification for diesel fuel and do not need to be labeled separately in most states.

4.3. CONSUMPTION COSTS

Drivers of heavy-duty vehicles (HDV) operating on 20 vol% biodiesel blends have incurred small decreases on average to fueling costs since 2015 relative to when operating on ULSD. While retail price data for 5 vol% and 10 vol% biodiesel blends is not available, the relationship between biodiesel blend and petrodiesel retail prices means that drivers of HDVs operating on those two blends have incurred almost no differences on average to fueling costs over the same period. That said, the wide variations in regional retail prices means that the actual impact to fueling costs of biodiesel blend utilization is largely a function of location (see Figure ES-15). This assumes that 20 vol% biodiesel blends has the same fuel economy as ULSD.

The impact of 20 vol% biodiesel blend usage on vehicle maintenance costs is relatively uncertain due to a lack of long-term trial data. Shorter-term studies have found that maintenance costs for 20 vol% biodiesel and pure ULSD consumption are comparable, with the former potentially needing more frequent fuel filter and fuel injector replacements during the early stages of consumption but reducing engine wear over longer periods of use. It has largely been accepted that 5 vol% biodiesel blends, on the other hand, incur maintenance costs that are unchanged from ULSD, as illustrated by the ASTM D975 specification's treatment of the two fuels as meeting the same category.

FIGURE ES-15. AVERAGE ANNUAL FUEL COST DIFFERENCE OF USING 20 VOL% BIODIESEL BLEND RELATIVE TO ULSD BASELINE. Assumes a fully loaded Class 8 tractor-trailer truck, a mixed drive cycle with fuel consumption of 17.2 gallons per 100 miles for both petrodiesel and a 20 vol% biodiesel blend, and 68,155 average annual vehicle miles. Based on average prices from January 2015 to December 2018.



Conclusion

U.S. BBD consumption has increased rapidly in a relatively short timespan to become a leading source of alternative transportation fuel. The availability of lipid feedstocks has grown at the same pace as higher agricultural oilseed productivity and the sourcing of residual and waste feedstocks have supported increased domestic production.

The last decade has also seen biodiesel complemented by the arrival of renewable diesel, and U.S. production capacity for the latter is on track to equal that of the former within the next five years. U.S. BBD consumption has also been met by substantial import volumes, although these have declined sharply since 2016.

BBD's widespread acceptance in the U.S. can be attributed to its broad compatibility with the U.S. transportation fuel infrastructure and positive environmental attributes. Biodiesel and renewable diesel are both miscible with petrodiesel and are commonly utilized as blends of 20 vol% or more. While biodiesel does encounter blending constraints at higher blend rates, current U.S. consumption volumes remain well below the levels permitted by existing infrastructure. Both BBD fuels provide improvements to technical performance relative to ULSD, although the specific advantages are different for biodiesel and renewable diesel. Likewise, while both BBD fuels also provide substantial environmental performance benefits relative to ULSD, especially with regard to lifecycle GHG emissions, these also vary by fuel type.

BBD production economics are driven by the combination of feedstock and ULSD prices. BBD fuels have had a breakeven price over the last decade that has been $1-2/gallon higher than the ULSD wholesale price. The widespread recognition by state and national governments of BBD fuels' environmental benefits have resulted in the implementation of a variety of government policies for the purpose of the internalization of these benefits. These policies, particularly those that have a carbon intensity component, have been an important driver of U.S. BBD demand over the last decade. The important role that carbon intensity has in many of these policies has also contributed to the expanded role of residue and waste feedstocks over the same period. These policies have also had the combined effect of BBD prices that are slightly less expensive than petrodiesel prices in the U.S. on average, although that discount does not exist in all U.S. regions.

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The Fuels Institute, founded by NACS in 2013, is a 501(c)(4) non-profit research-oriented think tank dedicated to evaluating the market issues related to vehicles and the fuels that power them. By bringing together diverse stakeholders of the transportation and fuels markets, the Institute helps to identify opportunities and challenges associated with new technologies and to facilitate industry coordination to help ensure that consumers derive the greatest benefit.

The Fuels Institute commissions and publishes comprehensive, fact-based research projects that address the interests of the affected stakeholders. Such publications will help to inform both business owners considering long-term investment decisions and policymakers considering legislation and regulations affecting the market. Research is independent and unbiased, designed to answer questions, not advocate a specific outcome. Participants in the Fuels Institute are dedicated to promoting facts and providing decision makers with the most credible information possible, so that the market can deliver the best in vehicle and fueling options to the consumer.

For more about the Fuels Institute, visit fuelsinstitute.org

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The Fuels Institute was founded in 2013 by NACS, the international association that advances convenience and fuel retailing. Through recurring financial contributions and daily operational support, NACS helps the Fuels Institute to invest in and carry out its work to foster collaboration among the various stakeholders with interests in the transportation energy market and to promote a comprehensive and objective evaluation of issues affecting that market and its customers both today and in the future. NACS was founded August 14, 1961, as the National Association of Convenience Stores, and represents more than 2,100 retail and 1,600 supplier company members.

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