Fuels Institute

Assessment of the U.S. Fuel Distribution Network

Prepared by

STRATAS ADVISORS

A HART ENERGY COMPANY

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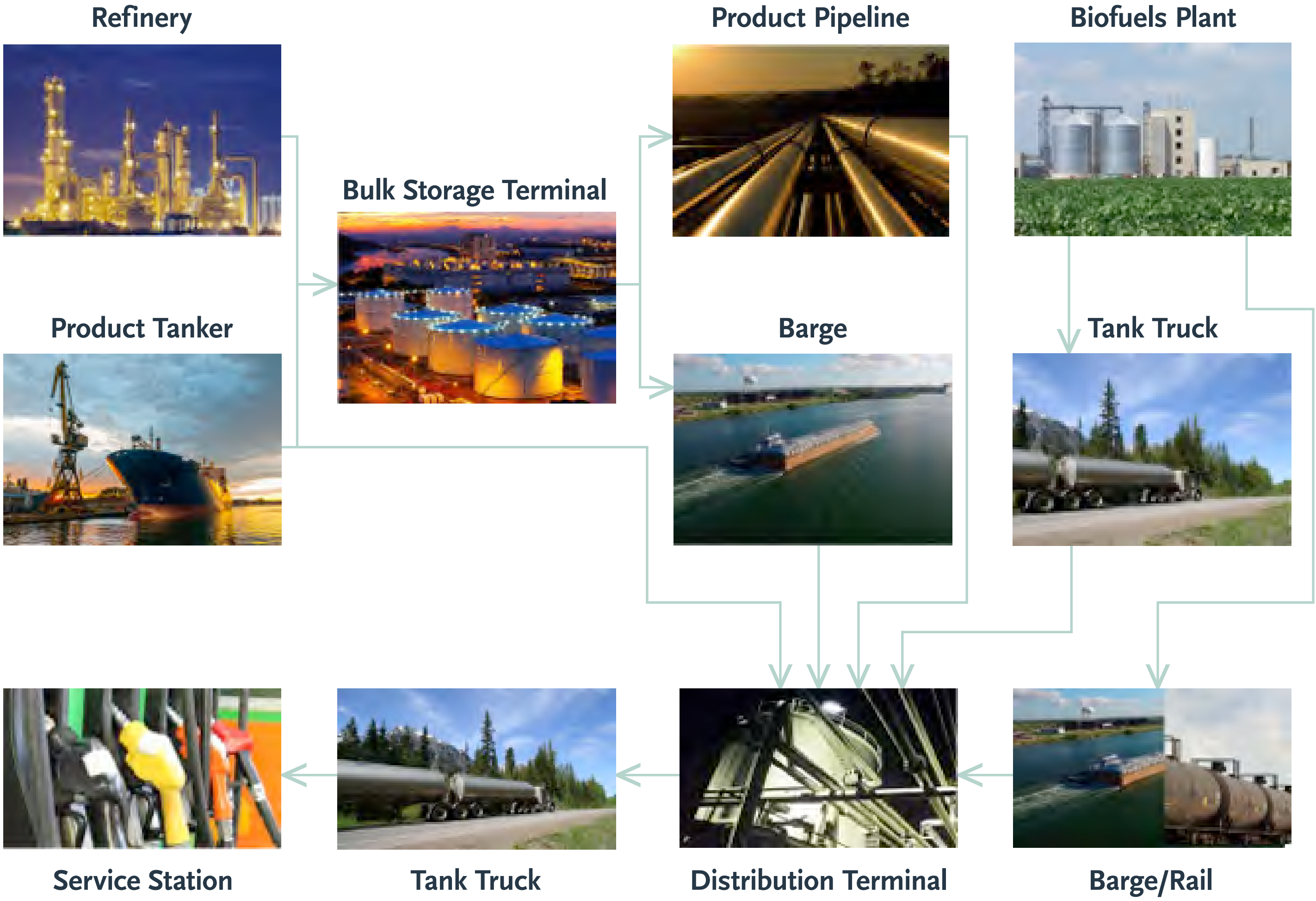
Executive Summary

With more than 12 million barrels of transportation fuel consumed every day, the U.S. lays claim to one of the largest and most complex fuel-supply chains in the world. Much of that complexity is attributable to the large number of fuel blends in the market, including those required in certain markets to address specific air quality issues known as "boutique" fuels that must be kept separate during their movement through the supply chain. These fuels typically include limits on volatility and are restricted in number by Federal law. Their existence, however, greatly reduces the flexibility of the supply chain, forcing investments at each point to accommodate various fuels. In addition to boutique fuels, the supply chain also manages increasing and significant volumes of biofuels, which carry with them separate logistical requirements. In this report we will evaluate the U.S. supply chain, how it works and what limitations/weaknesses exist at each point to accommodate diverse fuel specifications and achieving higher rates of biofuels penetration. Understanding the fundamentals of this complex system is essential for anyone considering introducing a new product into the market or adjusting market dynamics for any reason.

Gasoline and on-road diesel both begin either at the **refinery** or as **imports.** Once being refined or imported, it is placed in **terminal bulk storage** either at the refinery or at a centralized location such as a port. Once in bulk storage, either finished fuel or blending components are transported by **pipeline**, **rail** or **barge** to the **distribution terminal**. Concurrently, biofuels are produced at a **plant** and loaded into rail cars or **tank trucks** and shipped to the same **distribution terminal**. Once at the terminal, any blending with biofuels takes place before it is transported by **tanker truck** to the **service station**.

At every point along this supply chain there are structural and operational challenges to the successful adoption of boutique fuels and biofuel blends. These include operational limitations on pipelines, higher capital costs for terminals and increased complexity for refiners. This document will lay out these challenges in detail, while contextualizing those challenges in the future market environment.

Figure 1 Understanding the Supply Chain



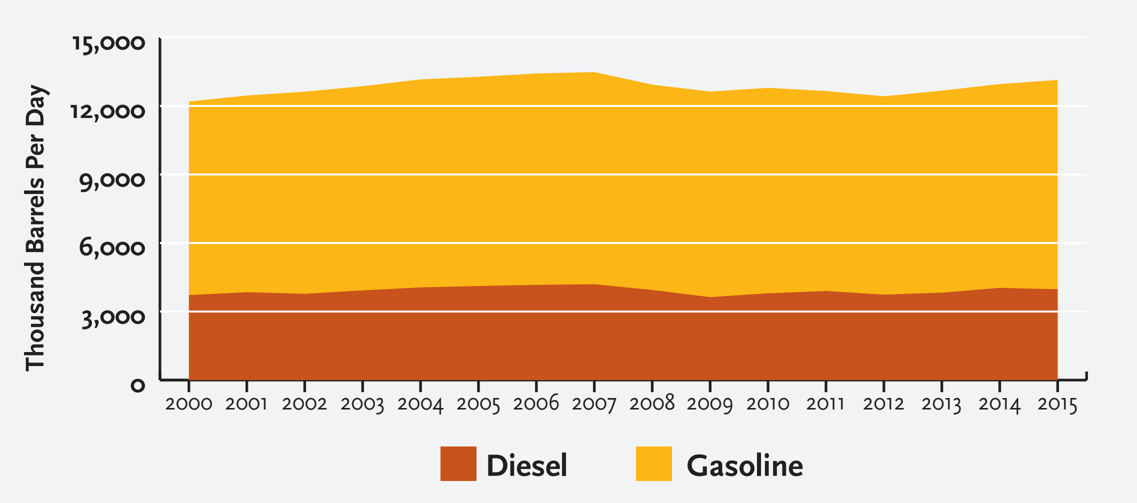
(Source: Stratas Advisors)

U.S. On-Road Fuel Market

During the past decade, the U.S. transportation fuel market has shifted dramatically. A consumer of roughly 12.5 million barrels of transportation fuel per day, the U.S. has gone from being one of the world's largest importers of petroleum products to a net exporter of transportation fuels. U.S. demand for petroleum-derived fuels hit an all-time high in 2007 but has struggled to reach that level once again. The great recession, combined with operational efficiencies in vehicles, has resulted in a structural decline in demand. Low oil prices combined with better than expected economic conditions, however, could push demand above those levels in 2016.

As part of its total transportation fuel consumption, the U.S. also uses roughly 1 million barrels per day of ethanol and biodiesel that are blended with the petroleum-derived portion to meet mandates and octane requirements. We will discuss those blends and the role they play in the supply chain later.

Figure 2 U.S. Gasoline and Diesel Demand



(Source: U.S. Energy Information Administration)

Note: Diesel includes non-road consumption.

The Changing U.S. Supply Landscape

Prior to 2007, the U.S. was growing at a strong pace in its demand for both gasoline and diesel, and was importing a substantial amount of those volumes from foreign markets. Now, the U.S. is close to being balanced on gasoline (produces almost as much as it consumes) and is long on diesel (is a net exporter).

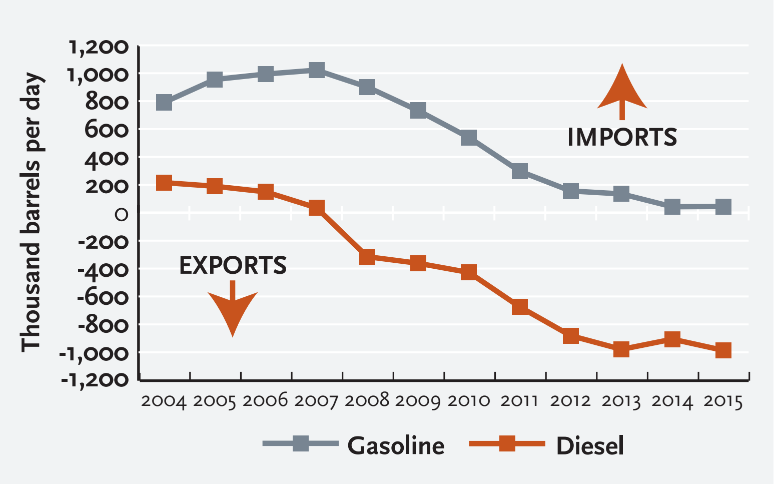
This shift has been due to a number of factors, including:

Economic downturn: U.S. transportation fuel demand peaked in 2007. While demand is on the rebound, it has yet to reach 2007 levels once again.

U.S. shale revolution: The U.S. shale revolution substantially drove down crude oil prices globally, but in the last several years it has also led to U.S. refineries being able to access cheaper crudes than other parts of the world. This crude "discount" has led U.S. refiners to be able produce economically at higher rates than refineries in other parts of the world.

U.S. Renewable Fuel Standard: The first version of the Renewable Fuel Standard (RFS), passed by Congress in 2005 and enacted in 2007, eliminated the oxygenate requirement of the Reformulated Gasoline (RFG) Program which led to the removal of MTBE (which was associated with ground water contamination) and effectively cemented the role of ethanol as the primary oxygenate in gasoline.

Figure 3 U.S. Net Product Imports



(Source: U.S. Energy Information Administration)

The expansion of the RFS in 2010 quickly increased the use of biodiesel in the diesel and heating oil pools. Biofuels have created alternate transportation logistics as they are produced primarily in the Midwest and have restrictions in traditional petroleum transportation pipelines. Along with California's Low Carbon Fuels Standard (LCFS), the 2010 revisions of the RFS were designed to encourage expanded retail sales of higher blends of biofuels (eg. E85, B20) and alternative fuels (e.g., biogas).

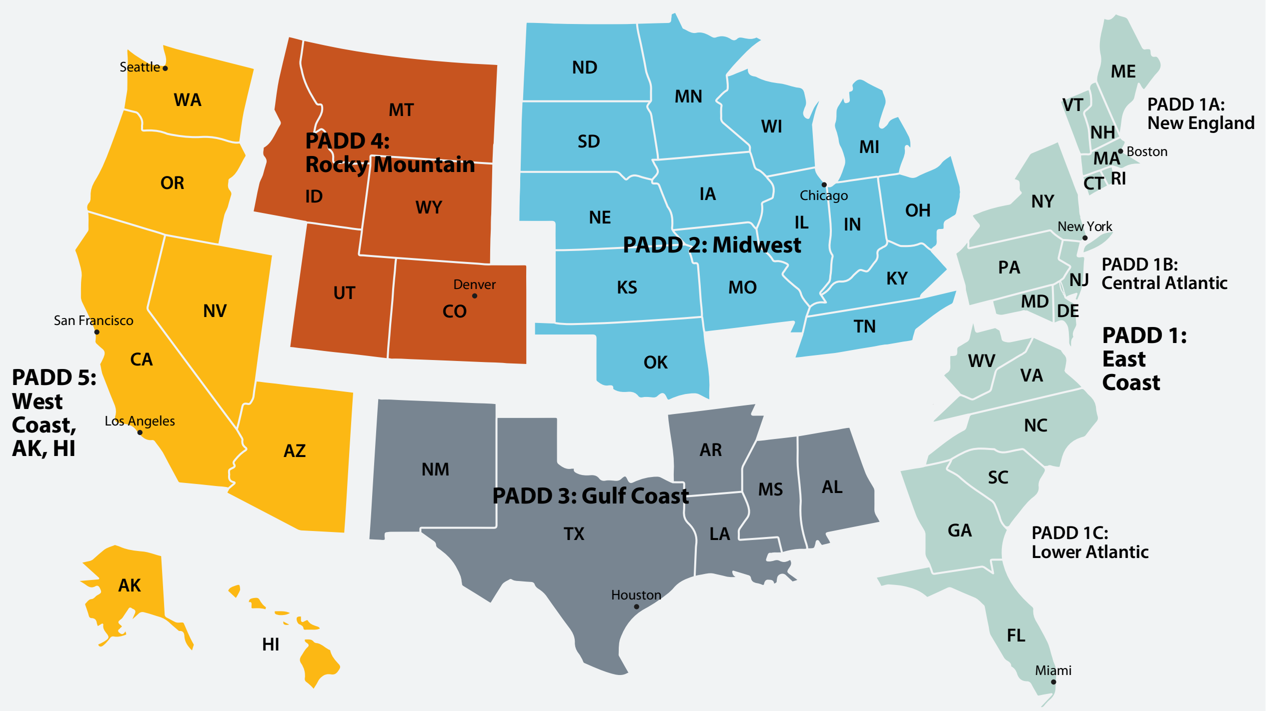
Expansion of U.S. refineries: In the mid-2000s, there was a strong belief, both globally and in the U.S., that diesel demand would be greater than gasoline demand. Since U.S. refineries have historically been configured to meet its enormous demand for gasoline, refinery operators invested large dollars in both expanding the overall size of their refineries (particularly Marathon and Shell) as well as configuring those expansions to run diesel. Once the economic downturn hit, global demand for diesel hit a roadblock, forcing many U.S. refiners to find alternative markets for their fuel.

With more than 1.7 million barrels of new refinery capacity during the last 15 years, this expansion has called considerable attention to pipeline and terminal constraints in moving product from the U.S. Gulf Coast to key demand centers on the East Coast and in the Midwest. In the next section we will discuss how the U.S. energy market is geographically segmented and how the imbalances among those segments are reconciled.

Understanding the PADDs

During World War II, the U.S. was divided into five unique sections, called PADDs—Petroleum Administration for Defense Districts. Today, major data collection on pricing and market fundamentals is still divided this way. The map, below, provided by the U.S. Department of Energy, shows the dividing lines. In this section we will break down the U.S. supply position for each individual PADD, which will assist in understanding the limitations and dynamics of each.

Figure 4 Petroleum Administration for Defense Districts

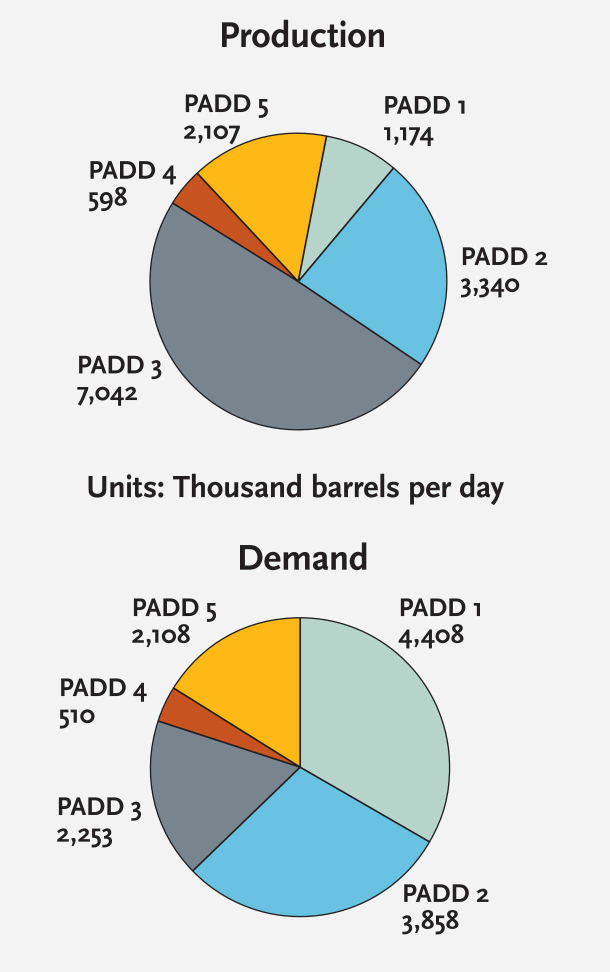


(Source: U.S. Energy Information Administration)

U.S. Supply/Demand Breakdown by PADD

With the exception of the U.S. West Coast (PADD 5), each PADD has an imbalance of supply and demand that is resolved through logistical connections that are used to make up those imbalances. In many cases the imbalance is resolved not just by inter-PADD movements but also through foreign imports and exports. This section will review each PADD in detail and provide a supply buildup for how each reconciles its supply/demand imbalances.

Figure 5
2015 U.S. Gasoline and Diesel by PADD



(Source: U.S. Energy Information Administration)

PADD 1: East Coast

The U.S. East Coast is the largest demand center in the U.S. for both gasoline and diesel demand. Because of the limited refinery capacity, much of the fuel consumed comes either from the U.S. Gulf Coast (PADD 3) or from foreign imports. Roughly 2/3 of PADD 1 consumption is made up of volumes moved from PADD 3 via pipeline through the Colonial and Plantation pipeline systems. The remaining volumes are moved by barge to areas that are not pipeline accessible, specifically Florida. PADD 1 also moves some volumes of gasoline and diesel to the west, primarily by barge, to the eastern part of PADD 2. Because of the size and diversity of PADD 1, it is also divided into sub-PADDs. PADD 1A covers New England, PADD 1B the Central Atlantic and PADD 1C the Lower Atlantic.

The supply position of the U.S. East Coast has a huge dependency on pipeline infrastructure and is serviced almost exclusively by two pipelines. This forces the East Coast to be subject to pipeline conditions and specifications. For example, when fuels are moved through pipelines, ethanol and biodiesel are not shipped in the pipeline due to economic and material compatibility concerns, whether blended or in their pure form (for more on biofuels and pipelines, see pages 23-24). Biofuels that are consumed in PADD 1 are obtained almost exclusively via rail from the Midwest (PADD 2). This means that both pipeline and rail accesses are critical components to terminal structure in PADD 1.

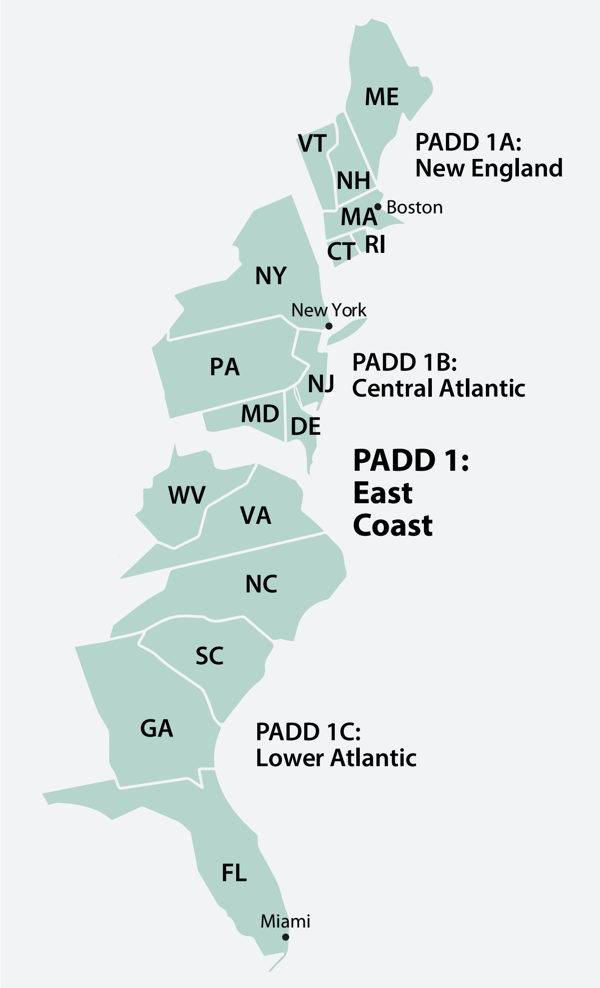
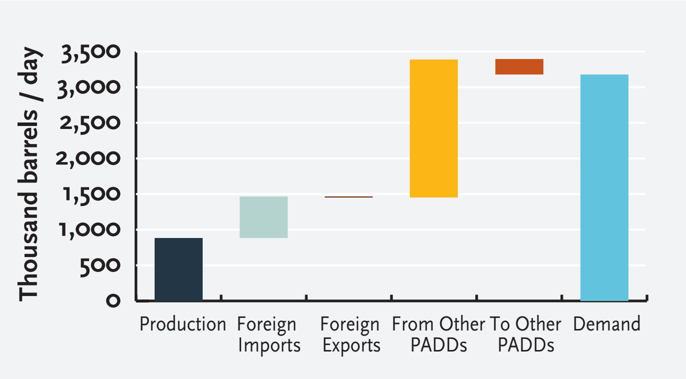
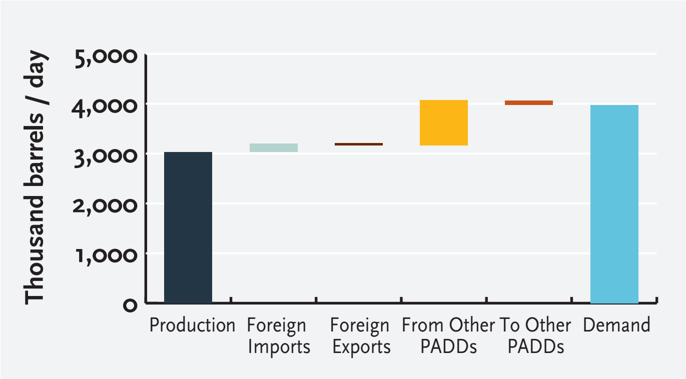


Figure 6a PADD 1 Gasoline Supply Position



(Source: U.S. Energy Information Administration)

Figure 6b PADD 1 Diesel Supply Position



(Source: U.S. Energy Information Administration)

PADD 2: Midwest

The Midwest is the second largest demand center for transportation fuels. PADD 2 has the benefit of being more balanced than PADD 1, and produces 86% of its total consumption within the region. Because the PADD is landlocked, access to foreign imports is limited. As such, the entire PADD 2 shortfall (with a small exception of imports from Canada) is made up by pipeline flows from PADD 3 and barge movements from PADD 1. PADD 2 has seen a hugely successful refining industry since the dawn of the U.S. shale revolution. Because of logistical bottlenecks on crude oil, PADD 2 refiners were fortunate to capitalize on inland crude discounts and run at margins that were multiple times larger per barrel than those recorded in the Gulf.

PADD 2 also contains more than 87% of the country's ethanol and biodiesel production due to the agrarian states that reside within it. This gives greater local logistical options with terminal or retail-station blending as they can receive smaller batches of biofuels supplies from local producers by truck. However, the transportation of biofuels to other regions has difficult logistics as biofuels don't travel in pipelines because of unfavorable properties and risk of cross-contamination. Most bulk transportation of biofuels is done by rail, which limits the destination choice to terminals with rail infrastructure and requires further redistribution to secondary terminals before blending and retail distribution occurs.

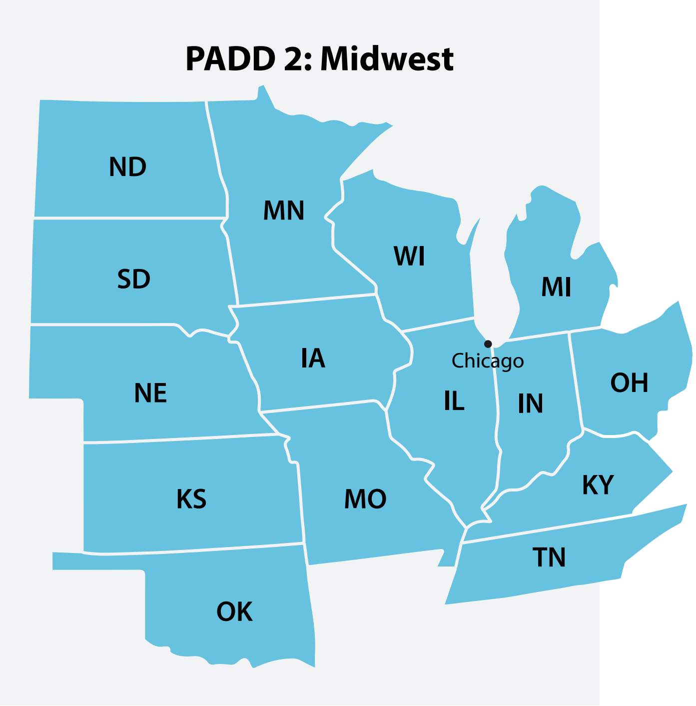
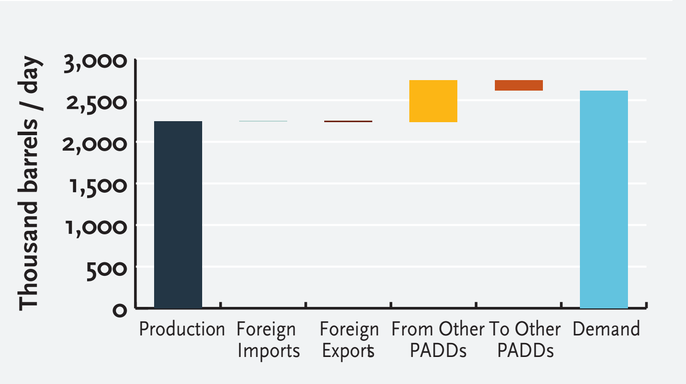
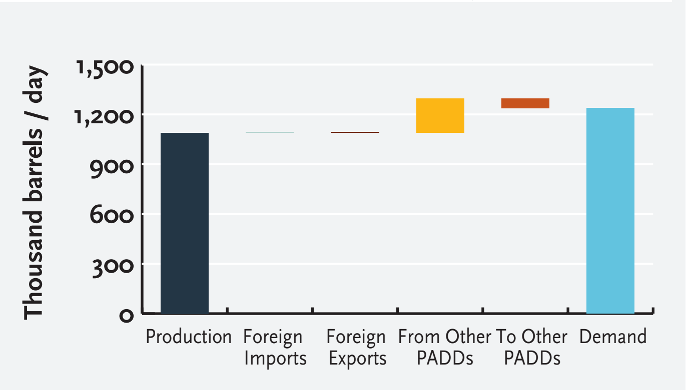


Figure 7a PADD 2 Gasoline Supply Position



(Source: U.S. Energy Information Administration)

Figure 7b PADD 2 Diesel Supply Position



(Source: U.S. Energy Information Administration)

PADD 3: Gulf Coast

The Gulf Coast is America's refining center. With more than half of all U.S. refinery capacity, it exports 70% of its total production either to other PADDs or to foreign markets. Its primary customers are PADD 1 and PADD 2, which are heavily dependent on the refining output of PADD 3 to make up local supply shortfalls. This also requires a large portion of Gulf Coast refineries to be able to produce gasoline to an assorted set of local specifications based on demand.

Starting in 2007, the U.S. became a net exporter of diesel. Recent investments in new refinery units at Marathon Garyville and Shell Motiva have dramatically increased diesel output—more so than the rise in domestic demand. While U.S. refiners in the mid-2000s were focused on the need for diesel in the future, they overbuilt capacity. As a result, PADD 3 is now exporting more than 1 million barrels per day of diesel, primarily to Latin American markets.

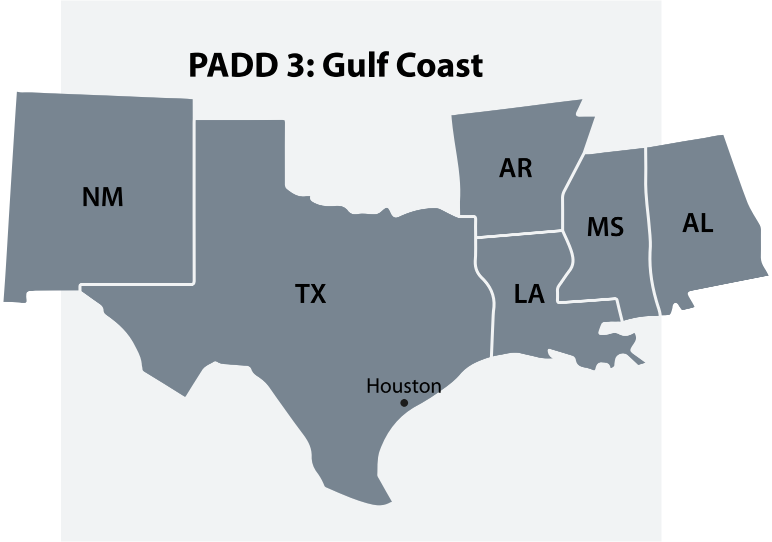
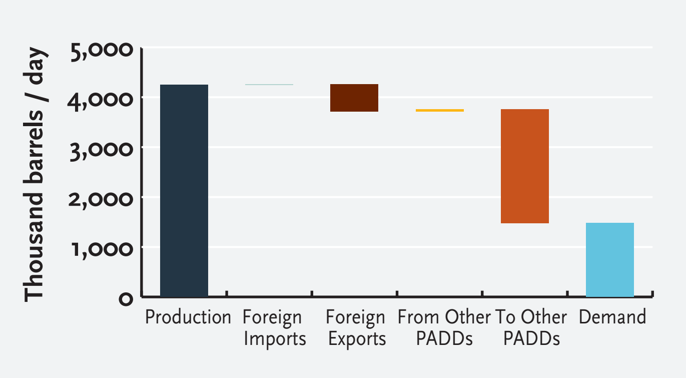
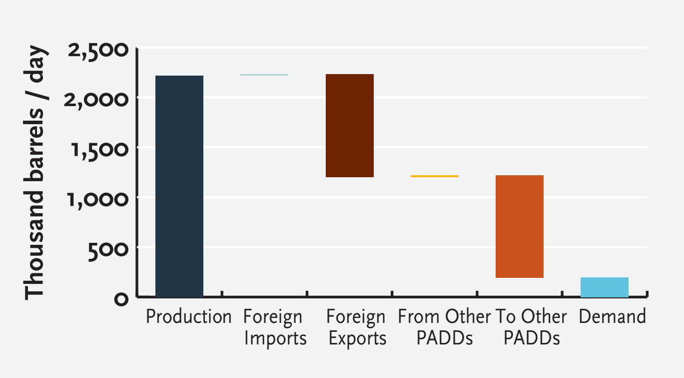


Figure 8a PADD 3 Gasoline Supply Position



(Source: U.S. Energy Information Administration)

Figure 8b PADD 3 Diesel Supply Position



(Source: U.S. Energy Information Administration)

PADD 4: Rocky Mountain

Because of its physical size, small population and topographical challenges, PADD 4 is generally an isolated market. Comprising only 4% of total U.S. consumption, fuels consumed in PADD 4 are almost exclusively produced in PADD 4, with some of the excess production being moved into parts of PADD 5. Since the beginning of the shale boom the region's proximity to Rocky Mountain and Canadian oil production has offered PADD 4 pricing and operational flexibility, but recent production declines due to the low oil price have limited these advantages as of late.

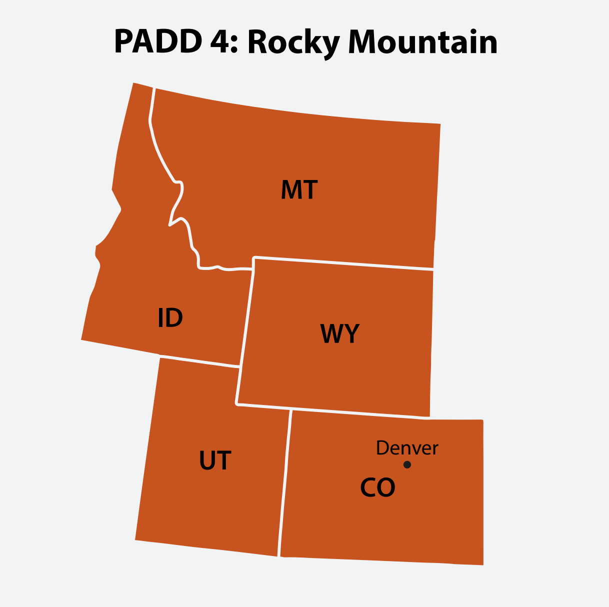
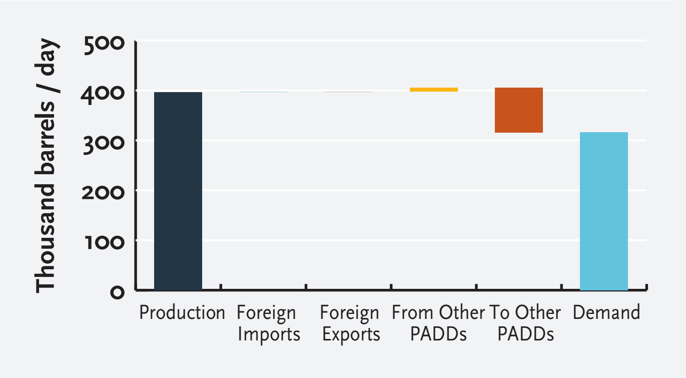
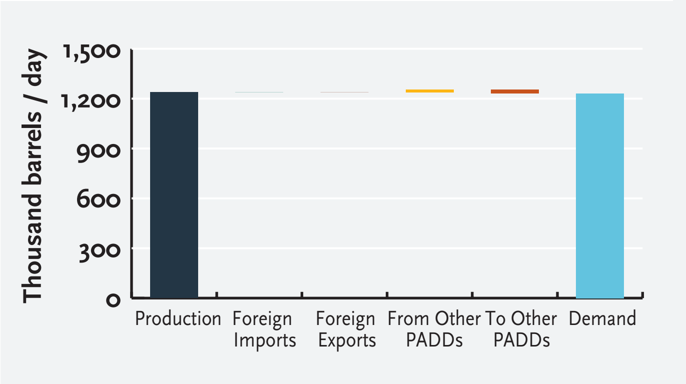


Figure 9a PADD 4 Gasoline Supply Position



(Source: U.S. Energy Information Administration)

Figure 9b PADD 4 Diesel Supply Position



(Source: U.S. Energy Information Administration)

PADD 5: West Coast, Alaska and Hawaii

The U.S. West Coast is also an isolated market. Topographical challenges created by the Rocky Mountains, combined with unique fuel specifications (boutique fuels) for key markets like California, make it impractical to obtain large volumes of fuel from other PADDs or import them from foreign markets. For example, the high cost of meeting California's specifications provides limited economic incentive for refineries outside of California (where refineries are the most complex in the U.S.) to upgrade to meet the specs. California is also currently facing intra-regional logistical challenges. The expansion of crude-by-rail infrastructure to alleviate transportation bottlenecks have faced large opposition as projects proposed by both Phillips 66 and Valero are currently delayed by the public utility commission.

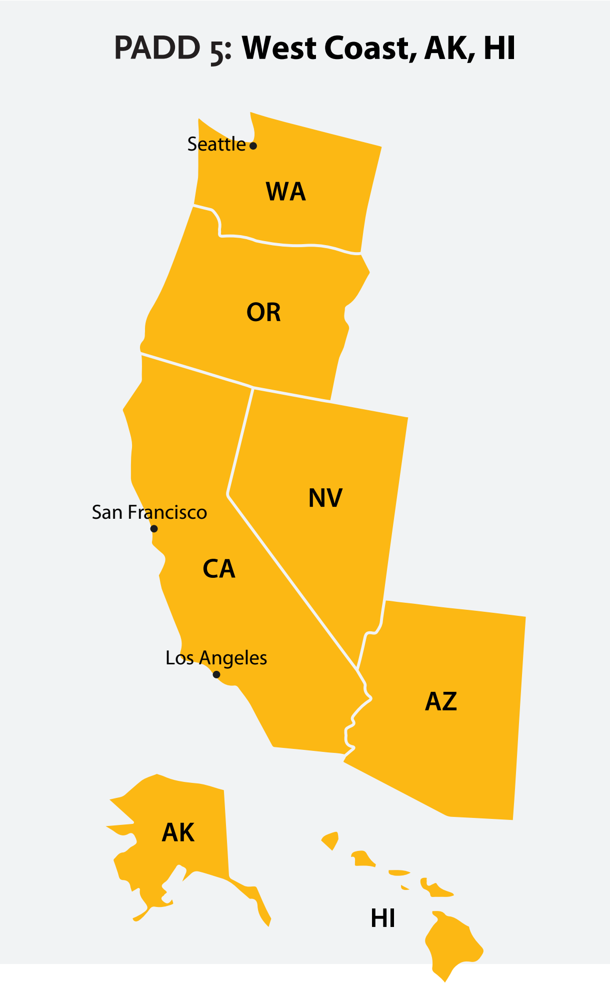
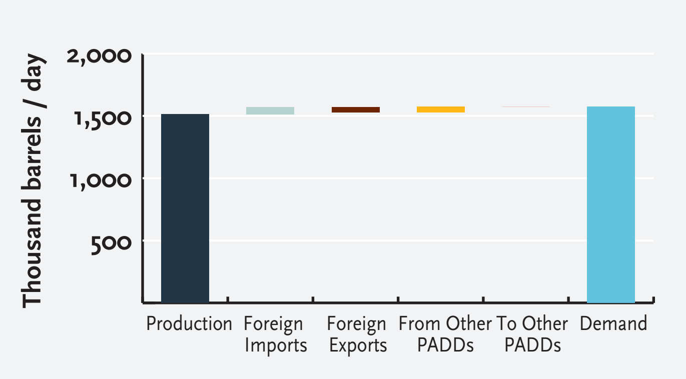
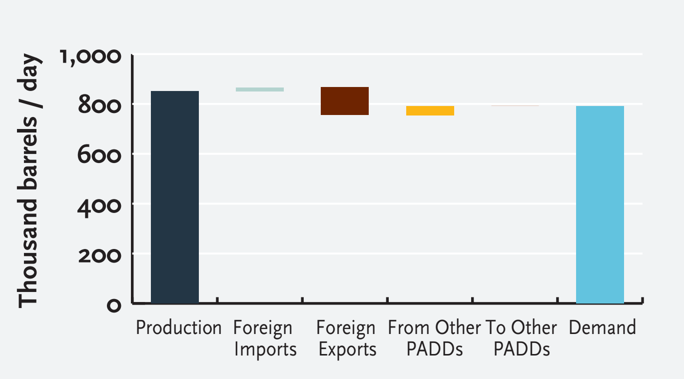


Figure 10a PADD 5 Gasoline Supply Position



(Source: U.S. Energy Information Administration)

Figure 10b PADD 5 Diesel Supply Position



(Source: U.S. Energy Information Administration)

Product Flows and Imbalances

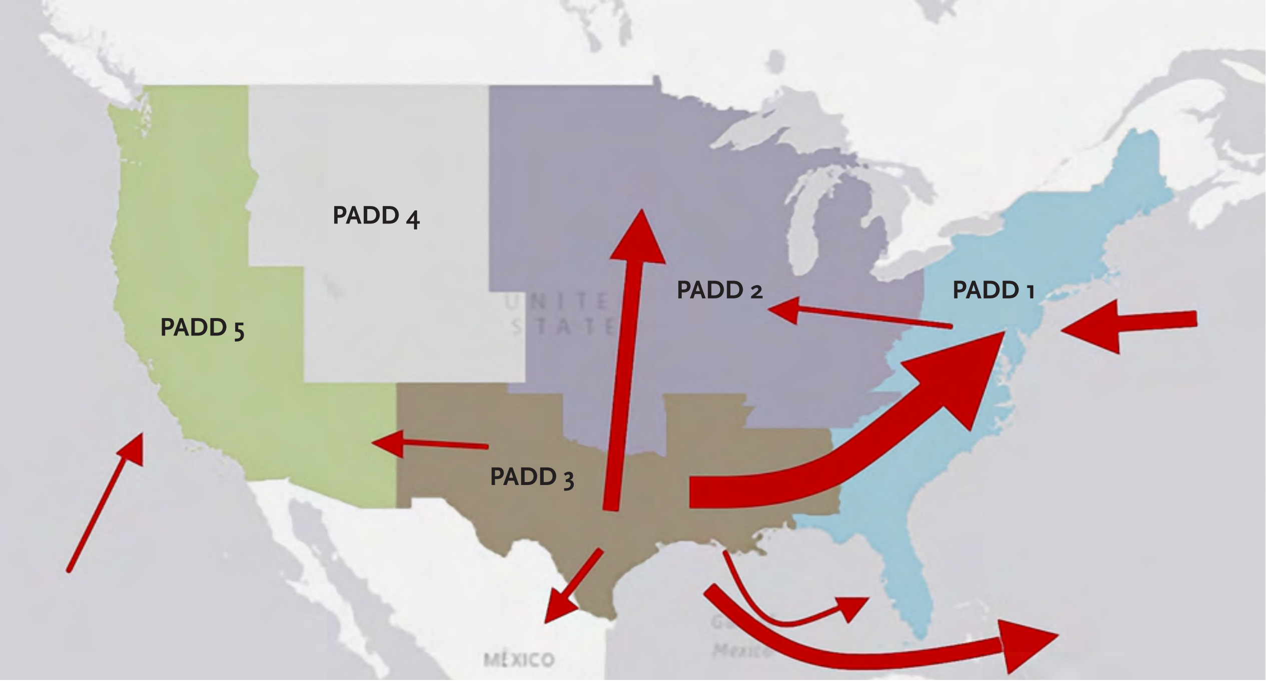
As a result of the imbalances that exist within the U.S. transportation fuel market, there are several major product flows that occur between PADDs to make up the shortfall. Logistically, these flows can occur by pipeline, tanker, barge or truck, and carry fuel from key production or import centers like the U.S. Gulf Coast to key demand centers like the U.S. East Coast. Below, in Figure 11, a map shows major product flows that are seen within the U.S., including the following:

PADD 3 to PADD 1: By far the largest flow, petroleum-derived fuels are moved up the Colonial and Plantation pipeline systems from the Gulf Coast to the East Coast. Colonial pipeline has been expanded recently but continues to face bottlenecks as a result of increased production from refineries and growing East Coast demand.

Europe to PADD 1: European gasoline comes in to the U.S. East Coast primarily to New England, where there is limited capacity to move product from the U.S. Gulf Coast.

PADD 3 to Latin America: The U.S. exports large volumes of diesel to South American countries and gasoline to Mexico. This is expected to continue to rise as U.S. refining becomes more operationally efficient and Latin American demand continues to rise.

Figure 11 U.S. Petroleum Products Flow



(Sources: Stratas Advisors, U.S. Energy Information Administration)

Imports and Exports

One of the supply chain quirks in the U.S. is that it both imports and exports gasoline and diesel from different markets. Exports primarily flow from PADD 3 to markets in Latin America and Europe while imports generally arrive in PADD 1. This drives some confusion as to why PADD 1 does not simply get its entire supply from PADD 3. There are several reasons for this:

Pipeline constraints: The Colonial and Planation pipelines are both running at full capacity, despite upgrades made in the last 15 years. Both pipelines terminate near New York City, leaving New England in need of alternative supply sources.

European excess: To make up the gasoline shortfall in PADD 1A, the U.S. imports gasoline from Europe. Despite trying to minimize gasoline output from European refineries (since they are more diesel-focused), they technologically must produce some gasoline no matter their configuration. This makes them willing to provide volumes at a large discount to U.S. markets.

Proximity: Because there is demand for fuels in foreign markets close to the U.S. Gulf Coast, such as Mexico, the cost to move volumes to Mexico or South America is lower than trying to move volumes around Florida and up the East Coast.

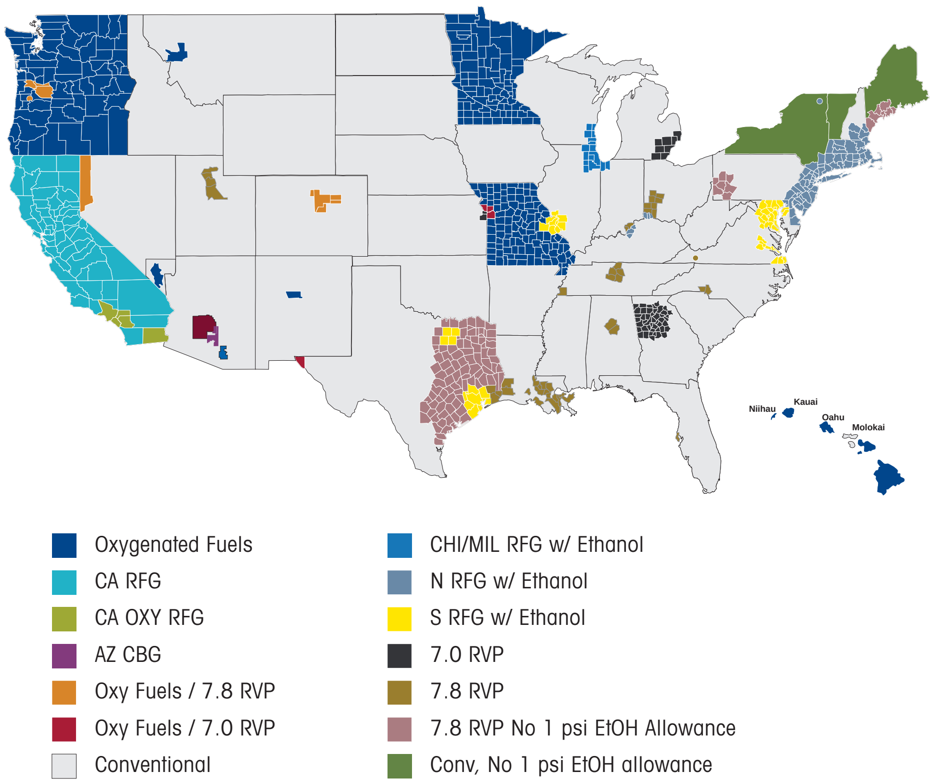
The Jones Act: The costs to move volumes from the Gulf Coast to the East Coast via tanker are also confounded by the Jones Act, which states that any ship or barge that moves from one U.S. port to another must be U.S.-flagged, U.S.-made and manned by a U.S. crew. This drives up movement costs considerably and makes moving volumes to Latin America much more economical.

Specifications: Fuel specifications in export markets in Latin America are substantially less stringent and easier to meet. This allows U.S. refiners to export fuels of most qualities without being concerned about boutique specs in U.S. demand markets.

Specifications, Grades and Mandates

One of the key limiters of the U.S. transportation fuel value chain flexibility is the varying specifications and mandates that exist across the U.S. The map (Figure 12) provided by ExxonMobil shows the states and municipalities that require boutique specifications, each of which exist generally to reduce emissions and/or meet specific weather requirements.

Figure 12 U.S. Gasoline Requirements



(Source: ExxonMobil – June 2015)

Some of the specifications that must be addressed include:

Reformulated Gasoline vs. Conventional Gasoline

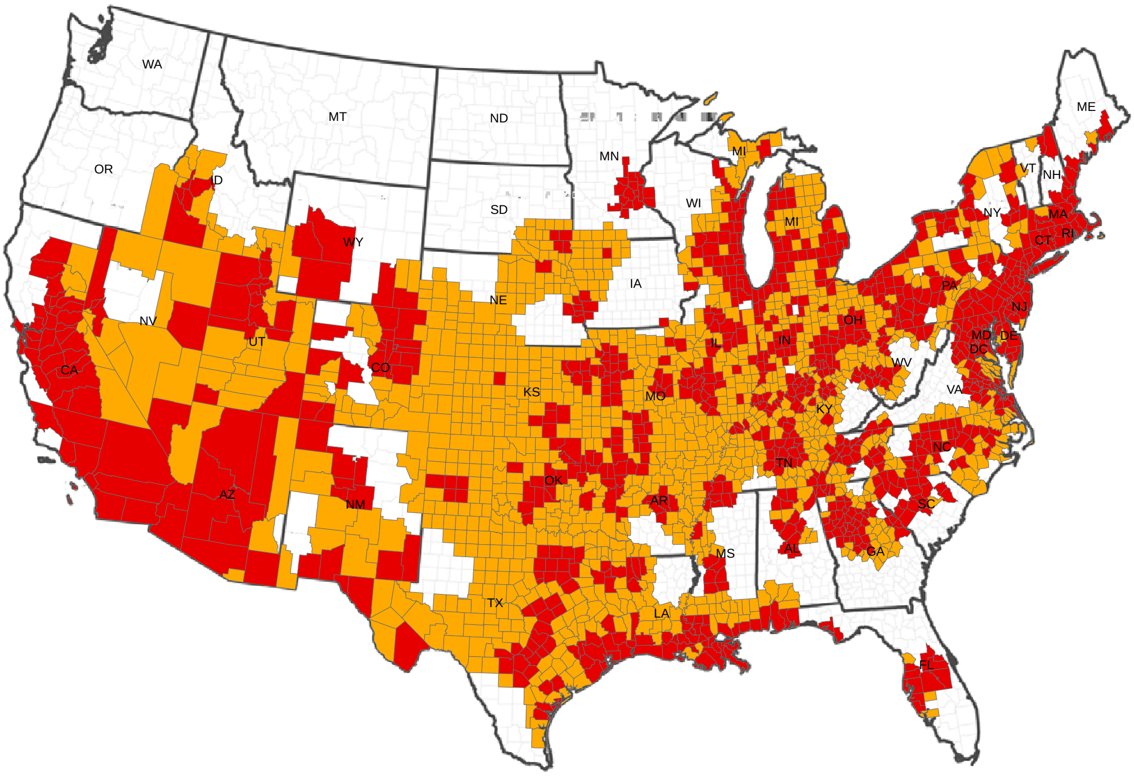
The Environmental Protection Agency describes the difference between reformulated and conventional gasoline in the following way:

> *"Reformulated gasoline (RFG) is gasoline blended to burn more cleanly than conventional gasoline and to reduce smog-forming and toxic pollutants in the air we breathe. The RFG program was mandated by Congress in the 1990 Clean Air Act amendments. The first phase of the RFG program began in 1995 and the second (current) phase began in 2000. RFG is required in cities with high smog levels and is optional elsewhere. RFG is currently used in 17 states and the District of Columbia. About 30 percent of gasoline sold in the U.S. is reformulated."*

National Ambient Air Quality Standards (NAAQS)

The National Ambient Air Quality Standards (NAAQS) are established by the EPA under the authority of the Clean Air Act. The goal of the standards is to reduce ground-level ozone that results from the emission of volatile organic compounds (VOCs). In October of 2015, the EPA finalized a rule reducing the existing ozone standard from 75 parts per billion (ppb) to 70 ppb. Many interest groups have taken issue with the rule, indicating that dozens of counties would be "nonattainment areas," or areas unable to meet the standard. These areas are shown on the map. Pro-business organizations like the U.S. Chamber of Commerce have raised concerns that the rule does not take into account the impact of foreign air pollutants on border areas of the U.S., while environmental groups like the Sierra Club have argued that the standard of 70 ppb is both arbitrary and insufficient. The rule is currently pending litigation.

Figure 13 **Projected 8-Hour Ozone Nonattainment Areas**



🟥 Monitored CBSAs and rural counties that would be violating a 65 ppb standard

🟧 Unmonitored areas that are anticipated to violate a 65 ppb standard based on spatial interpolation

Based on a 3-year period, 2011-2013.
Source: URS, July 7, 2014

(Source: API / energytomorrow.org)

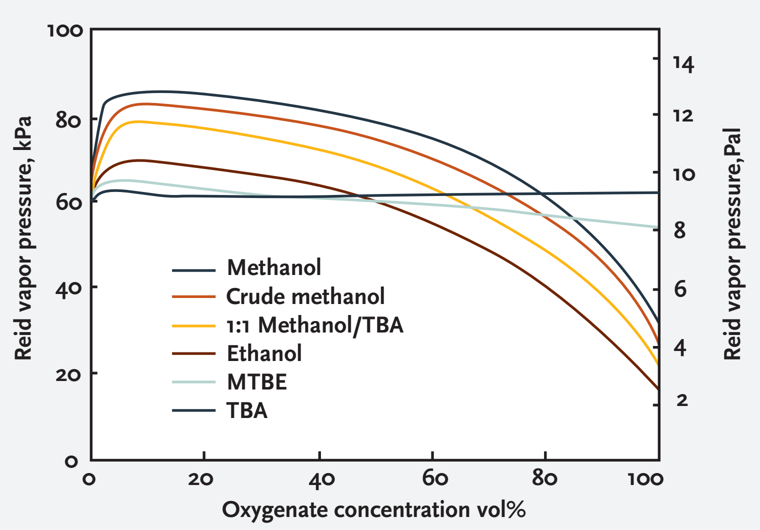
Vapor Pressure Specifications

Reid Vapor Pressure (RVP) is used to measure the volatility of gasoline. Fuels with higher vapor pressure are more volatile, causing more emissions (through evaporation) and ground-level ozone (smog) that are regulated by the Clean Air Act. Enforced by the EPA during summer months, different states and municipalities have varying RVP requirements depending on climate, population density and other local standards. RVP generally cannot exceed either 9.0 psi or 7.8 psi. (See map in Figure 12) Most state requirements to control RVP were enacted to address certain air quality issues for which RFG was considered unnecessary and for which the RVP specification was considered more cost effective for the affected market.

To promote ethanol usage as an oxygenate, however, in the Clean Air Act Amendments of 1990, Congress directed EPA to issue a waiver for increasing the summer vapor pressure specification in gasoline specific to the use of ethanol blends from 9% to 10% (which would normally exceed limits). Increased ethanol content in gasoline increases the fuel's vapor pressure, peaking at around blends of 10% and returning toward generally allowable levels past blends of 40%. While the fuel waiver was instrumental to allowing ethanol usage to up to 10%, the waiver does not apply to blends greater than 10%.

Boutique fuels with RVP controls are state programs that are submitted to EPA to demonstrate compliance with Clean Air Act standards. Such fuels can complicate the efficiency of the distribution system because it is unlawful to sell fuels within the affected market that do not meet that specific RVP requirement without a federal waiver. To reduce the impact of boutique fuels on the system, Congress enacted a provision in the Energy Policy Act of 2005 which capped the number of boutique fuels that EPA can approve to the number in existence at the time of enactment. The Act also granted EPA the authority to issue a waiver of boutique fuel requirements under certain market conditions, thereby allowing non-spec fuel to be sold in these markets for a limited period of time.

Figure 14
Vapor Pressure of Oxygenate/Gasoline Mixtures



(Source: IEA/AMF)

California's Fuel Specifications

It's no secret that California faces both significant environmental challenges and a unique political climate. In 2009, as part of its Low Carbon Fuel Standard (LCFS), the California Air Resources Board (CARB) set a unique set of specifications for its reformulated gasoline. Enacted on January 1, 2011, CARBOB (California Air Resources Blendstock for Oxygenate Blending) blended with ethanol became the only type of gasoline that could be purchased and consumed in California. CARBOB has a lower CO2 output per unit of energy consumed, which makes it more costly to refine—by some estimates upward of 10 cents per gallon.

The key challenge associated with the rollout of CARBOB was the manner in which it removed flexibility from California's transportation fuel supply chain. Because of this new spec, imports from foreign countries became more challenging as international markets are unable to meet California's specs. U.S. refiners outside of California, also unable to meet the spec, were not incentivized to upgrade their refineries to meet the spec since they would only get the low carbon premium if sold in California. For these reasons, California has been generally regarded as a closed market, whereby the entire value chain—refining through the pump—must be executed in California. This also raised pump costs for the consumer, giving California some of the highest gasoline prices in the U.S.

Mandated Biofuels Blending

With one exception, there are no federal or state mandates for unique blends (see figure below). While the RFS and LCFS encourage progressively larger amounts of biofuels into the market, the flexibility of the programs have allowed blends of ethanol to remain at 10% and blends of biodiesel to remain below 5% and still achieve compliance. The progressive schedule and credit system from both programs should reward obligated parties and/or retailers that voluntarily sell fuels with higher biofuel blend percentages.

Jurisdiction	Blend Level Mandate	Effective Date
Federal	RFS2: Requires an overall volume of biofuels to be used across the gasoline and diesel pool, effectively incentivizing minimum national ethanol blending to E10 and setting annual minimum biodiesel usage.	Began in 2009, but effective date for implementation of the program in its entirety was July 1, 2010.
California	LCFS: Requires reduction of net fuel carbon intensity, adding incentives that effectively set minimum ethanol usage at E10.	Jan. 12, 2010
Hawaii	E10	April 2, 2006, expired December 31, 2015
Iowa	Requires an overall volume of biofuels (including ethanol and biodiesel) to be used in the total transportation fuel pool	Began in 2009 and increases annually through 2020.
Minnesota	E10 B2 B5 B10 (April-October)	Nov. 1, 1997 July 1, 2007 May 1, 2009 July 1,2014
Missouri	E10	Jan. 1, 2008
Oregon	E10, B5	E10: Sept. 16, 2009 (statewide) B5: Oct. 1, 2011 (statewide)
Pennsylvania	B2	May 1, 2010
Rhode Island	B2 (heating oil)	July 2014
Vermont	B3 (heating oil) B5 (heating oil)	B3: July 2012 B5: July 2015
Washington	E2 B2 (on-road diesel only)	E2: Dec. 1, 2008 B2: Nov. 30, 2008

Major State and Federal Biofuels Programs

Only Minnesota has made efforts to increase the penetration of biofuel blends onto the market, with 10% blends of biodiesel (B10) being required in seasonal months. Other Midwest states with large biofuels fiscal incentives (in addition to the national programs) and high production levels (notably Iowa, Minnesota and Illinois) have managed to increase voluntary use of additional biofuel blends, primarily E85 and blends of biodiesel, above 5%.

Minnesota’s Biodiesel Mandate

On November 13, 2015, Minnesota’s increased biodiesel mandate went into effect. Requiring on-road diesel blends to contain at least 10% biodiesel by volume from April 1 to September 30 and 5% the rest of the year, Minnesota is the first state in the U.S. to require a biodiesel blend above the standard levels allowed in diesel (5%). When the initial statute was passed in 2002, the appeal was obvious. Minnesota was and continues to be the largest biodiesel producer in the U.S. with 63 million gallons per year of production from three different plants—nearly twice the estimated in-state demand at current blend levels. Additionally, the costs of retail-level experiments have proven minimal as existing underground storage tanks (USTs) are able to tolerate biodiesel blends up to 20% (B20). The fact that the consumer did not have a choice and was required to purchase B10 also meant that building a new UST tankage to hold multiple types of diesel was not required.

The implementation of the law was delayed, however, due to inadequate blending infrastructure at the terminal level. Often, terminal blending mechanisms are limited in the range of percentages that can be achieved and many operators are hesitant to use splash-blending for quality issues surrounding mixing. The law, which specifically cites the importance of not creating any “economic disruption,” had a delayed implementation due to a lack of blending infrastructure primarily in the southwestern part of the state. This delay lasted three years. Concerns have turned to technical issues of the ability of most engines on the road to tolerate B10. This is compounded by Minnesota’s current plan to move to a mandated B20 blend by 2018.

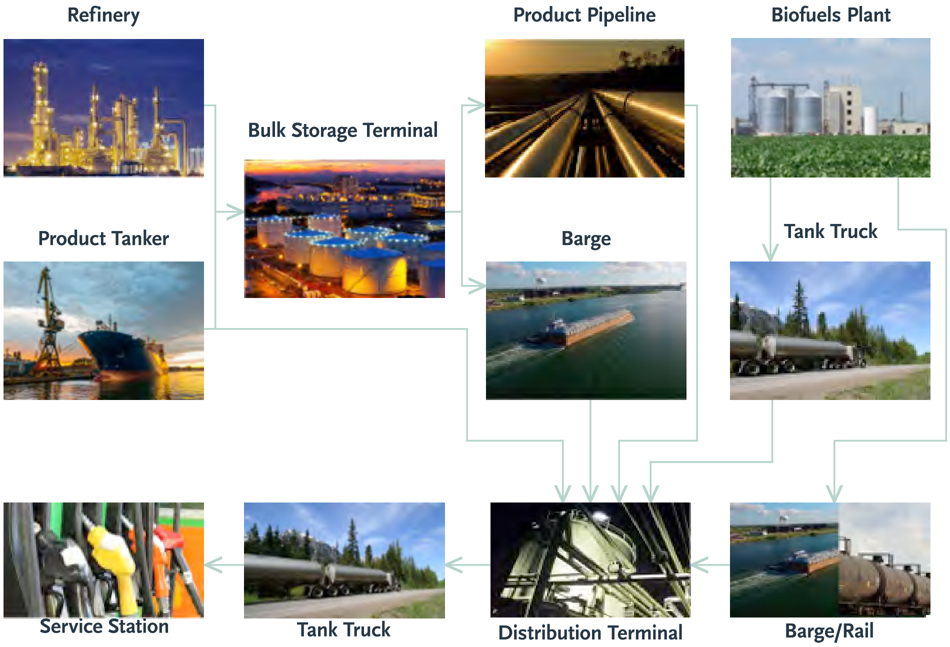
Getting Fuels to Market: The Value Chain

Before we can fully understand the U.S. Fuel Distribution network, it is essential to review the process by which transportation fuels reach the customer.

Gasoline and on-road diesel both begin either at the **refinery** or as **imports.** Once being refined or imported, it is placed in **terminal bulk storage** either at the refinery or at a centralized location such as a port. Once in bulk storage, either finished fuel or blending components are transported by **pipeline**, **rail** or **barge** to the **distribution terminal**. Concurrently, biofuels are produced at a **plant** and loaded into rail cars or **tank trucks** and shipped to the same **distribution terminal**. Once at the terminal, any blending with biofuels takes place before it is transported by **tanker truck** to the **service station**.

This section will review each step in this process along with structural, operational and regulatory challenges to supporting the marketability of primary, boutique and certain biofuel-blended fuels.

Figure 15 Understanding the Supply Chain

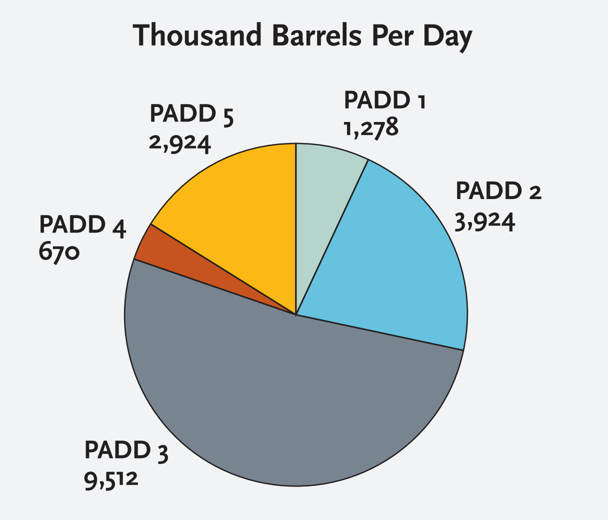


(Source: Stratas Advisors)

Refining

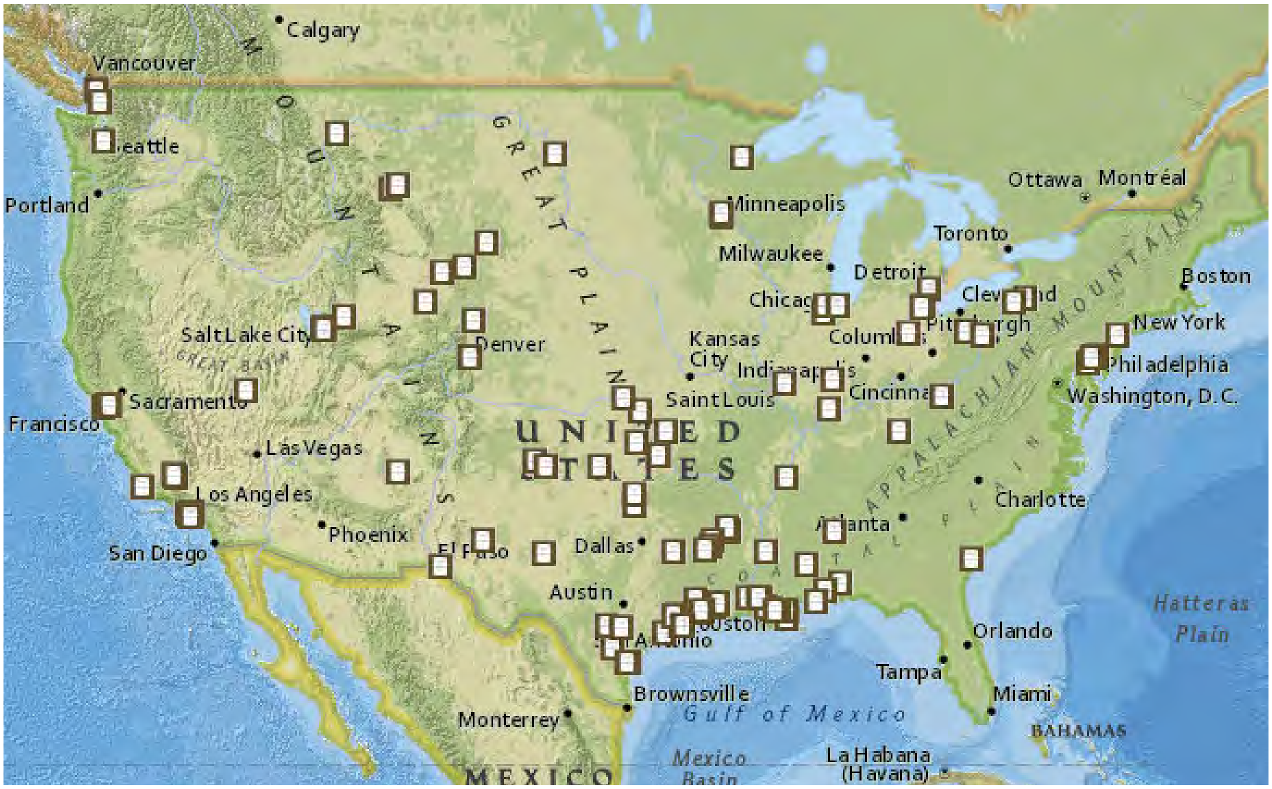
There are 137 operating refineries in the U.S. totaling 18.3 million barrels a day of capacity. Just over half of the refining in the U.S. is done on the U.S. Gulf Coast. The growth in PADD 3 refining has been primarily due to port access, which is essential for receiving crude imports as well as access to legacy domestic crude production, which has historically been primarily offshore. With the rise in oil production from shale, PADD 2 refining, which covers much of the Midwest, has been at a significant advantage in terms of access to greater, lower-cost crude oil. PADD 5, which covers much of the West Coast, is isolated not just in its physical location on the other side of the Rocky Mountains but is also subject to stringent fuel specifications set by the California Air Resources Board (CARB). Despite being the largest consuming market, PADD 1 has the smallest number of refineries and overall refining capacity, with the vast majority of the East Coast obtaining volumes from either from Gulf Coast refineries or importing from foreign sources. PADD 4 refining remains commensurate with small local demand due to a small population.

Figure 16
2015 U.S. Refining Capacity by PADD



(Source: U.S. Energy Information Administration)

Figure 17 U.S. Petroleum Refineries



(Source: U.S. Energy Information Administration)

Product Imports

At the end of 2015, the U.S. imported roughly 7% of the gasoline it consumed, totaling 663 thousand b/d. Imports peaked in 2007 at almost 1.2 million b/d when U.S. demand for transportation fuel was at its highest and prior to several large U.S. expansion projects. In 2015, about 88% of imported gasoline arrived into U.S. PADD 1.

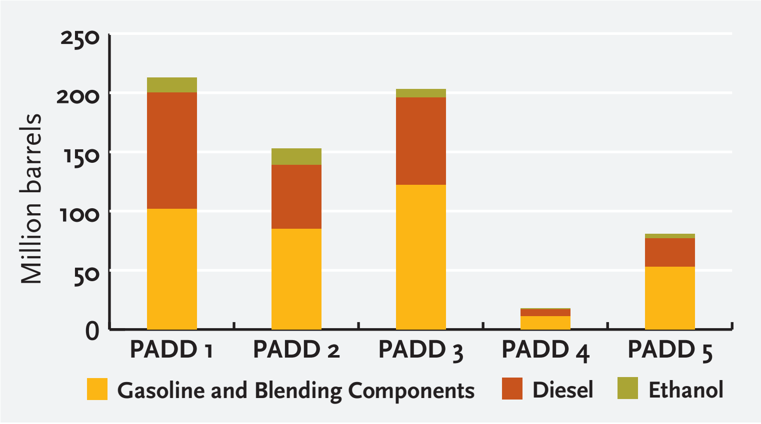
Imported Blending Components vs. Finished Motor Gasoline

Gasoline is imported into the U.S. in two forms: as finished gasoline or as gasoline blending components. The key differentiator is that finished gasoline already contains oxygenate (such as ethanol) that is necessary to meet specifications and enhance octane. Reformulated blendstock for oxygenate blending (RBOB) and conventional blendstock for oxygenate blending (CBOB) imports comprise 90% of the gasoline imported into the U.S. Because of the low-cost ethanol that is produced in the U.S., as well as the operational challenges with moving it, importing gasoline blending components is both more economical and operationally effective.

Bulk Storage Terminal

The U.S. has 669 million barrels of bulk storage for gasoline and diesel[1]. This storage is held at three core location types: refineries, pipelines and ports. Refinery storage holds gasoline and diesel fuel that has been produced but yet to be sent to market. Pipeline storage can be located at any point along the pipeline infrastructure, but typically resides at the point of product entry. Port storage is located at any U.S. port to store imports prior to moving to market. Once the gasoline or diesel is produced domestically or imported, the volumes could touch any number of bulk storage locations before moving to market. For example, imported gasoline blending components could be stored at an import bulk storage facility at a major U.S. port before being transferred to storage tanks owned and operated by a pipeline company prior to moving to market. Despite the difference in their chemical composition, storage operators have operational flexibility to store diesel volumes in tanks previously used for gasoline. Once a tank has been used for diesel fuel, however, it cannot be used for gasoline without being cleaned.

Figure 18
2015 U.S. Product Storage Capacity



(Source: U.S. Energy Information Administration)

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[1] This may include both on and off-road diesels

While both are a form of storage, bulk storage terminals are not used for the same purpose as distribution terminals. (A discussion of distribution terminals is provided in a future section.) Bulk storage terminals are typically larger and more strategically located (such as near a port) than distribution terminals. Product can also be stored for longer lengths of time (weeks to months) in order for product sellers or buyers to maximize profits. From a structural standpoint, bulk storage terminals are typically not set up with a "rack," or truck loading facility, for distribution to service stations (though some exceptions exist). Product volume purchases to and from bulk storage tend to be very large and moved through a high-volume mechanism like a pipeline, barge or tanker.

Bulk Storage Terminal Structure and Design

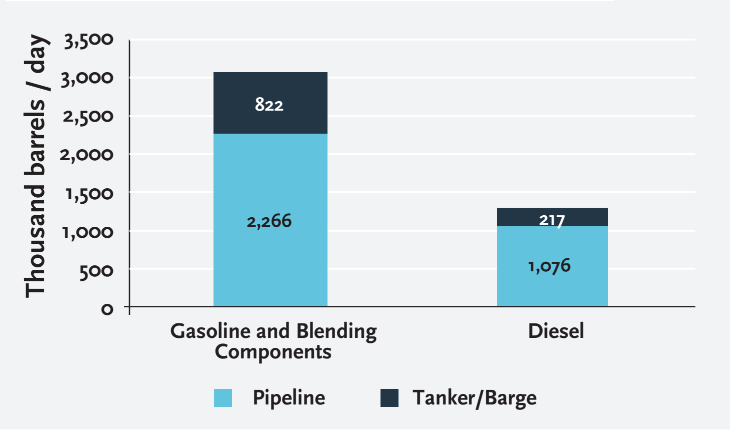
Bulk storage terminals typically resemble a "tank farm" of either a single or multiple types of tanks for storing a diverse set of products. Each tank can be either fixed-top or floating-top, depending on the location and type of product being stored. Each tank is designated for one product type because of the chemical and structural differences in each fuel. For example a tank that has been designated for diesel storage cannot be used for gasoline without being drained and thoroughly cleaned, typically a costly process. Gasoline must also be stored in floating roof tanks to minimize VOC emissions.

Bulk Storage is Typically Pre-Blending

Volumes stored in bulk terminals are typically stored as blending components (CBOB or RBOB) rather than as finished gasoline. Ethanol or biodiesel blending is instead done at the distribution terminal (which will be discussed later). This is for several key reasons:

1. Many states have varying requirements for blending. As such it is more efficient to blend at the distribution terminal, which is typically within the market where the product will be consumed.
2. Because of economics and certain tank management practices, ethanol is typically blended with gasoline when it enters the tanker truck for distribution to retail motor fuel dispensing facilities.
3. Heated storage is often required for biodiesel in colder climates, since certain biodiesels have much higher cloud-points than diesel. (The cloud point is the temperature below which the wax in diesel fuel solidifies and clogs up engine components, giving it a cloudy appearance.) Higher blends of biodiesel (greater than 5%) also run this risk, so bulk diesel is generally not stored with significant blends of biodiesel.
4. Biodiesel blends can cross-contaminate jet fuels in pipelines. Since diesel may move from the bulk terminal by pipeline, biodiesel blending at the bulk level is less common.

Figure 19
2015 Inter-PADD Fuel Movements by Mode of Transport



(Source: U.S. Energy Information Administration)

Moving to Market: Pipeline, Barge or Tanker

With just under 5 million barrels per day of gasoline and diesel moving among the PADDs in 2015, the two key methods by which these volumes can reach market are pipelines and barge/tankers. While the most popular method continues to be by pipeline, restrictions on operating specifications limit the movement of higher ethanol or biodiesel blends. While barge and tankers remain the most viable alternatives, barging is slow and limits batch size, while tankers remain costly due to Jones Act requirements.

Because of the cost efficiency associated with pipelines, it comprises 73% and 83% of gasoline and diesel inter-PADD movements, respectively, while the remaining volumes are moved by either tanker or barge. More than 90% of the tanker/barge movements among PADDs comprise the flow of gasoline and diesel fuel from the U.S. Gulf Coast to the western coast of Florida.

Pipelines

There are 70,000 miles of refined product pipelines in the U.S. and each system has some level of variability in their design and required product specifications. The major systems that exist are designed to carry large volumes from major refining centers in the Gulf Coast (PADD 3) to major demand centers like the East Coast (PADD 1) and Midwest (PADD 2).

Major pipeline systems such as TEPPCO, Plantation and Colonial tolerate both fungible and segregated products. Fungible products are represented as RBOB or CBOB that can be used in most (if not any) market with the proper blending at the terminal, while segregated products are specific to an individual market based on local specifications such as Reed Vapor Pressure (RVP) or oxygenates.

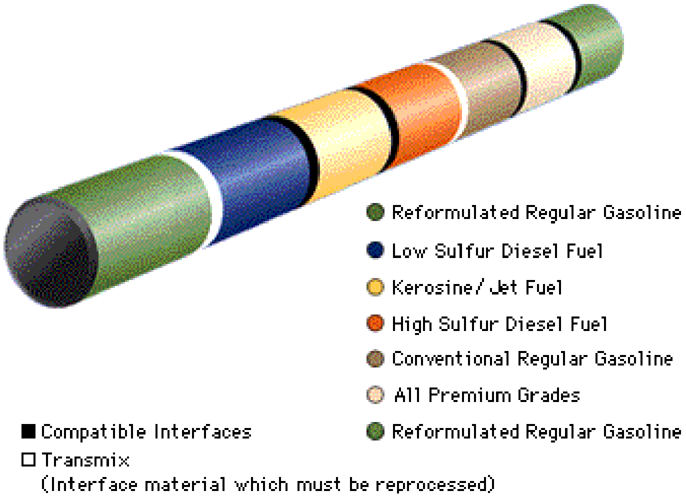
The pipeline company does not at any point own the product it is moving. The customer, who can be a trader or anyone along the value chain, pays a fee—referred to as a tariff—to move a gallon of fuel through a pipeline depending on its fuel type, origin and final destination. Rates for interstate product pipelines are set annually and regulated by the Federal Energy Regulatory Commission (FERC).

Figure 20 U.S. Product Pipeline

(Sources: Stratas Advisors, MySynerGIS)

In order to move product through a pipeline, it must be "batched." The batching process is shown below in a diagram from Colonial pipeline. Products are shipped in batches that can range in size and volume in a specific order to minimize what is known as "intermix" or "transmix," or the inevitable blending that occurs when you ship two non-compatible product-types next to one another. Intermix can be used but typically requires processing.

Figure 21
Typical Sequence in Which Products are Batched While in Transit on Colonial System



(Source: Colonial Pipeline Company)

While there are some exceptions, pipelines with traditional steel piping have limits on the amount of biofuels that can be blended with gasoline or diesel prior to insertion. Some studies indicate that ethanol can be damaging and corrosive to pipelines, even at lower blends, while others have refuted these claims. As such, major pipeline systems like Colonial and Plantation do not allow gasoline shipped through a pipeline to contain ethanol. Because of the limited quantity of biofuels in pipelines today—primarily for economic reasons —the amount of real-world data on this issue is limited. While there is one ethanol pipeline in the U.S. (Florida), it is lined with corrosion-resistant resin, and the ethanol must receive a specific additive in order to prevent corrosion.

The movement of biodiesel through some pipelines can also be limited due to its potential contamination of jet fuel, which is also moved through pipelines. Fatty acid methyl esters (FAME), which is the primary composition of biodiesel, cannot be more than 50 parts per million (ppm) in jet fuel per specifications set by the ASTM. Pipeline systems like Colonial are working around these limitations by allowing biodiesel (up to B100) into pipeline segments that do not service major airports, or are not likely to have any jet fuel cross-contamination risk.

Major U.S. Pipeline Systems

Colonial: 5,500-mile system that runs from Houston, Texas, to Linden, N.J. By far the largest pipeline system in the U.S. by volume, it carries large volumes of U.S.-produced transportation fuels to major U.S. East Coast demand centers.

Plantation: Runs parallel with Colonial from Louisiana to Washington, D.C. The 3,100-mile system carries 700,000 barrels per day from the Gulf to the East Coast.

Enterprise: Formerly called TEPPCO, this 3,400-mile system is the largest pipeline serving PADD 2. It runs from Houston through the Midwest and into the Northeast.

Explorer: 1,830-mile system that runs from the Houston Ship Channel to Chicago. Has a capacity of more than 660 mb/d.

Niche products like methanol and butanol remain outside the specification requirements for pipelines and are not shipped.

The Rise of Colonial Pipeline's Secondary Market

As demand for transportation fuel has grown on the U.S. East Coast, so too has demand for space on its largest pipeline—Colonial. Because the pipeline capacity has not kept up with this rising demand, a shortage of line space has developed. Traders are able to acquire space on the line and sell it in some cases for more than four times the posted tariff. This has generated a secondary market for space that has created consternation as these costs are ultimately passed on to retail consumers.

Colonial allocates space six times a month. While much of the space is divided among major shippers, the remaining 5% to 10% is issued by a lottery system to those interested in participating. Selection in the lottery grants a shipper the right to send at least 25,000 barrels of gasoline or diesel up the pipeline. But in many cases, the owners of that capacity choose to sell that space to someone else. The net result is a rapid increase in the number of firms looking to acquire space. The *Wall Street Journal* reported in November 2015 that the number of shippers has increased by 50%—from 140 to 210—in just the last two years.

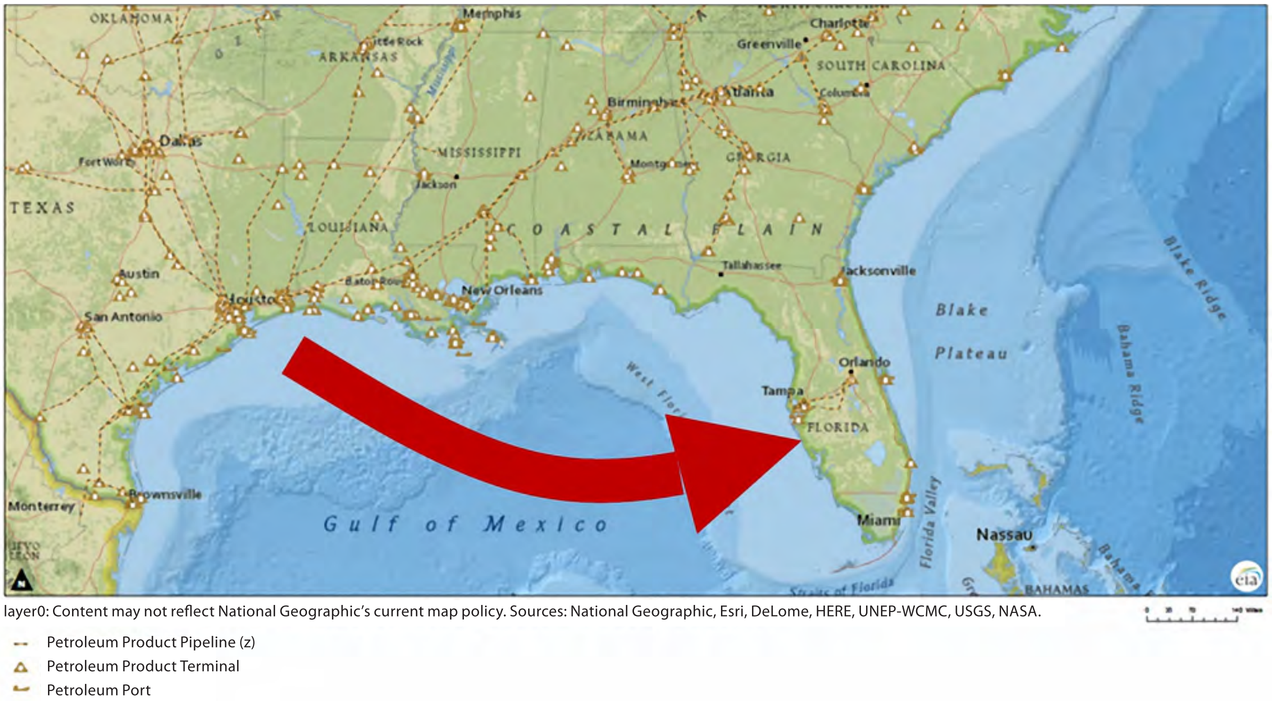
As of now there are no rules to prevent a company from reselling its pipeline space, and stakeholders indicate that Colonial has little recourse to prevent the practice from occurring—so much so that its popularity has spread to other pipelines, including Plantation and Explorer.

Florida: An Isolated Market

A current lack of pipeline or rail infrastructure to service much of Florida has created logistical bottlenecks for the Sunshine State. Only 24% of gasoline and diesel is moved between U.S. PADDs by barge or tanker, and of that volume more than 90% of that volume flow is barrels of gasoline and diesel being barged from PADD 3 refineries to the West Coast of Florida (Tampa). Once there, the Central Florida Pipeline (Kinder Morgan) carries volumes to key demand centers such as Orlando.

Because of the high cost and limited number of Jones Act vessels, there has been a concerted effort to debottleneck the region and connect Florida to the refining centers of the U.S. Gulf Coast. In the summer of 2015, the Florida Fuel Connection secured funding to build the infrastructure for petroleum product movements by rail, connecting a Colonial Pipeline terminal near Baton Rouge, La., to unserved parts of Georgia and Florida. This project is still in development.

Figure 22 Florida: An Isolated Market

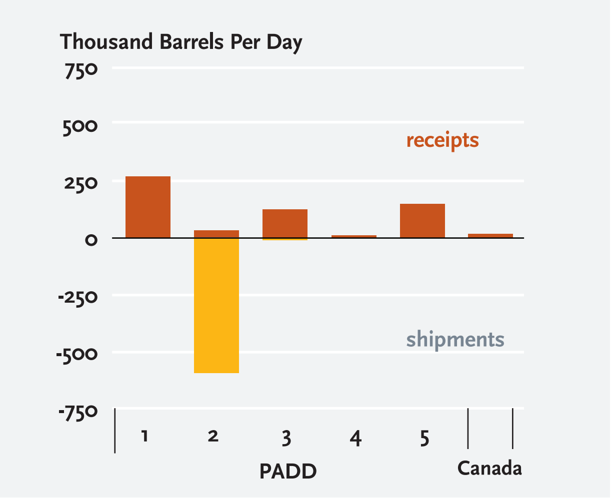


(Sources: National Geographic, Esri, DeLome, HERE, UNEP-WCMC, USGS, NASA)

Biofuels and Rail

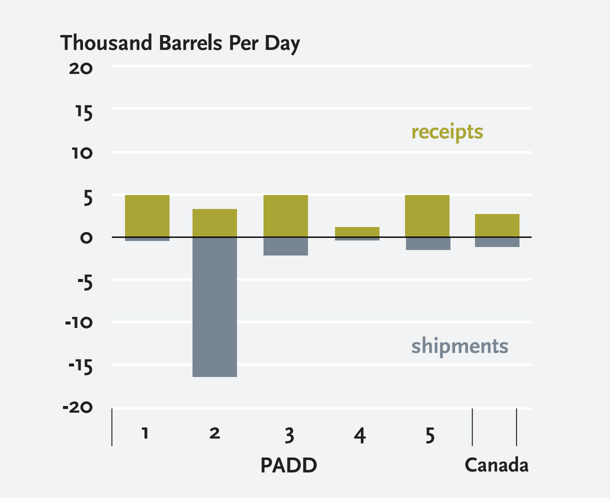
Unsurprisingly, the vast majority of U.S. biofuels are produced in the Midwest (PADD 2). With access to land and inexpensive agricultural feedstocks like corn and soy, biofuels produced in the Midwest or other parts of the U.S. are shipped directly to distribution terminals in key demand centers, where they are blended into gasoline or diesel. Even though ethanol uses a wide variety of transportation methods to move, more than 95% of ethanol that is transported is moved by rail.[2] Roughly 300,000 unique carloads[3] of ethanol move annually from key producing states like Iowa, Minnesota, Nebraska and South Dakota throughout the U.S.

Figure 23a
Movement of Ethanol by Rail (2015)



(Source: U.S. Energy Information Administration)

Figure 23b
Movement of Biodiesel by Rail (2015)



(Source: U.S. Energy Information Administration)

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[2] Between U.S. PADDs – Data from EIA

[3] AAR

Distribution Terminals

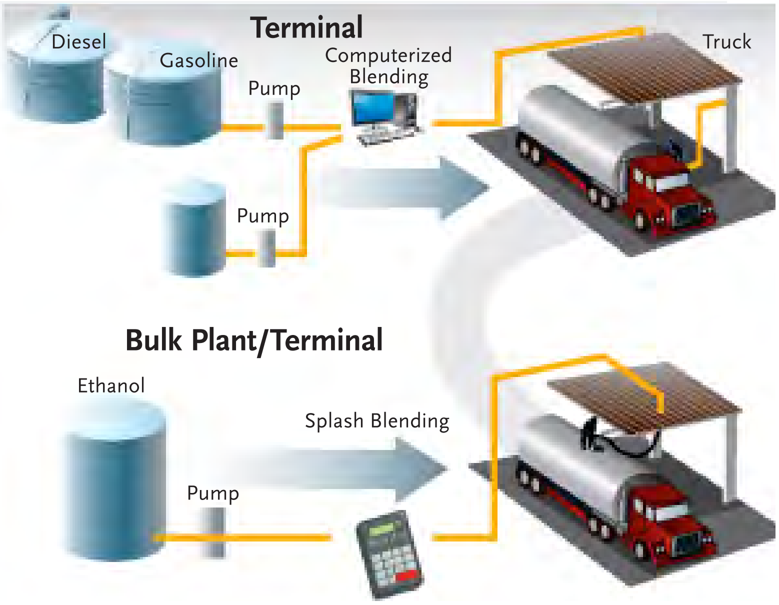
Distribution terminals are the primary access point between commercial and retail markets located either near a port, navigable waterway, rail or along a pipeline. In addition to a number of large above-ground storage tanks, distribution terminals also contain facilities to transfer gasoline, diesel and other products to tanker trucks (referred to as a "rack") for delivery to retail motor fuel dispensing facilities (gasoline stations, convenience stores and truck stops) and in some cases commercial (fleet and marine) motor fuel-dispensing facilities and bulk plants. Bulk plants are typically small facilities with 20,000 gallon underground or above ground tanks and a loading rack. Fuel is received from distribution terminals and transferred from the tanks through a loading rack to smaller tank trucks, typically holding 9,000 gallons. Bulk plants typically provide fuel to farms and businesses in rural areas outside of terminal distribution areas. Terminals are designed to service the market in which they are located, and as such are designed to hold volumes of both gasoline and diesel that meet local specifications and regional demand. The Colonial Pipeline alone serves more than 150 terminals of varying size, technology and market access.

Blending Process

Of key importance to fuels providers is that blending for both ethanol and biodiesel takes place almost exclusively at the distribution terminal. Because of the expanded role of ethanol, all terminals that sell gasoline have access to some sort of ethanol source via rail, barge or truck.

Blending takes place as the fuel is loaded into the tanker truck, which typically ranges from 8,000 to 9,000 gallons. There are two core techniques of blending, splash and computerized. Computerized blending, which is becoming more common especially to customers serving retail outlets, allows the driver to simply pull up to the loading rack and the fuel is blended either before it reaches the truck or injected directly into the tanker after the gasoline is loaded. Fuel is loaded from the bottom of the tank truck compartment to reduce splashing and associated emissions. However, not all of these systems are designed for expanded blending, so mixing higher ethanol blends (e.g., E85) may not be possible without upgrades. For wholesale or bulk loading splash blending is more common, whereby the driver loads a metered volume of petroleum-derived gasoline at one connection and then adds a metered volume of ethanol separately at another connection. The driver or the terminal operator is responsible for manually calculating the blend requirements for the market that the truck is bound to serve. This allows for more flexibility in blend levels and is often used to create renewable fuels. This technique can be more prone to blend errors and also can increase emissions due to the fact that volumes are typically loaded from the top of the truck rather than the bottom. In addition, blending of the two products is contingent upon the movement of product within the tanker truck during transit to the retail motor fuel dispensing facility.

Figure 24
Distribution Terminal



(Source: American Petroleum Institute)

Biofuels/Blending Credits

The strongest national drivers for biofuels use are the $1 per gallon biodiesel blender's credit and compliance with the RFS, demonstrated through the acquisition of Renewable Identification Numbers, or RINs. RINs serve as a tracking system for renewable transportation fuels and allow EPA to monitor RFS compliance. The RFS program, which assigns refiners, blenders and importers with a renewable volume obligation (RVO), uses RINs to track each gallon of ethanol and biomass-based diesel that goes into the fuel supply. RINs are technically "activated" at the point of biofuels blending, which generally occurs at the distribution terminal. RINs, which are valued on the commodities market, can be bought and sold by various parties to meet the requirements of the RFS.

The $1 per gallon biodiesel tax credit also goes to the owner of the biodiesel at the time of blending, and since almost all biodiesel used in the U.S. is blended the credit effectively helps lower the price of biodiesel in the marketplace. For example, the $1 per gallon credit combines with the market-priced biodiesel RINs to make biodiesel effectively cheaper than diesel, and this has encouraged increasing biodiesel blending to a 2.5% national average. However, the barrier to increased biodiesel blending has been rather low, as infrastructure and vehicles were already compatible with up to 5% blends.

Operational Challenges

The nature of unique, local boutique fuel programs and biofuel blending requirements create challenges for terminal operators and logistics companies. A terminal that services multiple markets with multiple specifications or multiple grades must have a dedicated tank infrastructure to support each fuel. The less fungible the fuel the less efficient the tank infrastructure becomes. The same is true for the fueling process, as the design of dedicated pumps for specific fuel types can result in long trucking lines and inefficient queuing.

Tanker Trucks

The tanker truck is responsible for moving finished product from the terminal to the retail outlet or service station. While the process of hauling petroleum products remains relatively straightforward, it is becoming more of a bottleneck in the value chain. Shortages in truck drivers reached critical levels at the height of the U.S. shale boom as trucking had been one of the key transportation methods of hauling fracking ingredients like sand and water. Trucking was also one of the primary hauling methods for liquid fuel output from oil and gas wells. While this has been alleviated somewhat by recent oil price declines, a 2015 report by the American Trucking Associations proclaimed a shortage of more than 38,000 truckers, with that number expected to grow rapidly as large numbers of truck drivers retire. Combine this with a Federal Motor Carrier Safety Administration rule that limits the number of hours that truck drivers are able to work before taking an extended break, and an already consolidated, low-margin business will continue to face challenges moving forward.

Motor Fuel Dispensing Facilities

Retail motor fuel dispensing facilities serve four major markets. The first is passenger vehicles and light duty trucks. These facilities typically include a convenience store and other related amenities such as a car wash, although some may be associated with vehicle repair facilities or major retail outlets (e.g., grocery chains). There are more than 159,000 retail motor fuel dispensing facilities serving automobiles and light duty trucks throughout the U.S. with varying ownership structures, operational capabilities and market access. Retail motor fuel dispensing facilities can have a dozen or more fueling positions offering two or three grades of gasoline and diesel fuel. In addition to passenger and light duty vehicles, retail facilities supply fuel for small engines such as lawn mowers, lawn tractors, generators, etc., dispensed into cans ranging from one-gallon to more than 10 gallons, vehicle mounted tanks or directly into the equipment. With the exception of two states (Oregon and New Jersey), retail motor fuel dispensing facilities are typically self-serve allowing the customer to select the fuel and control the transfer of the fuel to the vehicle.

Truck stops are retail motor fuel dispensing facilities that provide primarily diesel fuel for over-the-road trucks as well as gasoline and diesel for passenger vehicles and light-duty trucks. Truck stops can have a dozen or more diesel fueling positions as well as gasoline fueling positions for passenger vehicles and light-duty trucks. The passenger vehicle and light-duty truck fuel dispensing facilities are typically separated from the larger truck fuel dispensing facilities. These facilities are larger than other retail motor fuel dispensing facilities and provide a variety of amenities for truck drivers, including restaurants, convenience stores, showers, scales and truck repair.

Marine motor fuel dispensing facilities are retail motor fuel dispensing facilities typically located along recreational lakes and other waterways to fuel boats and other watercraft. Marine facilities are typically small consisting of one or two fueling positions and typically offer one or two grades of gasoline and/or diesel fuel for various water craft.

Fleet motor fuel dispensing facilities are typically owned by businesses and federal, state and local agencies to fuel private vehicle fleets. These facilities can range from large trucking companies to small service companies and municipalities. There are thousands of commercial motor fueling facilities that supply private fleet vehicles. These fleet motor fueling facilities typically have at least one UST or AST.

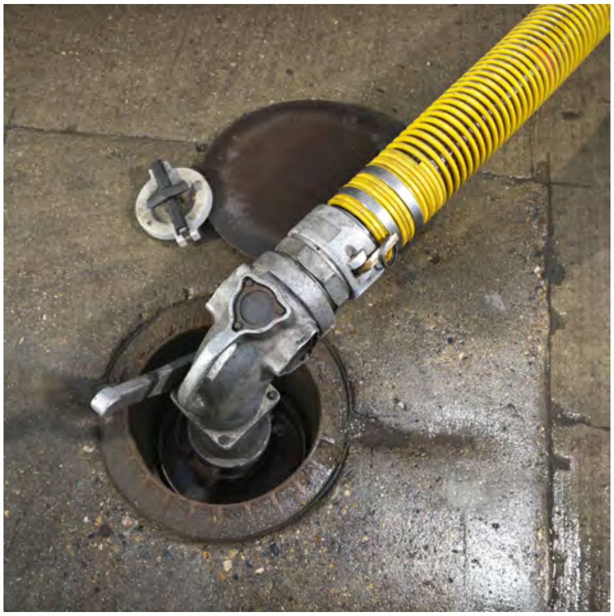
The ability of a motor fuel dispensing facility's infrastructure to distribute renewable fuel blends to customers is based upon two key factors—the configuration of the fuel storage and dispensing system and the compatibility of the fuel storage and dispensing system equipment with the fuel.

Fuel Dispensing and Storage Tank Systems

The fuel dispensing and storage system consists of a storage tank, piping to transfer fuel from the tank to the dispenser, a dispenser to control the flow and volume of fuel transferred to a vehicle and a hose, nozzle and related hardware to transfer the fuel to a vehicle. Fuel dispenser systems are typically regulated under the state fire codes. These codes generally require the dispenser and related equipment to be listed or approved for the fuel dispensed. The majority of dispensers in the U.S. are UL listed for not more than 10% ethanol; however, dispensers are available with UL listings for E25 and E85. Beginning in 2016, one manufacturer has indicated it will no longer sell E10 listed dispensers—the minimum listing will be for E25—and another manufacture has a UL-listed conversion kit for certain dispenser products to increase the listing from E10 to E25. Based on conversations with NACS, the cost to upgrade or replace an existing pump can range widely from $1,000 up to more than $20,000 each, depending on the current configuration. NACS has also indicated that it is uneconomical for retailers to occupy limited pump positions with any fuel if there are low expectations for sales volumes. Because of this high capital cost combined with low demand, the number of refueling locations that currently provide fuels with higher biofuel blend ratios is small. According to the Department of Energy, there are only 3,100 stations in the U.S. that provide E85 and only 700 that provide B20. This is compared to more than 70,000 that pump regular diesel fuel (B5). In late 2015, the USDA announced a public/private partnership to install 5,000 E15/E85 pumps at 1,400 unique service stations across the U.S. The estimated cost is $210 million.

When the tank truck arrives at a motor fuel dispensing facility, its contents are transferred into an underground storage tank (UST) or, in the case of some fleet and marine motor fuel dispensing facilities, into an above-ground storage tank (AST). The fuel storage system consists of a storage tank (UST or AST) and connected piping to store and transfer the fuel from the storage tank to the dispenser. UST systems are the most challenging aspect of renewable fuel management since they are the primary method for storage of fuels at retail and larger fleet motor fuel dispensing facilities. UST systems have been under enormous scrutiny through federal and state regulations to ensure proper installation, operation and maintenance to reduce the potential for a release and minimize the impact of a release, if one were to occur, from these systems.

A significant issue for UST systems with higher biofuel blends (those containing greater than 10% ethanol or 5% biodiesel) is the compatibility of the UST, piping and related components with the biofuel blend to be stored. The issue of compatibility is specifically addressed in the federal and state UST regulations, making it a violation of the regulations to store or handle a fuel in a UST system that is not compatible with the fuel. The challenge is being able to demonstrate, as required by the regulations, that all components of the UST system are compatible with the biofuel blend. This includes not only the UST and piping, but fittings, seals, adhesives and other components. Despite issues with legacy systems, many new UST systems are constructed of materials which are approved either through their UL listing or by the manufacturers for blends up to E100 or B20.



The configuration of the fuel dispensing and storage system is also an important consideration for the handling of biofuel blends. There are generally two primary configurations for retail motor fuel dispensing facilities. The first is the use of blending pumps where there are two storage tanks containing a conventional fuel and biofuel that are blended to a specification at the dispenser. Blending pumps are used widely today and represent the most popular method to produce mid-grade gasoline (blending regular gasoline with premium). The second configuration is dedicated storage tank and dispensing systems for each fuel sold. In the case of a dedicated storage tank and dispensing system, the addition of a biofuel blend would require replacement of an existing fuel with the biofuel, the addition of a new storage tank and dispensing system dedicated to the biofuel, or an upgrade to a blending system. The conversion of an existing storage and dispensing system to a new biofuel blend may be difficult to justify with small volumes of sales and limited compatible vehicles. Alternately, installing additional storage tank and dispensing systems for product flexibility presents an even larger cost than tank conversion and may not be possible because of space issues. These costs could be as high as $200,000 for a facility depending on the configuration and the cost of regulatory compliance associated with installations or major retrofits.

Liability Protection and Vehicle Warranties

Another challenge for the penetration of higher biofuel blended fuels is the lack of liability protection for service stations. Because not all engines are compatible with all fuels, service stations could be liable if a driver fills his or her vehicle with a fuel that damages a vehicle's engine. For example, except for flexible fuel vehicles, vehicles built prior to 2001 are prohibited by EPA from accepting ethanol blends higher than 10% because of potential damage to emissions control devices. Further, while EPA has approved E15 for those vehicles manufactured in 2001 or more recently, most cars made before 2013 are not warranted for fuels with ethanol blends higher than 10%. Most automakers advise customers to consult their owner's manuals for guidance on approved or recommended fuels and have advised that use of a non-recommended product could void the vehicle warranty. While potential liability for misfueling is not exclusive to biofuel blends, the issue has gained greater prominence than other potential liability issues due to the heavy politicization of biofuels penetration in recent years and many retailers have expressed concern they may be held responsible if a consumer damages their vehicle after purchasing a fuel from their facility.

Service station owners also face liability issues when it comes to tank compatibility. Per regulation, fire code and insurance policies, all storage and dispensing equipment must be compatible with the fuel being stored and dispensed. Determining compatibility of dispensers is relatively simple, but ownership of many of these facilities has transferred over the years and information concerning the UST system may have been lost during these transfers, making it difficult to produce the required documentation to demonstrate compatibility. Without documentation of compatibility for renewable fuels use, converting existing UST systems for renewable fuels use poses a huge liability to retail station owners.

The Fuels Value Chain and Hurricane Sandy

When Hurricane Sandy hit in October 2012, it exposed a number of weaknesses in the U.S. transportation fuel value chain. PADD 1 refineries were shut down, pipelines were closed for safety and imports to New York harbor were limited due to high seas. The biggest problems, however, arose downstream as terminals at ports and for local distribution were flooded and shut down—28 in all. Compounded by an inability for fuel to be trucked in from surrounding areas due to closed roads and downed trees, local inventories were quickly eroded and service stations were unable to service customers.

In response to Sandy, state and federal regulators took steps to provide waivers to rules that constrain supply chain flexibility and make it more difficult to respond in the cases of emergency:

Waivers on trucker hours: Typically, truckers are only allowed to drive 14 hours a day, but on October 29, 2012, the Federal Motor Carrier Safety Administration allowed waivers to be granted to truckers to allow them to exceed that limit so long as they were carrying emergency-related materials, including fuel.

Jones Act waivers: Temporary waivers were granted to assist in bringing more petroleum products to fuel-thirsty markets during the hurricane.

Fuel spec waivers: The U.S. EPA granted emergency waivers in states with Reformulated Gasoline (RFG) requirements, allowing those states to use conventional gasoline as a result of the hurricane. Waivers were also granted for Ultra Low Sulfur Diesel.

Future Challenges to Biofuel Penetration

Future market conditions will make it more difficult for certain biofuel blends to penetrate the U.S. market. While the key focus is on the "chicken-and-egg" problem of vehicles vs. fuel access, there are also several operational and economic hurdles at various points along the value chain that will support biofuels.

Vehicles

The phase out of the FFV CAFE (Corporate Average Fuel Economy) credit is likely to be a blow to the penetration of higher ethanol blends nationwide. Stratas Advisors forecasts that with the elimination of this credit, car makers will begin to phase out flex fuel vehicles in 2016. This is likely to limit interest in infrastructure investment along the value chain to support E85 blends—particularly at the service station. However, converting a station to be compatible with E15 and B20 may be economically sensible, especially considering the increased market share of vehicles both approved by the EPA and certified by manufacturers to operate on these fuels.

Service Station

The EPA has indicated that underground storage tanks (USTs) will tolerate blends of E10 or B20 without any operational challenges. Retailers can rely on affirmative statements from equipment manufacturers to demonstrate the compatibility of their underground equipment. To facilitate research, the Petroleum Equipment Institute (PEI.org) maintains a library of manufacturer statements about compatibility. For example, Xerxes Corporation, which manufactures fiberglass tanks, asserts units manufactured prior to 1981 were not designed to accommodate ethanol blended fuels. However, all double walled Xerxes tanks manufactured after 1990 are suitable for storing E100. Most diesel fueling equipment suppliers were ahead of gasoline suppliers in providing high blend (B20) compatible equipment, and B20 use in non-certified equipment also has a longer history of acceptance. However, gasoline equipment is continuing to evolve. By the end of 2016, some suppliers are only planning to sell dispensers with a minimum UL listing for compatibility of E25. Suppliers with older dispensers already in the market might be able to use a UL-listed upgrade kit to increase compatibility from E10 to E25. Despite the existence of such equipment, many retailers may elect to not invest in non-mandated or non-subsidized biofuels infrastructure without sufficient customer demand to justify the investment. For example, in Minnesota, when state subsidies for E85 infrastructure expired, the number of stations offering E85 declined.

Terminal

Terminals are not likely to pose huge operational limitations to higher ethanol blends. Because the tanks and logistics already exist for ethanol blending at all terminals, assuming a terminal has adequate storage capacity to accommodate additional products, only the blending pumps may need upgrading. This may be overcome in the short-term with splash blending. Terminals that require new tanks to accommodate a new fuel blend, however, will likely result in some pushback from terminal operators; especially with fuels that are less compatible with their existing infrastructure. In needing to either re-task existing tanks or invest in new tanks, this capital cost would be hard to support without demonstrated demand in the market.

Pipelines

Deployment in U.S. pipelines remains a problem for efficient transportation of high biofuels blends. Virtually all pipelines (with the exception of one in Florida) do not allow biofuels to run through their pipeline due to water seepage and, some argue, corrosion. Only biodiesel blends of less than 5% are expected to be allowed in the near term. The economics of ethanol pipelines have proved challenging as well, with much of the existing pipeline infrastructure being built around producers of refined products and not biofuels.

In general, the ability to move ethanol and biodiesel from key production sites to demand centers is limited to truck, barge and rail. Re-tasking of pipelines is unlikely due to low demand for high ethanol blends in most areas combined with existing pipeline bottlenecks in key markets like the U.S. East Coast.

Policy

Previous federal (and most state) credits for infrastructure upgrades for high blends of biofuels usage have lapsed. Policies that create price incentives for biofuels have been inconsistent, making returns on high-blend biofuels infrastructure investment uncertain. For example, each year the RFS has been revised downward from its original ambitiously increasing annual schedule that would have made high blends effectively mandatory to achieve compliance. Current RFS and California's LCFS seem to be back on track for mild progress, but a history of uncertainty will dissuade capital from investing in expanded use of high-blends of fuels.

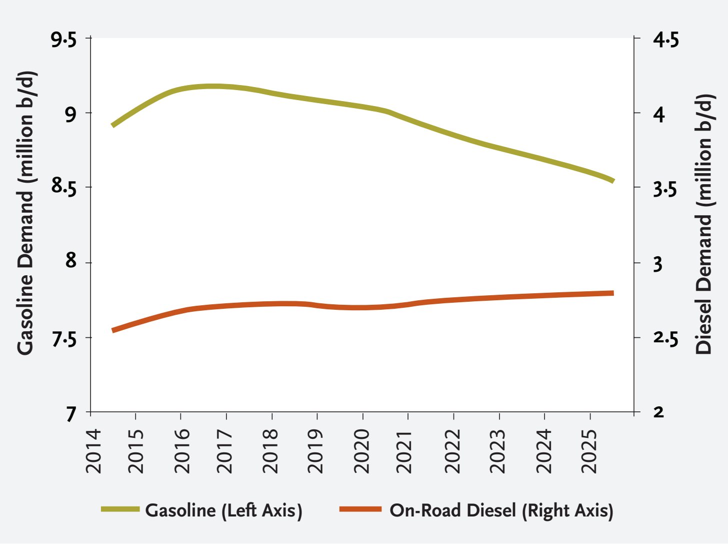
In order for certain ethanol blends (such as E15 and E30) or use of alternate oxygenates (such as butanol) to expand, there will need to be a change to the vapor pressure waiver for finished gasoline which is specific to ethanol blends between 9% and 10%. However, the RVP waiver was established by Congress in the Clean Air Act Amendments of 1990 and the EPA claims it does not have the authority to extend the waiver beyond 10% ethanol. It is unclear how or if this issue will be resolved.

10-Year Market Outlook

Stratas Advisors believes that U.S. demand for transportation fuels, particularly gasoline, is likely to see declines over the next 10 years. As the U.S. economy continues to grow at a slower structural rate combined with increases in fuel efficiency and the penetration of alternative vehicles, much of the short-term growth that has been seen over the past 24 months is not forecasted to be sustained. The decline is not expected to be substantial, dropping 0.6% per year for the next 10 years.

Stratas Advisors forecasts diesel demand to remain very weak over the next 3-5 years due to lagging industrial output. Increased trucking and shipping activity both directly and indirectly related to increases in U.S. domestic oil and gas production has been a strong driver of diesel growth. Low oil prices are expected to depress that demand center, and demand for diesel is not expected to see much growth until after 2020.

Figure 25
U.S. Transportation Fuel Outlook



(Source: Stratas Advisors, IEA, EIA)

U.S. Light Duty Vehicle Fleet

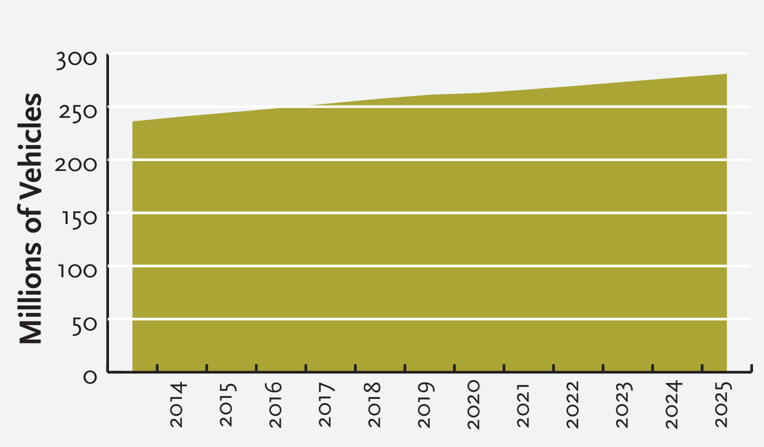
Despite short-term headwinds, Stratas Advisors is bullish on the long-term state of the U.S. economy and, by extension, the U.S. vehicle fleet. The U.S. light duty vehicle fleet is forecasted to increase from 240 million vehicles in 2015 to 280 million vehicles by 2025—a 35% increase, or 1.4% annually.

The market share of alternative fuel vehicles (AFVs) will continue to grow. As of 2014, conventional gasoline-fueled passenger cars were only 86.4% of the light duty vehicle market, and TDI diesel vehicles were approximately 2.8%. The other 10.8% of cars sold in 2014 were either FFVs, electric, hybrid, natural gas or fuel-cell powered. Over the next 20 years, we expect that the market share of alternative-fuel vehicles will rise slightly to 14.6%. The largest portion of this share will belong to gasoline-electric hybrid vehicles, followed by flex-fuel (capable of running on E85) vehicles. Other up-and-coming segments of the AFV market are PHEVs (plug-in hybrid electric vehicles) and BEVs (fully electric vehicles).

Several factors will limit the growth of specific alternative-fuel options. Since 2007, American automakers have been awarded CAFE credits for every FFV sold. However, beginning in model year 2017 and ending in 2020, these credits will be progressively phased out and replaced with credits that are only awarded for the amount of E85 actually consumed by those vehicles. This means that after 2020, no FFV credits will be earned and Stratas Advisors believes that automakers will start reducing FFV offerings as soon as 2016. This decrease in the number of flex-fuel vehicles manufactured and sold will lead to an eventual smaller share of the market for E85-capable cars. Due to these factors Stratas Advisors projects that the alternative fuels segment will account for approximately 9.8% of the passenger car LDV sales by 2019, with FFVs making up 4.3%.

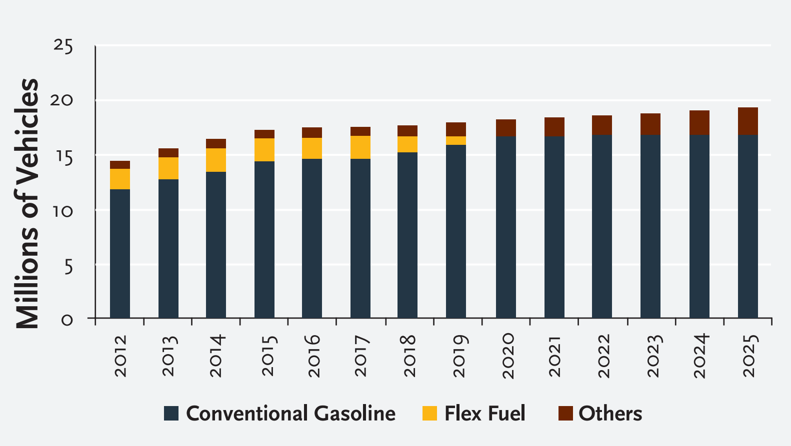
In addition, PHEVs and BEVs require improvements in battery technology through increased power-to-energy (P/E) ratio. This improvement could be spearheaded by the transition away from the older nickel-metal-hydrie (Ni-MH) battery packs to the more common and more energy dense lithium-ion (Li-ion) battery packs. Stratas Advisors uniquely foresees that one of the large key drivers for the electrification of vehicles will be with the adoption of lithium polymer (Li-pol) battery packs. These battery packs are unique from Li-ion batteries because while they offer the same energy density they have a polymer electrolyte, which means that the battery cell is not restricted to a cylindrical shape and can be used to make more efficient designs that will benefit automakers in price, range, and vehicle dynamics.

Figure 26
U.S. Light Duty Vehicle Fleet Size



(Sources: U.S. Department of Transportation, Stratas Advisors)

Figure 27
Light Duty Vehicle Sales by Fuel Type



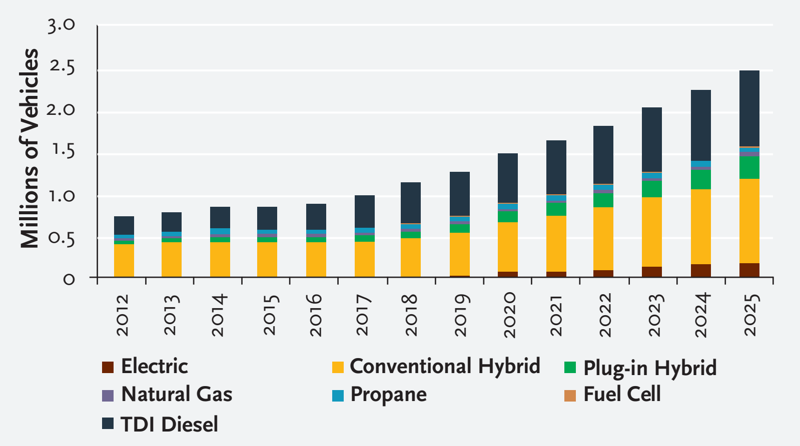
(Sources: U.S. Department of Transportation, Stratas Advisors)

Despite these forecasted technological advances, current electric vehicles face a number of challenges. At the moment they are too expensive for widespread adoption, with a limited charging infrastructure coupled with "range anxiety" —concerns over running out of power without access to a recharging station. According to the Alternative Fuels Data Center (AFDC), there are approximately 14,600 recharging stations in the United States. Similarly, for hydrogen fuel-cell vehicles (HFCVs) to really catch on, the hydrogen refueling infrastructure must grow substantially. According to the AFDC, the nation only has 12 hydrogen refueling stations, 10 of which are in California.

Finally, while compressed natural gas (CNG) vehicles are very popular in other parts of the world such as Argentina, where both vehicle conversion technology and natural gas are cheap, they haven't caught on in the U.S. because there is a lack of CNG refilling stations—and the conversion process is relatively expensive.

Generally, for the next 20 years, we expect that gasoline internal combustion engines will maintain a huge majority of the light duty vehicle market with a shift toward the electric hybrid variant. Both the "clean diesel" and alternative fuel markets will grow, but technological barriers as described above will only provide step increases in the uptake of new types of power in the future. Overall, as gasoline internal combustion engines improve in efficiency and fuel economy, the large majority of light- and heavy-duty vehicles drivers will continue to buy relatively standard liquid fuels for their relatively inexpensive internal combustion and diesel engines.

Figure 28
Alternative Light Duty Vehicle Sales by Type



(Sources: U.S. Department of Transportation, Stratas Advisors)

About the Author

Stratas Advisors, a Hart Energy company, is a global consulting and advisory firm that covers the full spectrum of the energy sector and related industries. We can help you develop a deeper understanding of the developments that are shaping the future of oil & gas. Our support includes customized consulting that is focused on a client's specific strategic objectives, competitive challenges and asset base. Additionally, we offer support through subscription services and comprehensive market studies.

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About the Fuels Institute

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. Our 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 www.fuelsinstitute.org.

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