2024 Bioenergy Industry Status Report

Kristi Moriarty, Kelcie Kraft, Arpit Bhatt, Ling Tao, Tom McCarran, and Anelia Milbrandt

National Laboratory of the Rockies

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April 2026

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List of Acronyms

ASTM	ASTM International
B5	5% biodiesel, 95% petroleum diesel blend
B20	20% biodiesel, 80% petroleum diesel blend
B100	pure biodiesel
DOE	U.S. Department of Energy
E10	10% ethanol, 90% gasoline blend
E15	10.5%–15% ethanol and gasoline blend (approved for use in model year 2001 and newer vehicles)
E85	high-ethanol blend between 51% and 83% ethanol, depending on season and geography
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
HEFA	hydroprocessed esters and fatty acids
RFA	Renewable Fuels Association
RFS	Renewable Fuel Standard
RIN	Renewable Identification Number
RNG	renewable natural gas
SAF	sustainable aviation fuel
TBtu	trillion British thermal units
USDA	U.S. Department of Agriculture

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Executive Summary

The *2024 Bioenergy Industry Status Report* compiles and integrates information to provide a snapshot of the current state and historical trends influencing the development of domestic bioenergy markets as of the end of 2024. The information is intended for technology developers, policymakers, and other bioenergy stakeholders interested in bioenergy industry development. The bioenergy economy engages multiple industrial sectors across the biomass-to-bioenergy supply chain—from agricultural- and forestry-based industries that produce biomass materials to manufacturers and distributors of biomass-based fuels, products, and power, to the ultimate end-user markets. It also highlights some of the key energy and regulatory drivers that have impacted the bioenergy industry as it develops. The breadth of this report focuses on activities that occur after the production of biomass.

At the end of 2024, U.S. bioenergy consumption (shown in Figure ES-1) was led by ethanol, which accounts for 55% of total U.S. bioenergy production. The other leading contributors were renewable diesel (22%), biodiesel (11%), and biopower (7%). Other advanced biofuels contributed a small but increasing amount (more than 4%). Compared with 2015, the relative market share for ethanol and biopower declined, while biodiesel, renewable diesel, and other advanced biofuels increased.

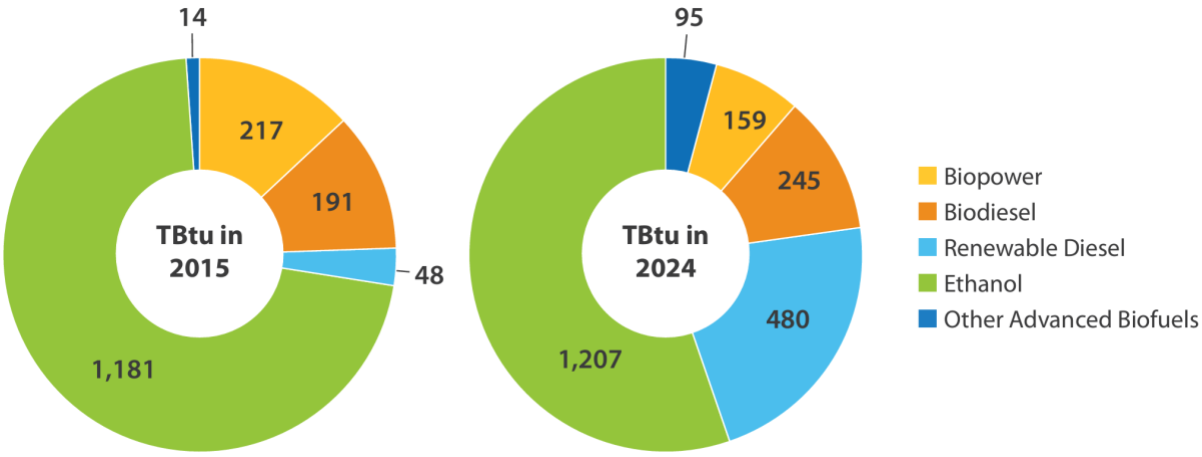

Figure ES-1. U.S. bioenergy market (1,651 trillion British thermal units [TBtu] total in 2015 and 2,186 TBtu total in 2024).

1 TBtu = 0.001 quads.

Sources: Ethanol, biodiesel, and renewable diesel: U.S. Energy Information Administration (EIA) (2025j, 2025k, 2025l); biopower: EIA (2025e); other advanced biofuels: U.S. Environmental Protection Agency (EPA) (2025e). Advanced biofuels include heating oil, jet fuel, naphtha, renewable gasoline, renewable natural gas (RNG), and renewable propane (detailed fuel volume data are available in Appendix A). This figure only includes the volume and electricity produced, not the associated coproducts.

Figure ES-2 shows the development of the biofuels industry from 2015 through 2024. Renewable diesel, a drop-in fuel, experienced tremendous growth in capacity and consumption in recent years due to the conversion of existing refineries. Biodiesel's contribution has largely remained at a similar level, with a slight decrease in recent years that is likely a result of the growing renewable diesel market. Ethanol remains the top contributor to the bioeconomy. Other

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advanced biofuels continue to increase market share, with RNG representing 70% of this category.

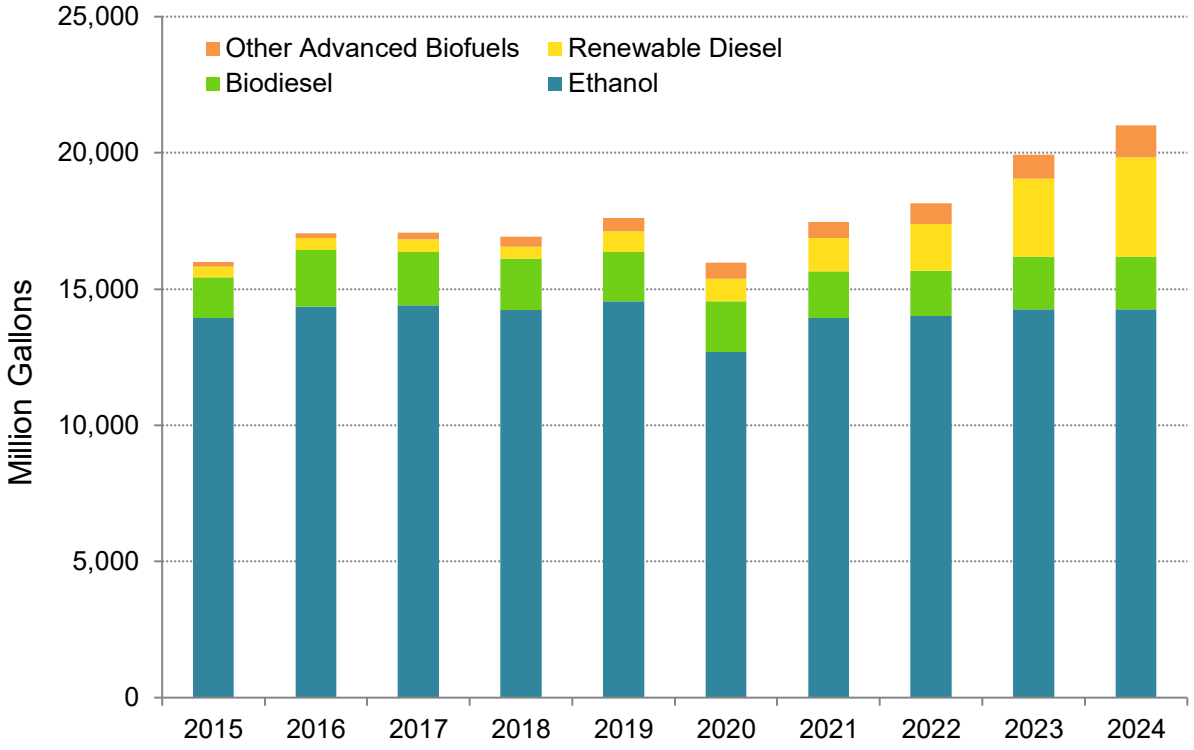

Figure ES-2. U.S. biofuel consumption.

Sources: Ethanol, biodiesel, and renewable diesel: EIA (2025j, 2025k, 2025l); other advanced biofuels: EPA (2025d). Data for advanced biofuels were obtained from the EPA's public Renewable Fuel Standard data and were based on volume. Other advanced biofuels include biogas, butanol cellulosic diesel, cellulosic gasoline, cellulosic heating oil, naphtha, renewable heating oil, RNG, and sustainable aviation fuel (SAF; also referred to as synthetic aviation fuel). This dataset includes small volumes of imported advanced biofuels.

Economic and job impacts from the bioeconomy are considerable. Industry organizations that fund studies use economic input-output models to estimate economic and job impacts. The Renewable Fuels Association (RFA) funds an annual study of ethanol's impact on the economy. The study found the 2024 impacts to gross domestic product, household income, and taxes were $53 billion, $28 billion, and $10 billion, respectively (RFA 2025c). Ethanol's direct and induced jobs were more than 56,000 and 258,000, respectively. A study based on 2024 biodiesel, renewable diesel, and SAF markets found an economic impact of $42 billion and support of 107,400 jobs and $5.8 billion in wages paid (GlobalData 2025). RNG's contribution included an estimated 55,000 jobs and $7 billion to gross domestic product. The average wage was $66,890, and 75% of jobs did not require a college degree (Guidehouse 2024).

SAF, made from non-petroleum feedstocks, is a drop-in fuel that reduces emissions from air transportation. SAF can be blended at different levels with limits of 10% to 50%, depending on the feedstock and how the fuel is produced.. At the time this report was prepared, there were five commercial domestic producers and one international producer supplying the U.S. market. 2024 consumption was 112 million gallons, a substantial increase from 1.8 million gallons in 2018 (EPA 2025d). While this report focuses on 2024 data, the increased domestic SAF production

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has led to 2025 consumption of 147 million gallons as of August 2025. This represents a small fraction of the domestic 2024 jet fuel consumption of 26 billion gallons (EIA 2025m).

Renewable diesel meets the same ASTM D975 fuel quality specification as petroleum diesel. It is a drop-in fully fungible replacement for diesel and can be used in existing infrastructure and engines. Consumption grew from 370 million gallons in 2015 to nearly 3.7 billion gallons in 2024 (EIA 2025l). Between 2022 and 2024, domestic production has grown significantly, largely driven by the conversion of existing refineries. As of January 2025, there are 19 plants with 4.7 billion gallons of capacity (EIA 2025s). More plants are expected in the near term.

Biodiesel production and consumption have been stable over the past decade, peaking in 2018 and minimally declining between 2020 and 2024. In 2024, production and consumption were about 1.7 and 1.9 billion gallons, respectively (EIA 2025k). The number of plants has been declining since 2018, and there are currently 48 plants with just under 2 billion gallons of capacity (EIA 2025o). Blends up to B5 (5% biodiesel, 95% petroleum diesel) are considered diesel fuel per ASTM D975. B20 (6%−20% biodiesel) that meets ASTM D7467 is approved for use in various vehicles and engines. Biodiesel is also used for off-road applications such as home heating oil.

Renewable diesel combined with biodiesel consumption represented 9.6% of the 58-billion-gallon-per-year diesel market (EIA 2025k, 2025l, 2025m). The West Coast consumes the majority of renewable diesel due to financial incentives from state low-carbon fuel standards (EIA 2025b). Consumption of renewable diesel has been higher than biodiesel since 2022 (EIA 2025k, 2025l).

Currently, biodiesel, renewable diesel, and SAF use the hydroprocessed esters and fatty acids pathway and same feedstocks, which include waste fats, oils, and greases and vegetable oils. There is considerable competition for these feedstocks as new plants come online, particularly the large renewable diesel plants. There is also competition from other industries who use these feedstocks. SAF research is focused on commercializing technology pathways that use other feedstocks.

Ethanol serves as a substitute for gasoline and as an octane enhancer. Nearly all commercial ethanol biofuel is produced from corn. Production and consumption in 2024 were nearly 16.2 and 14.3 billion gallons, respectively (EIA 2025j). The U.S. has been a net exporter of ethanol for 15 years and 2024 exports were valued at $4.2 billion (RFA 2025b). As of January 2025, there were 191 plants with 18.5 billion gallons of capacity. Half of the capacity is in Iowa, Nebraska, and Illinois (EIA 2025q). For years, the United States has effectively been at a blend wall—where the entire gasoline market is blended with E10 (10% ethanol, 90% gasoline). As of 2024, the blend rate of ethanol into gasoline was 10.4% (RFA 2025b). Opportunities for growth include increasing the number of stations with E15 because 97% of light-duty gasoline vehicles

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are model year 2001 or newer and approved for its use through consumption of E85 in flexible-fuel vehicles.[1,2] E85 used in flexible-fuel vehicles also contributes to the blend rate.

RNG is a pipeline-quality gas made from biomass waste feedstocks that is interchangeable with natural gas. It provides a secondary source of income to waste generators. It can be used in natural gas vehicles in compressed or liquefied form. RNG qualifies as a cellulosic biofuel under the Renewable Fuel Standard and is currently the main contributor to this fuel category. In 2024, the EPA reported consumption of 973 million ethanol gallon equivalents, or roughly 73.6 TBtu of compressed and liquefied RNG (EPA 2025d). At the end of 2024, there were nearly 500 operational RNG facilities located at landfills, wastewater treatment plans, and agriculture facilities (Guidehouse 2024). An analysis study of future RNG potential estimated 1,628 TBtu utilizing 10% of available biomass resources and up to 3,728 TBtu utilizing 23% of available biomass resources (American Gas Foundation 2025).

Biomass electricity generation (biopower) accounts for nearly 5.2% of all utility-scale renewable energy generated in the United States and about 1.1% of total U.S. electricity generation (EIA 2025e, 2025d). Both installed biopower capacity and generation have been declining since 2017. In 2024, the top five states with the largest biopower generation were Virginia, California, Florida, Georgia, and Alabama (EIA 2025g). Most of the biopower is generated from woody biomass, including byproducts (e.g., black liquor), solids (e.g., railroad ties and utility poles), and residues, such as those from pulp and paper mills or sawmills (EIA 2025g).

Biochemicals and bioproducts are two broad categories used to classify products produced from biomass feedstocks. Conventional bioproducts, including building material, pulp and paper, and forest products, have long been available, whereas emerging bioproducts with a focus on R&D include chemicals, plastics, and adhesives. Many biochemical and bioproduct manufacturers currently treat their production and pricing information as confidential because they pursue competitive advantages within this emerging market sector. However, wood pellets are a well-established competitive market, and EIA reports plant, pricing, and export data (EIA 2025i). This report considers four types of bioproducts: (1) wood pellets; (2) platform and intermediate chemicals (emerging bioproducts), as well as conventional bioproducts; (3) lignin; and (4) biochar. A 2023 USDA report evaluated multiple biobased products including agriculture and forestry, biorefining, bio-based chemicals, enzymes, bioplastic bottles and packaging, forest products, and textiles as the seven major bio-based product industries contributing to the U.S. economy. It specifically excluded contributions to the economy from energy, livestock, food, feed, and pharmaceuticals. The USDA report stated that bio-based products accounted for 3.9 million jobs and a $489 billion contribution to the economy (Golden et al. 2024).

[1] E15 is a blend of 10.5%–15% ethanol and gasoline; E85 is an ethanol-gasoline blend containing 51%–83% ethanol, depending on geography and season.
[2] The National Laboratory of the Rockies purchases vehicle registration data from Experian and compared the total number of vehicles versus model year 2001 and newer: www.experian.com/automotive/auto-vehicle-data.

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1 Biomass to Bioenergy Overview

Bioenergy—fuel, heat, and power derived from biomass sources—is an evolving market that produces and supplies renewable alternatives to fossil fuel sources. This report covers the following:

- Biodiesel: An alternative to diesel that is typically produced from lipids (vegetable oils and fats, oils, and greases).
- Ethanol: Typically produced from corn starch and less often from cellulosic feedstocks.
- Renewable diesel: A drop-in replacement for diesel currently produced from lipids.
- Renewable natural gas (RNG): Pipeline-quality gas, derived from renewable organic sources, that is interchangeable with conventional natural gas.
- Sustainable aviation fuel (SAF): A drop-in replacement for jet fuel currently produced from lipids; alcohols are expected as a feedstock soon.
- Marine biofuels: Both drop-in and other replacement fuels produced from various renewable sources.
- Biopower: Generation of electricity from biomass sources such as wood wastes, municipal solid waste, landfill gas, and other biomass.
- Biochemicals and bioproducts: Production of platform and intermediate biochemicals, lignin, biochar, and wood pellets.

The production, distribution, and use of bioenergy involve activities across a broad supply chain. These activities include the production of raw biomass in fields or forests; harvest, collection, storage, and transportation of these materials; and preprocessing of the raw biomass materials—sizing, drying, or other mechanical, thermal, or chemical treatment—to produce a feedstock that can be fed into biorefinery conversion processes or biopower-generating facilities. Distribution and use include delivering the bioenergy to market as well as the technical capability for the end use of these products. While the bioenergy market is global and well established in other parts of the world, only the U.S. market was investigated and documented for this report.

In 2024, U.S. bioenergy production was about 2,186 trillion British thermal units (TBtu)[3] from ethanol, biodiesel, renewable diesel, advanced biofuels, and biopower (U.S. Energy Information Administration [EIA] 2025j, 2025k, 2025l, 2025e; U.S. Environmental Protection Agency [EPA] 2023a). U.S. bioenergy consumption (Figure 1) was led by ethanol, which accounts for 55% of total U.S. bioenergy production. The other leading contributors were renewable diesel (22%), biodiesel (11%), and biopower (7%). Other advanced biofuels contributed a small but increasing amount (more than 4%). Compared with 2015, the relative market share for ethanol and biopower declined, while biodiesel, renewable diesel, and other advanced biofuels increased.

[3] One TBtu is equivalent to 0.001 quads.

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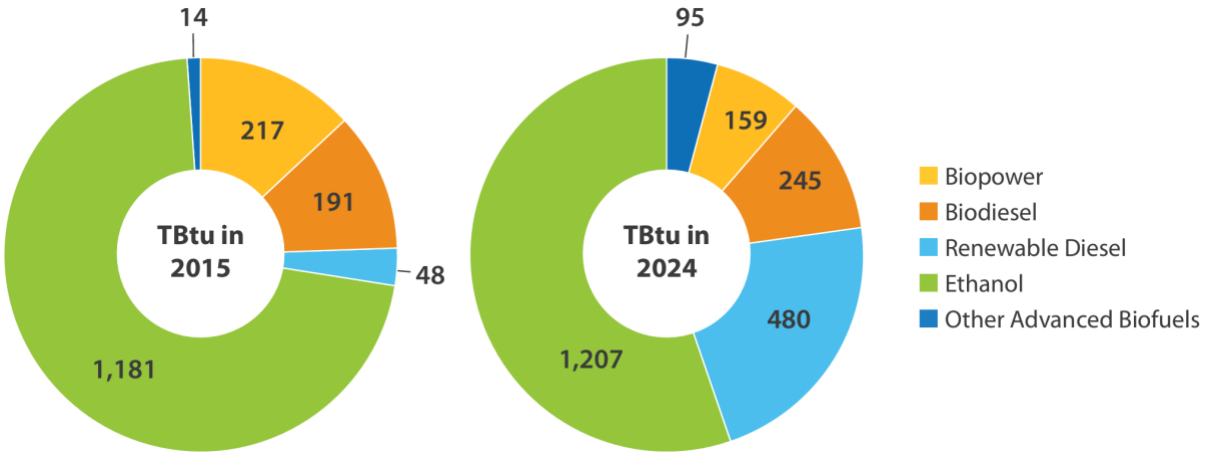

Figure 1. U.S. bioenergy market (1,651 TBtu total in 2015 and 2,186 TBtu total in 2024).

Sources: Ethanol, biodiesel, and renewable diesel: EIA (2025j, 2025k, 2025l); biopower: EIA (2025e); other advanced biofuels: EPA (2025d). Advanced biofuels include heating oil, jet fuel, naphtha, renewable gasoline, RNG, and renewable propane (detailed fuel volume data are available in Appendix A). This figure only includes the volume and electricity produced, not the associated coproducts.

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2 Biofuels

Figure 2 shows the development of the biofuels industry from 2015 through 2024. Over the past decade, ethanol has represented the largest share of the biofuels market. Renewable diesel, a drop-in fuel, experienced tremendous growth in capacity and consumption in recent years due to the conversion of existing refineries. Biodiesel's contribution has largely remained at a similar level, with a slight decrease in recent years, likely due to the growth of the renewable diesel market and demand for feedstock. Ethanol remains the top contributor to the bioeconomy. Other advanced biofuels continue to increase market share, with RNG dominating this category.

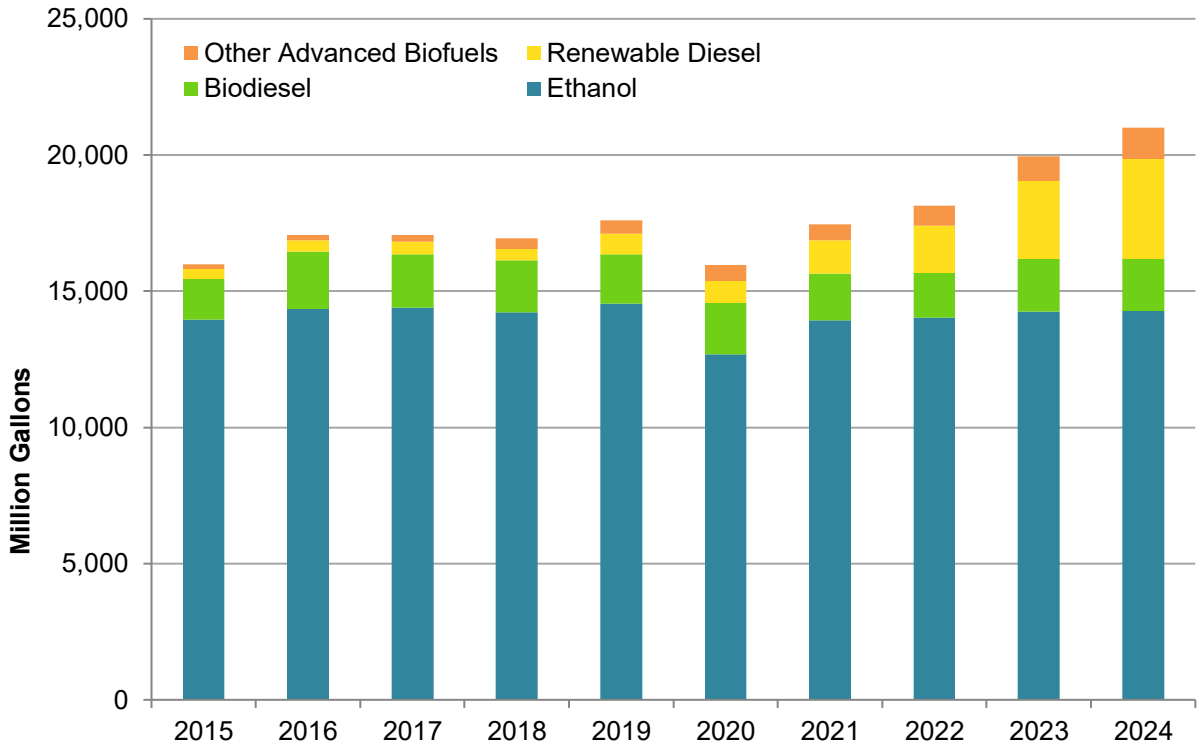

Figure 2. U.S. biofuel consumption.

Sources: Ethanol, biodiesel, and renewable diesel: EIA (2025j, 2025k, 2025l); other advanced biofuels: EPA (2025d). Data for advanced biofuels were obtained from the EPA's public Renewable Fuel Standard (RFS) data and were based on volume. Other advanced biofuels include biogas, butanol cellulosic diesel, cellulosic gasoline, cellulosic heating oil, naphtha, renewable heating oil, RNG, and renewable jet fuel (EPA's term for SAF). This dataset includes small volumes of imported advanced biofuels.

The following sections cover multiple biofuel topics, including policies that impact the market, feedstocks, and detailed sections on SAF, renewable diesel, biodiesel, ethanol, and RNG.

2.1 Biofuels Industry Drivers

The following is a summary of significant factors impacting biofuels markets. Ethanol is an important component of the gasoline market, as 98% of gasoline is blended with 10% ethanol (Alternative Fuels Data Center 2025b). The majority of the gasoline component shipped from refineries is 84 sub-octane fuel, and blending it with ethanol brings it to 87 octane fuel of regular gasoline.

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A primary market driver for U.S. biofuels production and consumption is the Renewable Fuel Standard. The RFS originated with the Energy Policy Act of 2005 and expanded under the Energy Independence and Security Act of 2007 (U.S. Congress 2007). The RFS established biofuels volumes increasing annually and provided the EPA with the authority to adjust required volumes based on availability. While the legislated volumes were through 2022, the EPA is responsible for establishing volume standards for each year. The RFS program assigns obligated parties (fuel refiners and importers) a renewable volume obligation each company is required to blend based on a percentage of the company's total fuel sales.

EPA manages and tracks the RFS through Renewable Identification Numbers (RINs). There are four overall RFS categories: (1) renewable fuel, which is largely satisfied by conventional corn grain ethanol; (2) advanced biofuel; (3) biomass-based diesel; and (4) cellulosic biofuel (EPA 2026a).[4] Figure 3 illustrates how these RIN designations are nested in a way that allows fuels to meet more than one RFS category. RINs are generated when designated biofuels are imported or produced and conveyed with the volumetric sale of those biofuels until blended with petroleum products or sold to an obligated party. RINs may also be sold or saved for meeting renewable volume obligation requirements in the next compliance year. Table A-1 details 2024 RIN generation (EPA 2025d).

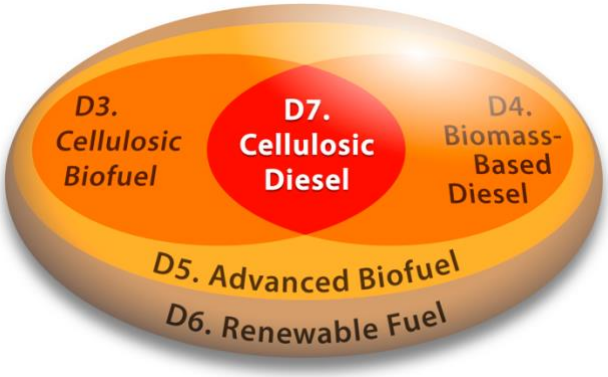

Figure 3. Nesting of biofuel categories under the RFS.

Cellulosic biofuel (D3) and biomass-based diesel (D4) are both nested within advanced biofuel (D5), which is nested within renewable fuel (D6). Diagram not to scale.

Figure 4 compares the volumes required each year and the RINs generated. Energy Independence and Security Act volumes were reduced annually due to the lack of available cellulosic biofuels. Obligated parties have exceeded the required volumes the past 6 years.

[4] Details of approved pathways and associated RINs are available from the EPA: www.epa.gov/renewable-fuel-standard-program/approved-pathways-renewable-fuel.

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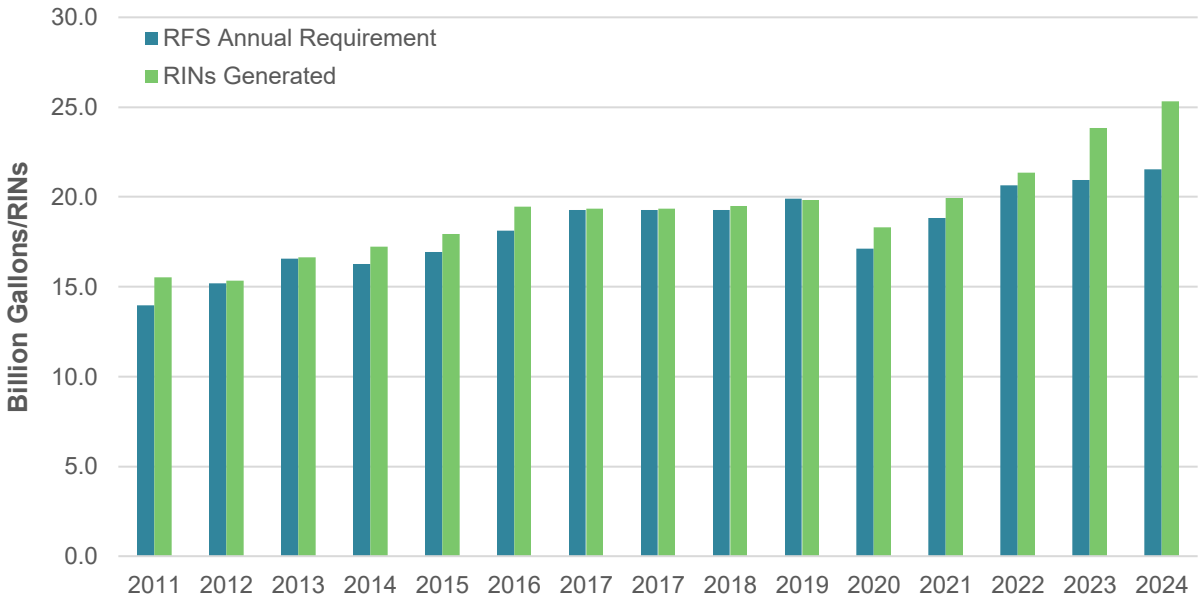

Figure 4. RFS comparison of Energy Independence and Security Act renewable volume obligation and RIN volumes.

Source: EPA (2025e, 2025f)

The 2022 Inflation Reduction Act created the 45Z credit to encourage domestic biofuels production. The 2025 credit available to American-controlled biofuels producers was $1.75/gal for SAF and $1.00/gal for other biofuels meeting various criteria. 45Z was amended in the 2025 One Big Beautiful Bill Act providing clarification on allowable feedstocks from the United States, Canada, and Mexico, and the credit is up to $1.00 for biofuels meeting criteria for biofuels produced between Jan. 1, 2026, through Dec. 31, 2029.

There are several other programs that enable biofuels, including loan guarantee programs from both the U.S. Department of Energy (DOE) and U.S. Department of Agriculture (USDA). The Alternative Fuel Infrastructure Tax Credit provides a tax credit of 30% of infrastructure costs or 6% of property subject to deprecation up to $100,000 expiring Dec. 31, 2032. (IRS 2023). In recent years, USDA has provided grants to gas station and terminals owners to extend the availability of ethanol and biodiesel under the Higher Blends Infrastructure Incentive Program (USDA 2025).

2.2 Feedstocks

In 2024, 98% of domestic ethanol production was from corn grain, 1% from cellulosic biomass, 1% from sorghum and wheat, and less than 1% from waste sugars (RFA 2024). The 1% cellulosic biomass is derived entirely from bolt-on technology at existing conventional ethanol plants that extracts the nonedible corn kernel fiber, which is designated as a cellulosic feedstock under the RFS. In 2024, 36% of U.S. corn production was used to produce ethanol (USDA Economic Research Service 2025).

Currently, biodiesel, renewable diesel, and SAF (via the hydroprocessed esters and fatty acids [HEFA] pathway) utilize the same feedstocks, which include waste fats, oils, and greases and vegetable oils. There is considerable competition for these feedstocks as new plants come online,

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particularly the large renewable diesel plants. There is also competition from other industries who use these feedstocks. SAF research is focused on commercializing technology pathways that use other feedstocks. There is near-term potential to use ethanol as a feedstock for SAF via the alcohol-to-jet pathway.

Figure 5 and Figure 6 show the inputs to domestic biodiesel, renewable diesel, and SAF production in 2024. The breakout for soybean oil use shows that biodiesel uses more than renewable diesel (Table 1). The breakout of biodiesel and renewable diesel by vegetable oil type is available in Table 1.

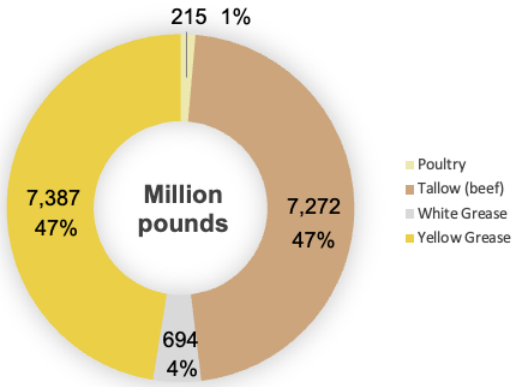

Figure 5. U.S. biofuel use of waste fats, oils, and greases.

Source: EIA (2025h)

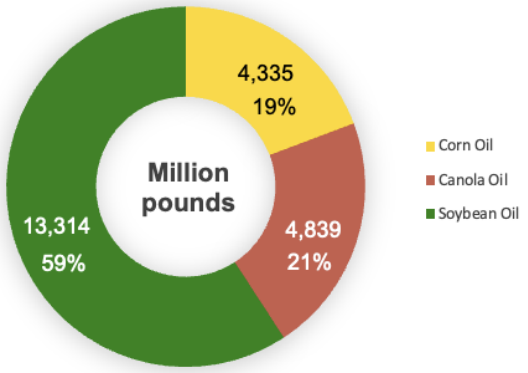

Figure 6. U.S. biofuel use of vegetable oil feedstocks.

Source: EIA (2025h)

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Table 1. U.S. Biodiesel and Renewable Diesel Use of Vegetable Oils.

Source: EIA (2025h)

Feedstock	Biodiesel	Renewable Diesel
	% of vegetable oil used	
Corn oil	21%	79%
Canola oil	36%	64%
Soybean oil	55%	45%

RNG is produced from anaerobic digestion of wastes from landfills, wastewater facilities, livestock/agriculture facilities, and food wastes; 589 landfills capture and produce 521 billion cubic feet annually, and 40% is used for RNG. The EPA identified an additional 741 landfills that could produce biogas (American Biogas Council 2025). Feedstocks used to produce RNG in 2022 included landfilled organic matter (~72%), livestock/agricultural waste (~20%), food wastes (5%), and wastewater sludge (3%) (EPA 2023a). There is considerable opportunity for increased use of available feedstocks. For example, only 10% of collected landfill biogas is used for RNG production, while 53% is flared to reduce methane emissions, 28% is used for electricity generation, and 8% is used in direct heating applications (EPA 2023a). It is estimated that biogas recovery systems are technically feasible for more than 8,000 livestock manure locations, but only 400 systems were operational as of June 2024 in the United States (EPA 2025a).

Figure 7 highlights biomass feedstocks used to produce electricity. Most U.S. biopower is generated from woody biomass—including byproducts (e.g., black liquor) and solids, such as low-quality wood (e.g., railroad ties and utility poles) and residues—in dedicated or cogeneration plants, such as pulp and paper mills or sawmills (EIA 2025i). Biogas, produced from landfills, wastewater, manure, and other organic wastes, is used to generate electricity for on-site use or sold to the grid. In 2024, solid wood and wood waste and black liquor accounted for 68% of total biomass power generation, landfill gas was 16%, and the organic portion of municipal solid waste was 12% (EIA 2025i).

DOE's Alternative Fuels and Feedstocks Office funds the *Billion-Ton Report*—a comprehensive feedstock analysis report of potential biomass feedstock resources in the United States inclusive of price, quantity, geographic location and distribution, and market maturity. The updated 2023 version was released in March 2024 (DOE 2024a).

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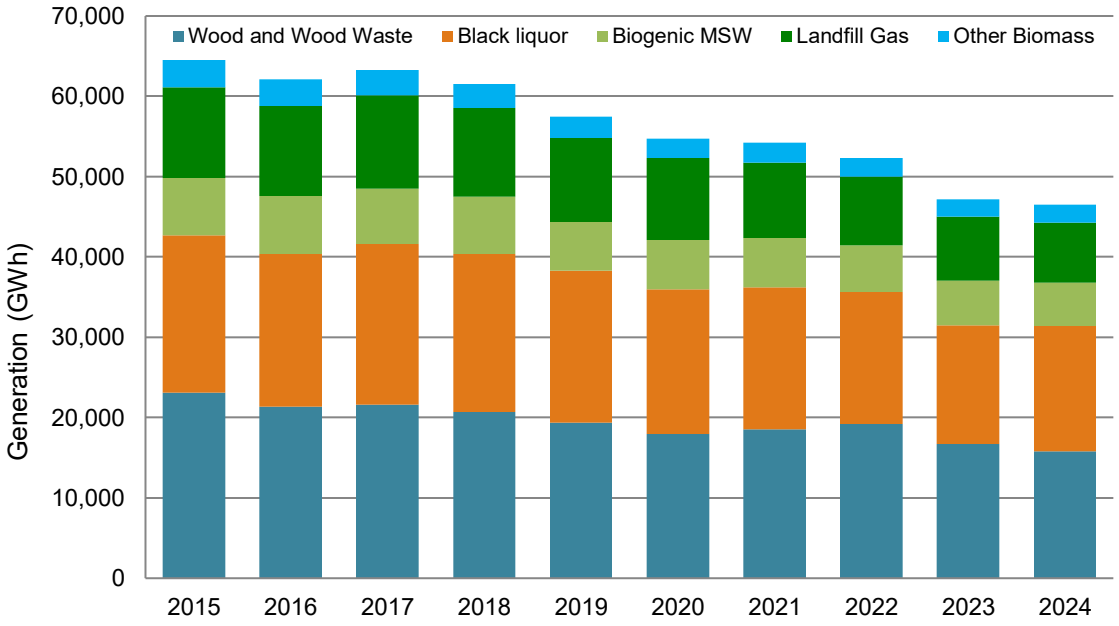

Figure 7. U.S. biopower generation sources.

GWh: gigawatt-hour; MSW: municipal solid waste.

Source: EIA (2025g). Other biomass includes other biomass solids, other biomass gases, agricultural crop residues, sludge waste, wood-waste liquids, and other biomass liquids.

2.3 Economic Impacts and Jobs

The economic impacts for ethanol, biodiesel, renewable diesel, SAF, and RNG are available from their respective industry organizations. These studies use IMPLAN—an economic input-output model—to estimate gross value added (total value of the goods and services produced by businesses), income, and employment resulting from the various types of alternative fuels produced annually. The following summarizes information provided by the Renewable Fuels Association (RFA), Clean Fuels Association of America, and Renewable Natural Gas Coalition:

- The ethanol industry's 2024 contribution to the economy was $53 billion to gross domestic product, $28.3 billion in household income, and $10.3 billion in taxes (RFA 2025c). In 2024 it supported 55,810 direct jobs and 258,089 indirect/induced jobs, two-thirds of which were agriculture based.
- The 2024 economic impact for biodiesel, renewable diesel, and SAF production was $42 billion in economic activity, supporting 107,400 jobs and $5.8 billion in wages paid (GlobalData 2025).
- RNG's contribution includes an estimated 55,000 jobs and $7 billion to gross domestic product. The average wage was $66,890, and 75% of jobs did not require a college degree (Guidehouse 2024).

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DOE's *United States Energy & Employment Report 2024* provides statistical data on biofuels employment (DOE 2024c). Table 2 shows the demographic data for corn ethanol, other biofuels, woody biomass/cellulosic biofuels, the overall energy workforce, and the national workforce.[5]

Table 2. Biofuels Job Demographics Comparison.

Data source: DOE (2024c)

Demographic	Corn Ethanol	Other Biofuels	Woody Biomass and Cellulosic Biofuels	Energy Workforce	National Workforce
# of jobs	36,100	41,900	33,800	8,500,000	157,407,407
Percentage of Workforce					
Male	68%	66%	68%	73%	53%
Female	31%	33%	31%	26%	47%
Veterans	16%	13%	14%	9%	5%
18 to 29	28%	30%	29%	29%	22%
30 to 54	48%	54%	48%	52%	54%
55 and over	24%	16%	22%	19%	24%

2.4 Sustainable Aviation Fuel

SAF is a domestically produced drop-in replacement fuel produced from renewable and waste feedstocks that can be used in existing aircraft, engines, and associated infrastructure. SAF provides a near-term solution to reducing aviation emissions, which represented 9% of U.S. transportation emissions in 2022 (EPA 2025b). SAF is a commercial fuel that has been in use since 2016.

The SAF Grand Challenge is a joint initiative of DOE, the U.S. Department of Transportation, and USDA that seeks to expand U.S. production and reduce costs. The near-term goal is to increase SAF production to 3 billion gallons per year by 2030, and the long-term goal is 100% SAF at 35 billion gallons by 2050 (DOE n.d.). R&D is heavily focused on improving technology pathway efficiency to reduce costs and increase production.

ASTM D7566, *Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons*, dictates fuel quality standards for non-petroleum-based jet fuel and outlines approved SAF-based fuel production pathways and the percentage allowable in a blend with Jet A. There are currently eight synthetic paraffinic kerosene, synthetic kerosene with aromatics, and other approved pathways (Table 3). ASTM D1655, *Standard Specification for Aviation Turbine Fuels*, allows coprocessing of non-petroleum feedstocks at petroleum refineries at a rate of up to 5% and up to 10% for HEFA biointermediates. Blending limits are shown in Table 3. Research is underway to enable pathways that allow 100% SAF.

[5] The report defines "other biofuels" as fuels made from non-woody biomass, biodiesel, renewable diesel, waste fuels, and ethanol not produced from corn.

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Table 3. ASTM-Approved SAF Production Pathways.

Sources: ASTM D7566 and ASTM D1655

Pathway	Acronym	Blending Limit	Example Feedstocks
ASTM D7566			
Annex 1: Fischer-Tropsch Synthesized Paraffinic Kerosene	FT-SPK	50%	Municipal solid waste, agricultural and forest wastes, energy crops
Annex 2: Hydroprocessed Esters and Fatty Acids Synthesized Paraffinic Kerosene	HEFA-SPK	50%	Fats, oils, and greases
Annex 3: Hydroprocessed Fermented Sugars Synthesized Isoparaffins	HFS-SIP	10%	Sugars
Annex 4: Fischer-Tropsch Synthesized Kerosene With Aromatics	FT-SKA	50%	Municipal solid waste, agricultural and forest wastes, energy crops
Annex 5: Alcohol-to-Jet Synthesized Paraffinic Kerosene	ATJ-SPK	50%	C_2–C_5 alcohols
Annex 6: Catalytic Hydrothermolysis Jet Synthesized Kerosene Esters and Fatty Acids	CHG	50%	Fatty acids, fatty acid esters, or lipids from fats, oils, and greases
Annex 7: Hydroprocessed Hydrocarbons and HEFA Synthesized Kerosene	HC-HEFA SPK	10%	Algae
Annex 8: Alcohol-to-Jet Synthetic Paraffinic Kerosene With Aromatics	ATJ-SKA	10%	C_2–C_5 alcohols
ASTM 1655			
Annex 1: Co-Hydroprocessing HEFA With Petroleum	HEFA	5%	Fats, oils, and greases
Annex 1: Co-Hydroprocessing Fischer-Tropsch Hydrocarbons With Petroleum	FT-SPK	5%	Municipal solid waste, agriculture and forest wastes, energy crops
Annex 1: Co-Processing of HEFA	HEFA	10%	HEFA

Airlines are committed to purchasing SAF and have entered into numerous offtake agreements with existing and future producers. The International Civil Aviation Organization (2025) maintains a list of current offtake agreements that highlights the potential size of the market and committed airlines. General aviation also enters into offtake agreements.

2.4.1 Consumption, Plants, and Capacity

EIA does not publish SAF data; therefore, the best approximation of SAF volumes is derived from EPA's RIN data. As evidenced in Figure 8, SAF production increases each year. This trend is expected to continue with new domestic plants starting up in late 2024 and spring 2025. Figure 9 shows the high variability of monthly SAF RIN generation, which may represent market dynamics of plants producing both SAF and renewable diesel and potentially competition for

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foreign SAF in the United States (Neste 2022). Figure 9 extends into 2025 to highlight a significant shift to consumption of domestically produced SAF.

Despite increased production, SAF represents a tiny fraction of the overall U.S. jet fuel market of 26 billion gallons in 2024 (EIA 2025m). In 2024, the United States accounted for 26% of the world's overall jet fuel use (EIA 2025a).

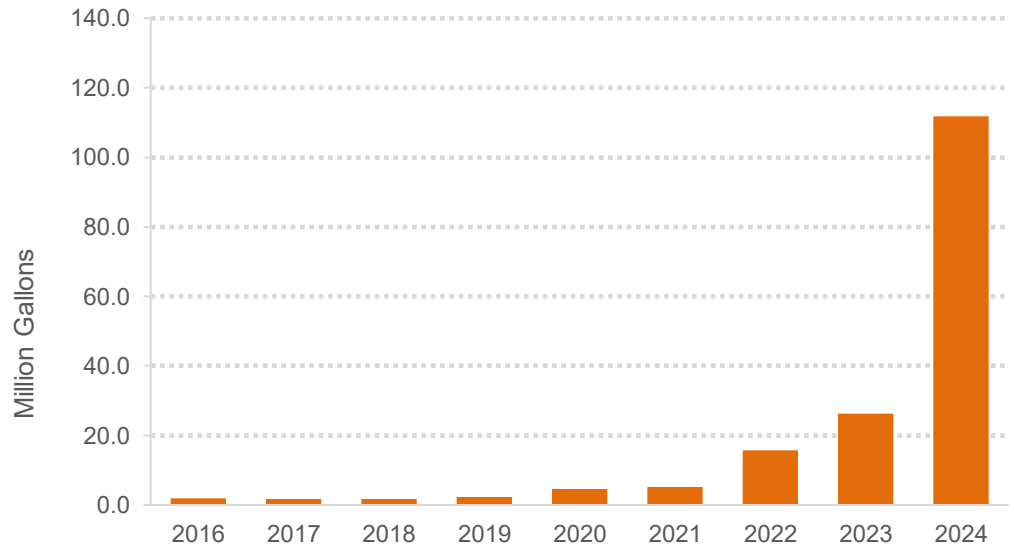

Figure 8. U.S. estimated annual SAF volumes.

Source: EPA (2025d)

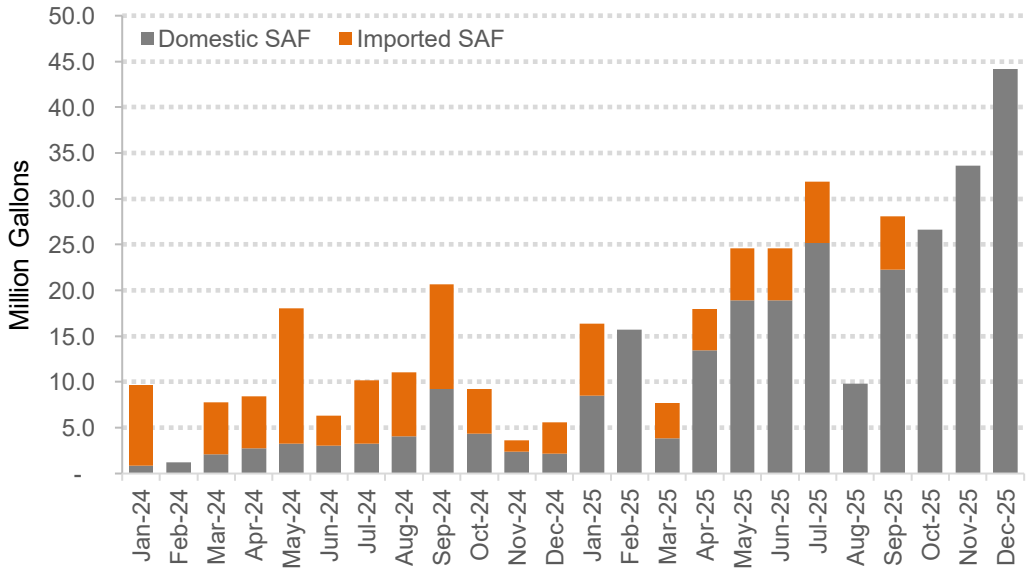

Figure 9. U.S. estimated monthly SAF volumes.

Domestic RINs were SAF produced in the United States; foreign RINs represent imported SAF.

Source: EPA (2025d)

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SAF has been commercially available since 2016, with substantial new production capacity coming online in late 2024 and early 2025 (Table 4). In 2024, there were five domestic commercial plants and one international producer supplying the U.S. market. Three of the plants are conversions of refineries—World Energy, Montana Renewables, and Phillips 66—while Diamond Green Diesel and New Rise Renewables are new plants. Neste, an international producer, has plants in Finland, the Netherlands, and Singapore. Neste exports to the United States, and their production capacity was 515 million gallons (34,000 barrels/day) as of May 2025 (Neste 2025). Section 2.5.1 of this report details renewable diesel producers. While most of those plants do not produce SAF today, they have the potential to do so if market conditions are favorable. New domestic alcohol-to-jet facilities are expected in late 2025.

Table 4. U.S. SAF Plants.

Sources: EIA (2025s); Krueger (2024); World Energy communicated their capacity by email on April 30, 2025.

Plant	Location	Pathway	Feedstocks	Capacity (barrels/day)	Start Year
Diamond Green Diesel	Port Arthur, Texas	HEFA	Fats, oils, greases	15,000	2025
Montana Renewables	Great Falls, Montana	HEFA	Fats, oils, greases	2,500	2023
New Rise Renewables	Reno, Nevada	HEFA	Fats, oils, greases	3,000	2025
Phillips 66	Rodeo, California	HEFA	Fats, oils, greases	10,000	2024
World Energy (idle)[a]	Paramount, California	HEFA	Fats, oils, greases	2,325	2016

[a] Idle as of April 2025 (Travel and Tour World 2025).

2.4.2 Sustainable Aviation Fuel Trade

EIA does not report SAF trade data. EPA's RIN data from past years show both imports and exports (Figure 10). SAF imports were from Neste facilities (Neste 2025).

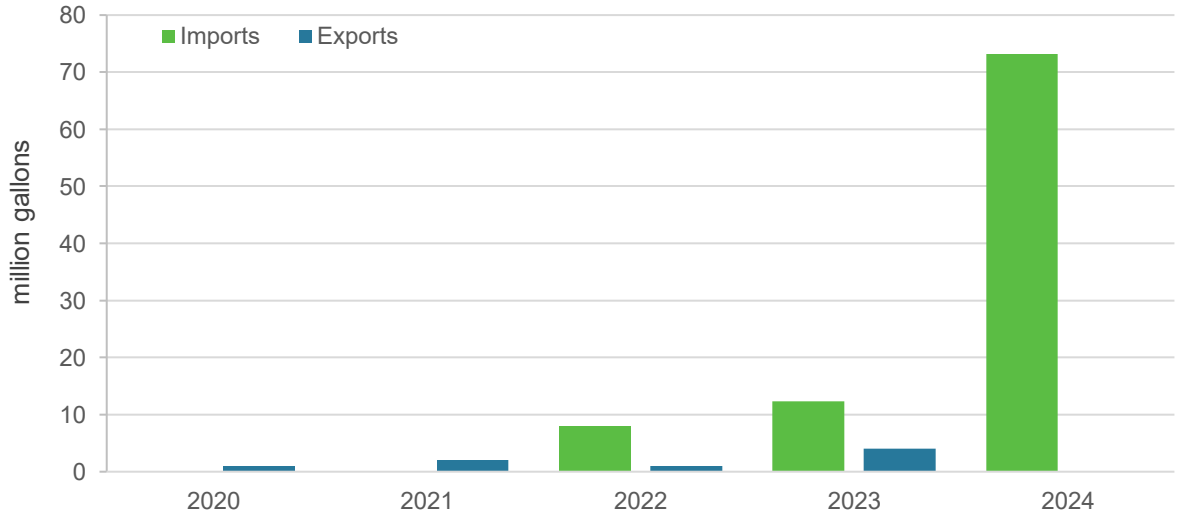

Figure 10. U.S. estimated SAF trade (based on RIN data).

Sources: EPA (2025e, 2025d). 2024 export data was unavailable.

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2.4.3 Blending and Logistics

SAF must be blended with conventional jet fuel, tested, and certified per ASTM D1655 prior to use in aircraft. Jet A is moved primarily by pipeline or vessel to terminals and onward to airports by pipeline or truck (Figure 11). SAF coprocessed at an existing refinery or blended into refinery storage is certified per ASTM D1655 and flows through the supply chain in a business-as-usual scenario.

SAF produced at a stand-alone facility must be blended somewhere in the supply chain with Jet A—previous reports examined options (Moriarty and McCormick 2024; Moriarty, Milbrandt, and Tao 2021). Fuel quality requirements and establishing SAF as ASTM D1655 certified prior to the airport was the key reason for identifying existing terminals as the best option for blending. Terminals have blending equipment, technology, permits, insurance, and staff knowledge because it is a part of their on-road transportation fuel activities. Blending can occur at the terminal directly linked to an airport or anywhere upstream. Demonstration projects brought SAF blended in Houston up the Colonial Pipeline to Linden, New Jersey, and onward on Buckeye's pipeline to LaGuardia International Airport in New York and by truck to Patrick Leahy Burlington International Airport (Neste 2022; Business Air News 2025). While blending could occur at an airport, it would result in increased truck traffic, the need to add staff and blending infrastructure and technology, and a change to insurance (Moriarty and McCormick 2024).

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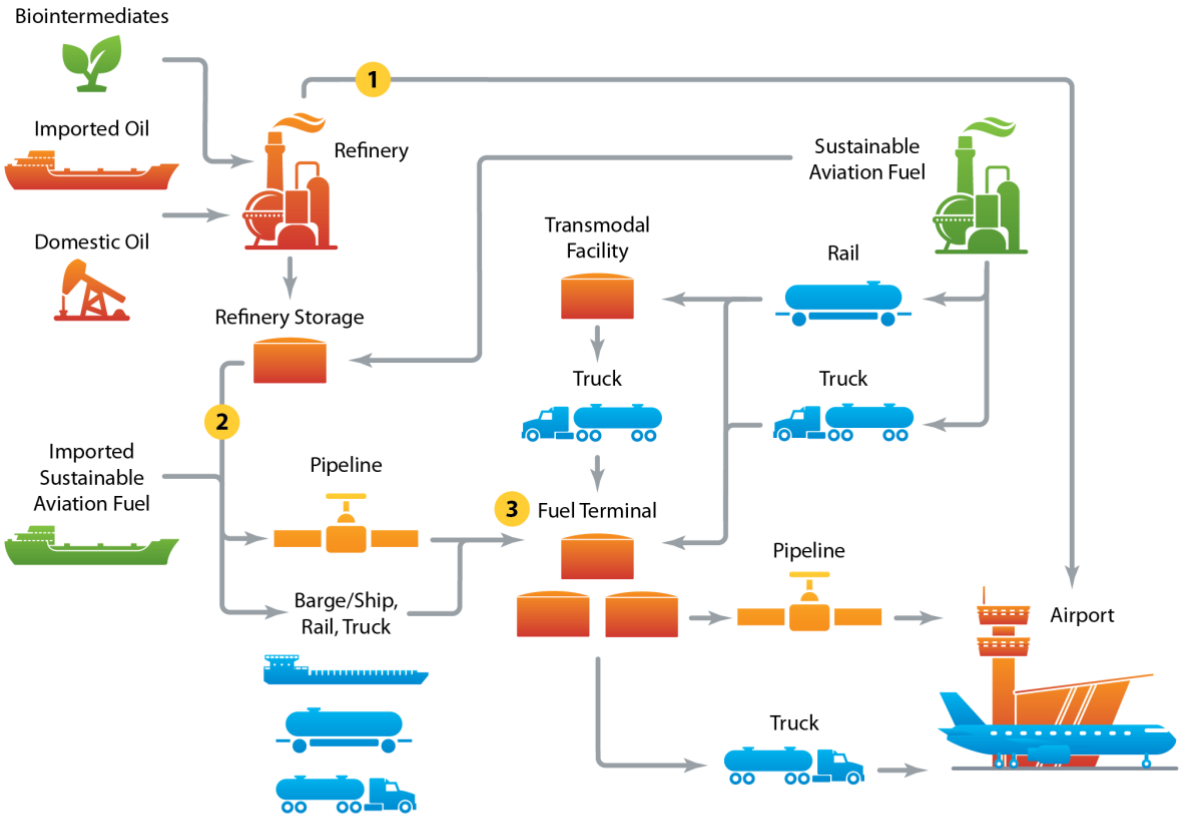

Figure 11. U.S. SAF and conventional jet fuel logistics

2.5 Renewable Diesel

Renewable diesel is a drop-in replacement for diesel typically produced from fats, oils, and greases. It is chemically the same as petroleum diesel and meets the ASTM D975 standard. As a drop-in fuel, it can be used in all existing infrastructure and engines intended for petroleum diesel. Renewable diesel qualifies as either an advanced biofuel D5 RIN or biomass-based diesel D4 RIN under the RFS, depending on how it is produced (EPA 2025e).

Renewable diesel and biodiesel are not the same fuels. They use different production technologies and meet different ASTM fuel quality specifications. Biodiesel details are available in Section 2.6 of this report.

Renewable diesel domestic production and consumption have grown significantly, largely due to conversion of refineries and increased demand from states with low carbon fuel standards. Renewable diesel has good performance in cold weather and can therefore be blended in any amount up to 100%.

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2.5.1 Production, Consumption, and Capacity

Renewable diesel is produced by traditional hydrotreating, which is how petroleum diesel is made. Hydrotreating involves reacting the feedstock with hydrogen under elevated temperatures and pressures in the presence of a catalyst. There are other production pathways that are not currently used for commercial production—they include biological sugar upgrading, catalytic conversion of sugars, gasification, pyrolysis, and hydrothermal processing.[6]

There has been tremendous growth in both production and consumption; consumption was nearly 3.7 billion gallons in 2024 (Figure 12) (EIA 2025l). In January 2022, renewable diesel consumption exceeded biodiesel consumption, and this trend continued as capacity grew (Figure 13). EIA reports that the majority of renewable diesel is consumed on the West Coast due to state low-carbon fuel standards (EIA 2025b).

The number of plants and capacity have grown over the past 5 years (Figure 14, EIA 2025s). While most plants are conversions of existing refineries, coprocessing at existing petroleum refineries also occurs. Up to 10% renewable feedstock can be used at existing petroleum refineries with minimal or no capital expenditures (Shell 2023). Considerations include increased hydrogen consumption and heat release, as well as potential challenges blending into the diesel pool due to cold flow properties. Four renewable diesel plants also produce SAF. While the other plants do not produce SAF, their production processes could be updated to do so if market conditions were favorable.

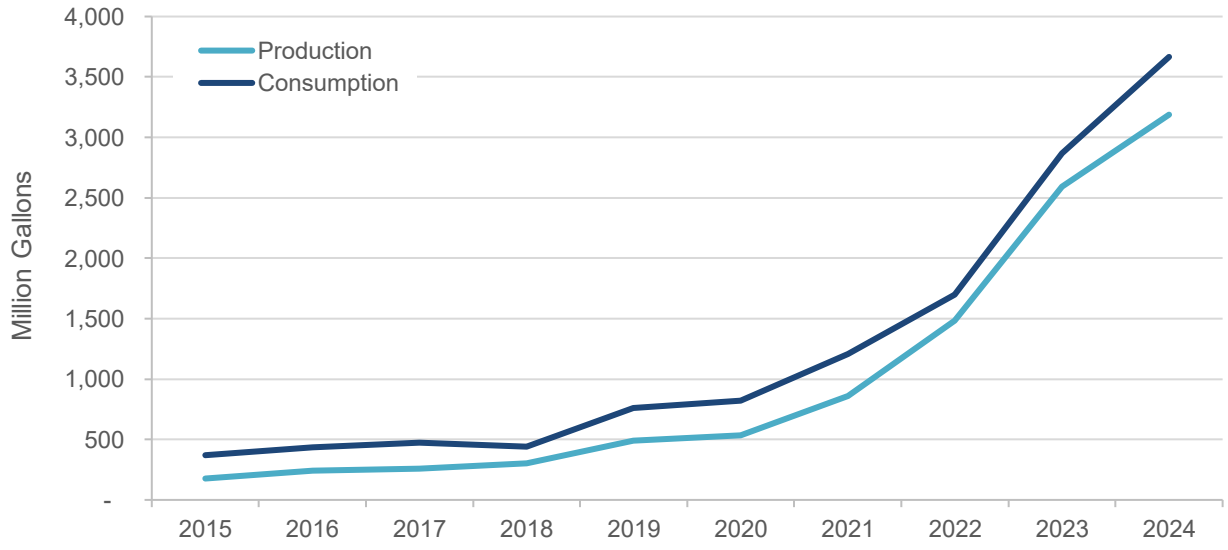

Figure 12. U.S. renewable diesel production and consumption.

Source: EIA (2025l)

[6] Details of other technology pathways are available on the Alternative Fuels Data Center: afdc.energy.gov/fuels/renewable_diesel.html.

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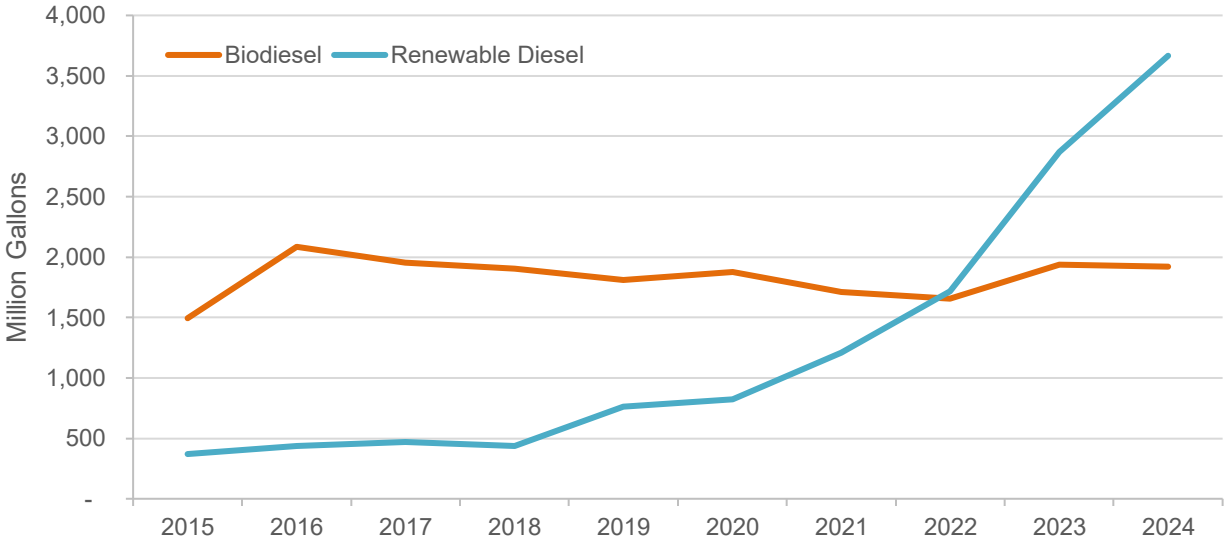

Figure 13. U.S. renewable diesel and biodiesel consumption.

Source: EIA (2025k, 2025l)

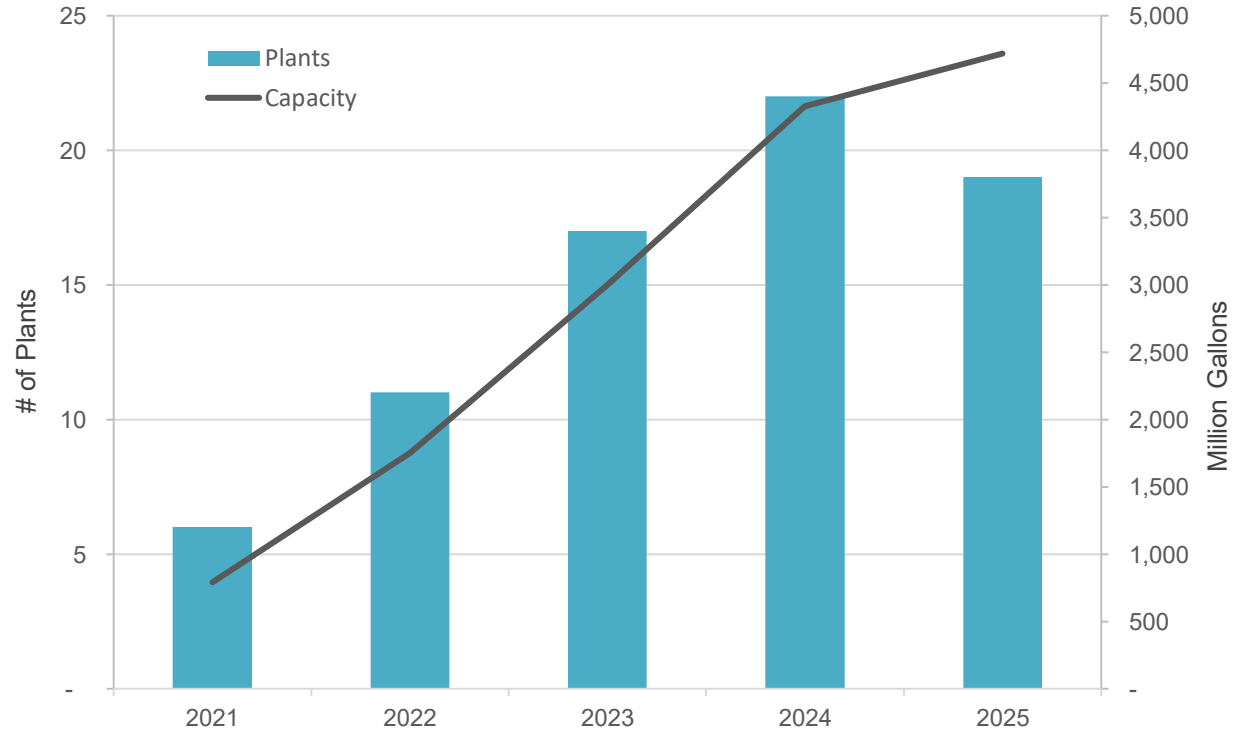

Figure 14. U.S. renewable diesel plants and capacity as of January 2025.

Source: EIA (2025s)

2.5.2 Renewable Diesel Trade

All imports are from Neste's Singapore plant (EIA 2025t). The reduction since 2022 may be due to domestic production and foreign competition (Figure 15). EPA's public RIN data show a much higher number of imported and foreign generated RINs of 446 million in 2022 compared with EIA's import data of 263 million gallons in 2022 (EPA 2025e; EIA 2025t).

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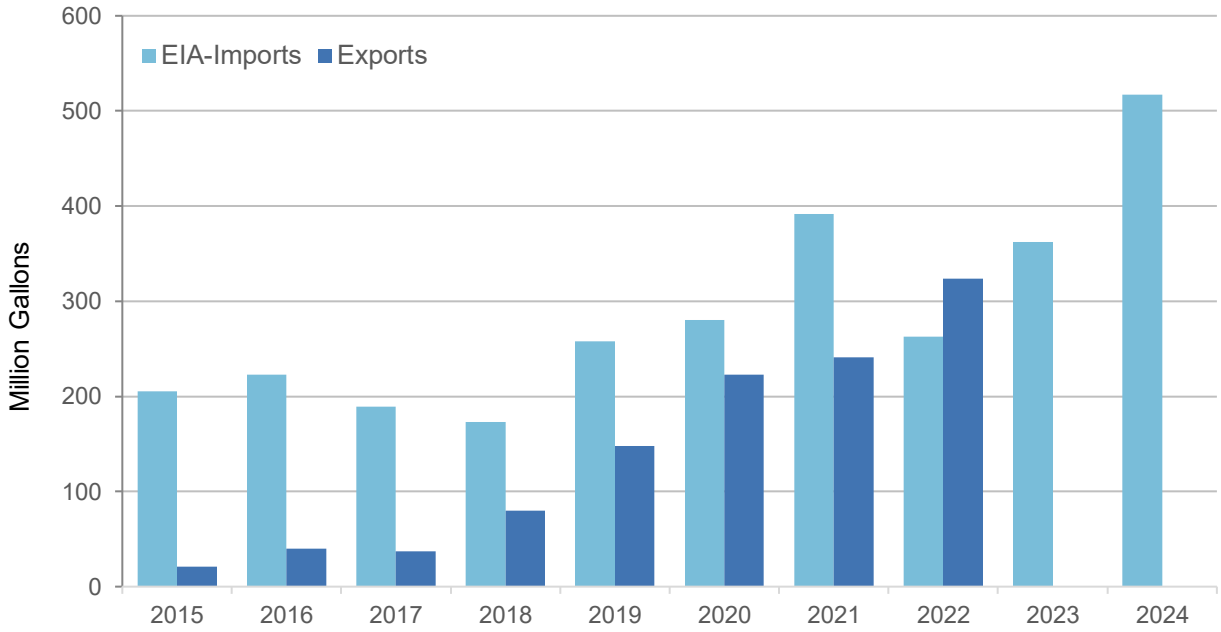

Figure 15. U.S. renewable diesel imports and exports.

Source: EPA (2023c). EIA reports renewable diesel export data, which vary slightly from EPA data (EIA 2025t). EPA data were used because they include both imports and exports.2023 and 2024 export data are unavailable.

2.6 Biodiesel

Biodiesel is an alternative fuel manufactured for use in diesel engines. It is referred to as biomass-based diesel in the RFS, along with renewable diesel, which is a different alternative fuel described in Section 2.5 of this report. In 2024, biodiesel consumption accounted for 3.3% of the nearly 58-billion-gallon annual diesel market (EIA 2025k, 2025m).

Blends of biodiesel and conventional diesel fuel have physical properties similar to those of petroleum diesel. Blends of B5 (5% biodiesel, 95% petroleum diesel) or below meet fuel quality specification ASTM D975 for conventional diesel fuel and can be used in existing infrastructure and any compression-ignition engine intended for petroleum diesel. The ASTM D7467 specification covers blends of B6 to B20 blends. B20 is the most common higher-level biodiesel blend, and engines operating on B20 have similar fuel consumption, horsepower, and torque to engines running on petroleum diesel. Some, but not all, engine and diesel vehicle manufacturer warranties cover the use of B20. B20 is approved for use in home heating oil, and there is an opportunity for growth in this market.

Pure biodiesel (B100; specification ASTM D6751) is typically used for blending with petroleum diesel and is rarely used in engines due to higher costs, cold-weather performance issues, and lack of compatibility with existing vehicles and infrastructure. The biodiesel industry established a voluntary quality assurance program known as BQ-9000 to support higher-quality fuels in the market.

Under the RFS, biodiesel generally meets the biomass-based diesel 50% greenhouse gas emissions reduction threshold. Biodiesel has historically been the main contributor to this fuel

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category, though renewable diesel overtook biodiesel in 2022 to become the most significant contributor to diesel RFS compliance. This trend has continued through 2024 (EPA 2025d).

2.6.1 Production, Consumption, and Capacity

Biodiesel is produced by transesterification—a process that converts fats and oils into biodiesel and glycerin (a coproduct) by reacting them with alcohol (typically methanol) and catalysts. Biodiesel production peaked at 1.8 billion gallons in 2018 and has declined in recent years to just under 1.7 billion gallons in 2024 (EIA 2025k). Excluding the 2 years of 2021 and 2022 when production nearly matched consumption, biodiesel consumption has generally exceeded production from 2015 to 2024 due to biodiesel imports (Figure 16).

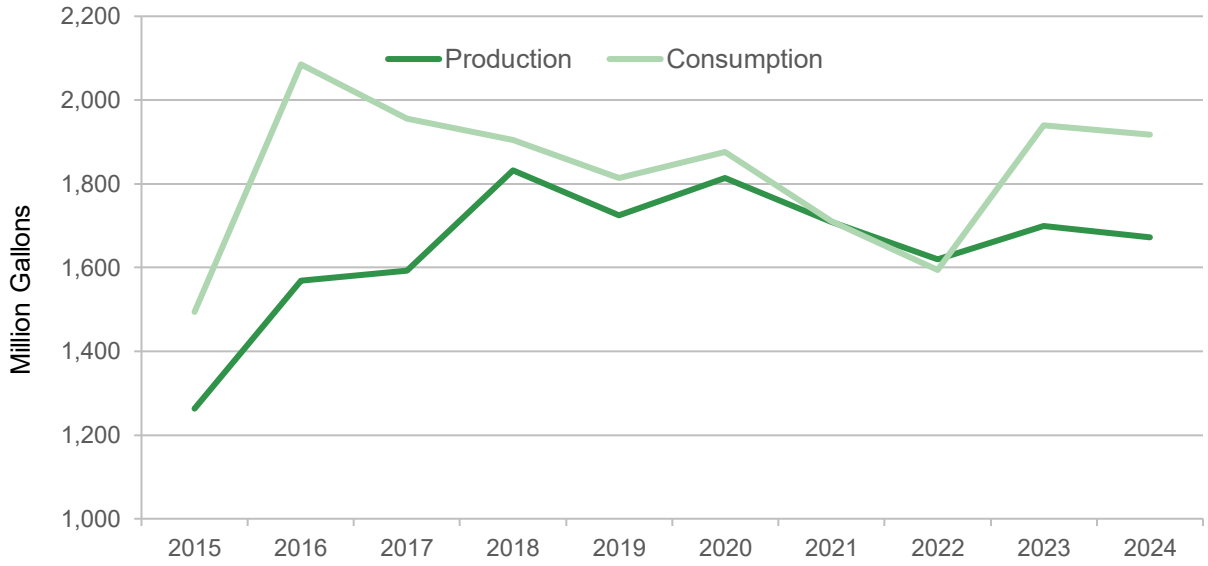

Figure 16. U.S. biodiesel production and consumption.

Source: EIA (2025k)

As of Jan. 1, 2025, there were 48 biodiesel plants with a total industry production capacity of nearly 2 billion gallons in 26 states (Figure 17 and Figure 18). Biodiesel plant capacity ranges from less than 1 million gallons to up to 144 million gallons. The average biodiesel plant size is about 42 million gallons. About 70% of the production comes from the Midwest; the largest biodiesel producer is Chevron Renewable Energy Group, which operates four plants with a total production capacity of 339 million annual gallons (EIA 2025o). Both the number of plants and capacity have declined since 2018; however, utilization of capacity has increased. The decline in plants and capacity is likely due to economic impacts as well as increased renewable diesel production, and competition for feedstock (Figure 13).

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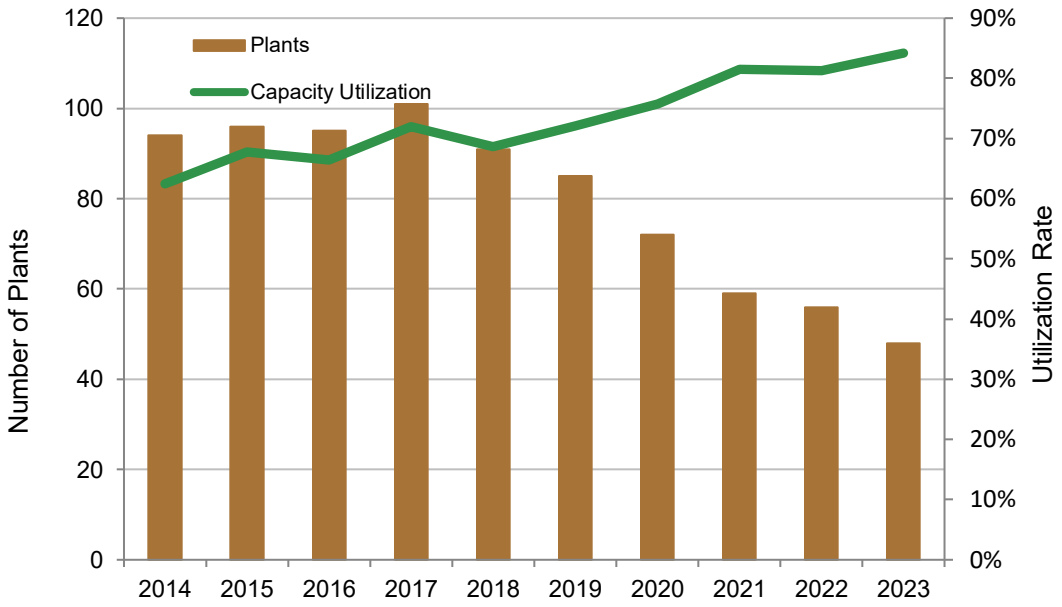

Figure 17. U.S. biodiesel plants capacity and utilization as of Jan. 1, 2025.

Source: EIA (2025k, 2025o)

Capacity utilization calculated based on capacity and production.

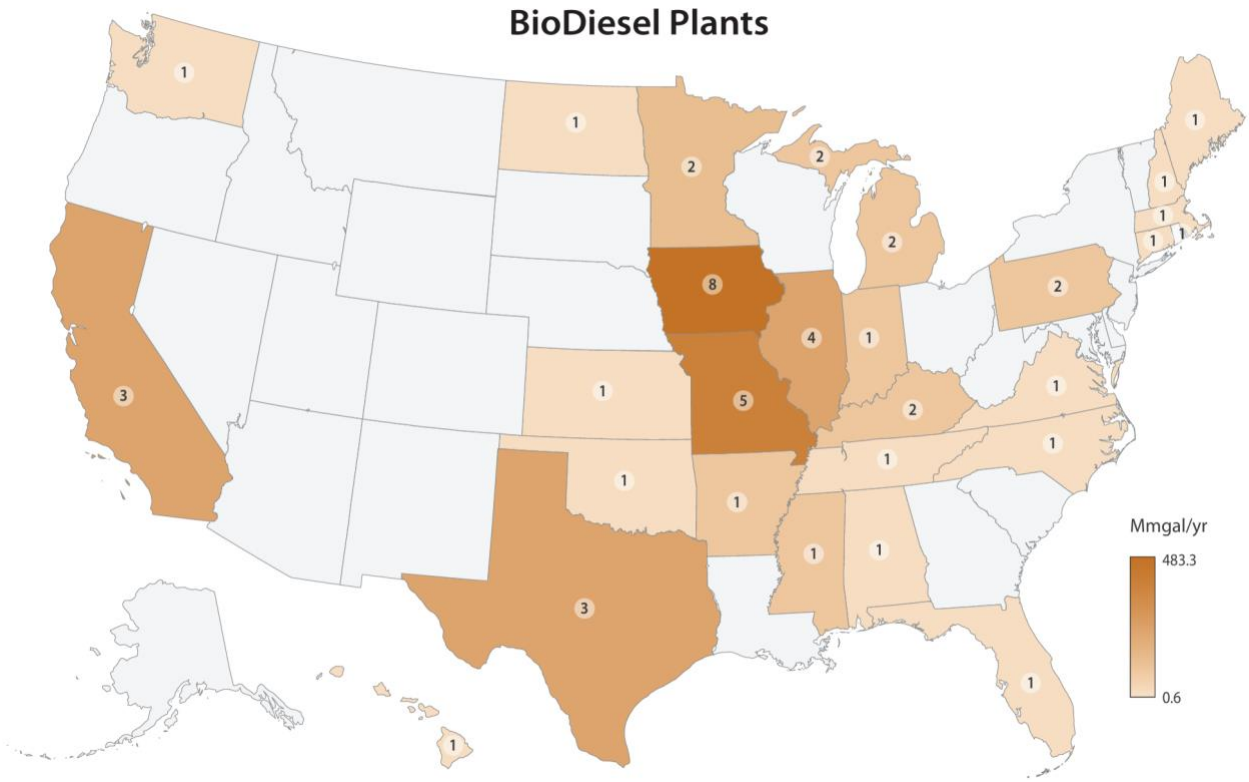

Figure 18. Biodiesel plants by state, January 2025.

Source: EIA (2025o)

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2.6.2 Biodiesel Production Cost and Market Prices

Biodiesel prices are collected quarterly and are directly correlated with petroleum diesel prices (Figure 19) (DOE 2026). Biodiesel production costs vary based on the feedstock being used; plant size, type, and design; when the plant was built; and how the plant is managed. Iowa State University developed a model to track Iowa's biodiesel profit margins and production costs over time based on Iowa's biodiesel prices and costs for soybean oil and methanol, as well as other operating costs (Hofstrand 2025a). Historically, soybean oil has accounted for about 87% of operating costs at an average Iowa biodiesel plant, with lower costs for methanol and other costs. Soybean oil prices began increasing in 2020 and peaked at roughly 93% of operating costs in 2022. Since mid-2023, prices have begun to drop, and from 2023 to 2024 soybean oil represented roughly 90% of operating costs. Production costs varied between $2.28/gal and $7.33/gal between January 2015 and December 2024 (Figure 20) (Hofstrand 2025a). Biodiesel plants using other feedstocks, such as corn oil, canola oil, tallow, and waste grease, would experience different costs; however, feedstock costs typically comprise 70%–95% of overall operation costs (Tao and Aden 2009).

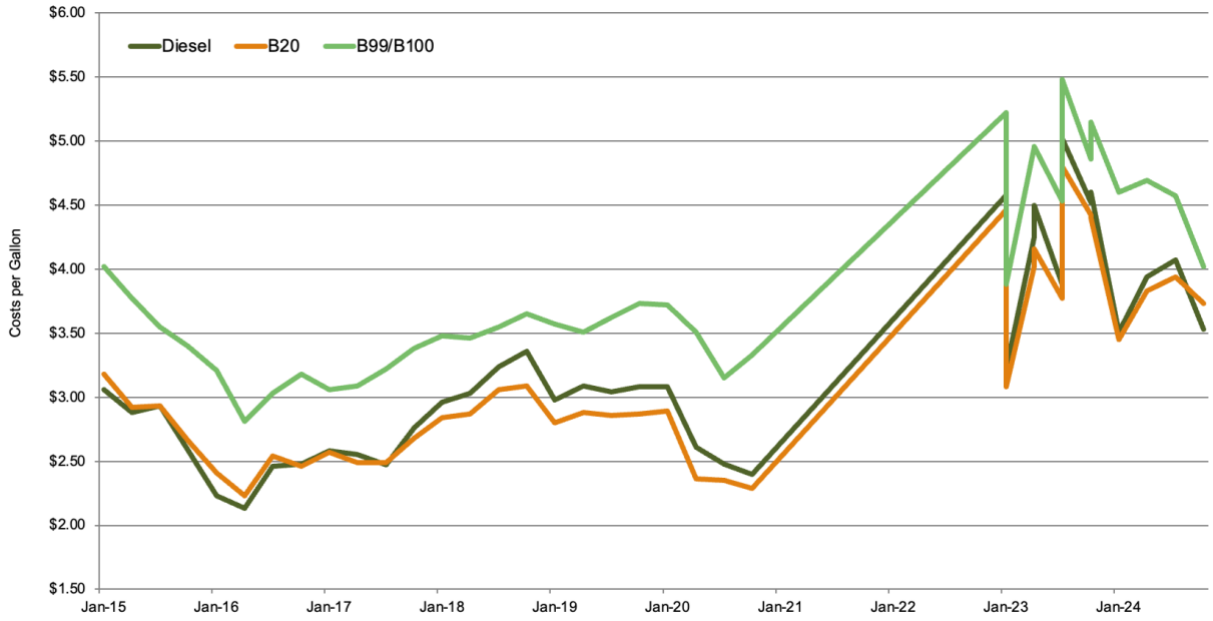

Figure 19. U.S. retail biodiesel prices.

Source: DOE (2026)

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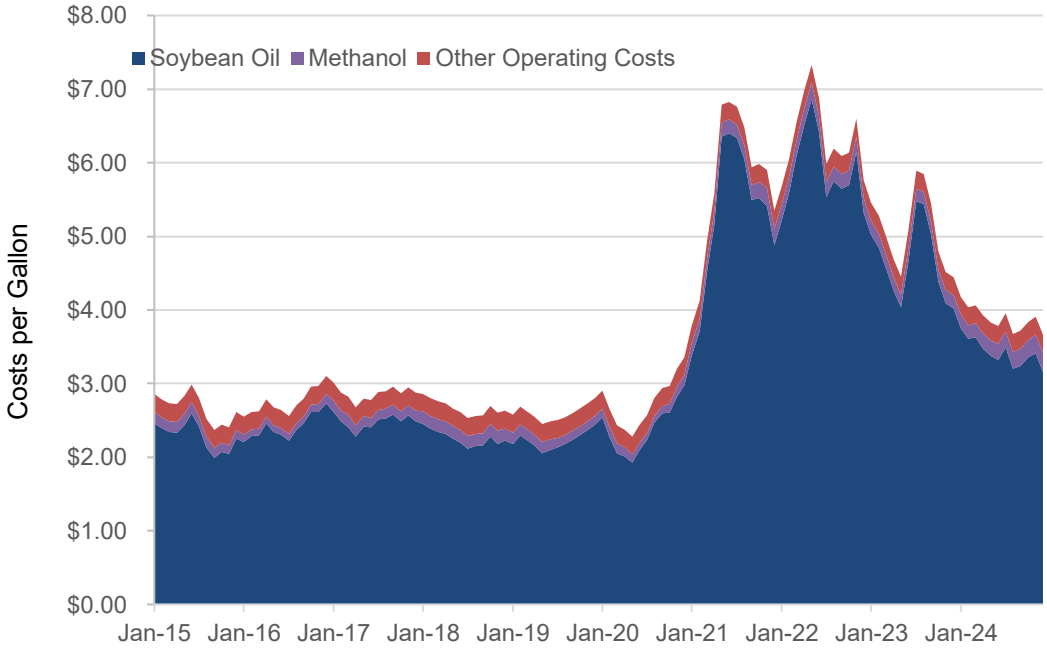

Figure 20. U.S. soybean-based biodiesel production cost trends.

Source: Hofstrand (2025a)

2.6.3 Coproducts Overview

The only coproduct of biodiesel production is glycerin, which is used in food, hygiene, and pharmaceutical products. Each gallon of biodiesel produced results in 1 pound of glycerin. Declining biodiesel production in recent years has contributed to higher prices for glycerin in U.S. markets. While glycerin had historically produced only pennies in revenue per gallon of biodiesel produced, glycerin prices in 2024 were between $265 to $285 per metric ton (Maggelanium 2024).[7]

2.6.4 Biodiesel Trade

U.S. biodiesel trade dynamics (Figure 21) are largely affected by policies. Imports grew significantly in 2016 and fell in 2017 because the United States imposed import duties on biodiesel from Argentina and Indonesia. Imports doubled in 2023 and 2024 compared to 2022 levels due to a biodiesel surplus in Europe creating low prices (EIA 2024). Imports in 2024 were from nine nations; the majority came from Germany (31%), Canada (30%), and Spain (20%) (EIA 2025t). The United States exported to six nations in 2024, with Canada accounting for 89% and Peru 10% (EIA 2025r).

[7] Approximate value per gallon of biodiesel produced of $0.12 to $0.13 assuming 0.9 pounds of glycerin per gallon of biodiesel produced (Gerveni et al. 2023).

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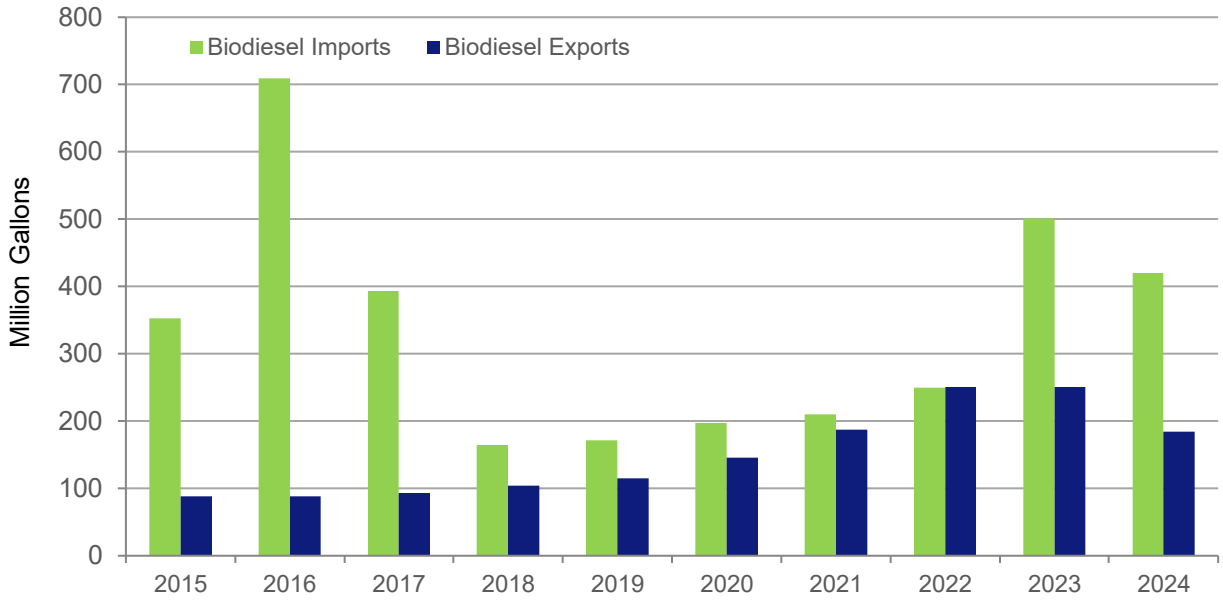

Figure 21. U.S. biodiesel imports and exports.

Source: EIA (2025t, 2025r)

2.6.5 Infrastructure

A patchwork of infrastructure regulations applies to the storage of biodiesel blends. Codes and standards for refueling agencies are developed and enforced by many organizations, including the EPA's Office of Underground Storage Tanks, authorities having jurisdiction (typically fire marshals), UL (a third-party safety certification organization), the Occupational Safety and Health Administration, fire safety code organizations, and industry groups.

Blends of B5 and below are approved for use in all existing petroleum diesel infrastructure. For B20 blends, aboveground equipment at a gas station needs to be third-party certified for the fuel. Federal underground storage tank regulations require demonstration of compatibility for blends above B20, which can be demonstrated by using third-party-certified equipment or by obtaining a compatibility letter from the manufacturer. All existing steel and fiberglass underground storage tank manufacturers have issued letters stating compatibility with B100; however, the decades-long usage of tanks means that there are tanks installed by manufacturers that are no longer in business, and these tanks cannot store blends above B20.[8]

As of the end of 2024, there were 1,403 stations offering B20 (Figure 22) (Alternative Fuels Data Center 2025b). The reason for the significant increase in 2022 was due to a single large station reporting their station data. Biodiesel fueling stations are highly concentrated in the upper Midwest, with lesser concentrations in West Coast states. Minnesota mandates the sale of biodiesel,[9] Illinois provides a sales tax exemption, and Iowa provides a retailer tax credit. USDA's Higher Blends Infrastructure Incentive Program has also resulted in more B20 stations

[8] A list of biodiesel-compatible tanks, associated equipment, and UL-listed dispensers and hanging hardware is available on the Alternative Fuels Data Center website: www.afdc.energy.gov/fuels/biodiesel_infrastructure.html.
[9] Minnesota's blend requirement varies based on time of year. Details are available on Minnesota's legislature's website: www.house.mn.gov/hrd/pubs/ss/ssbiofuel.pdf.

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and more terminals offering biodiesel in recent years. An estimated $500 million was available from the program through 2024 (USDA 2025).

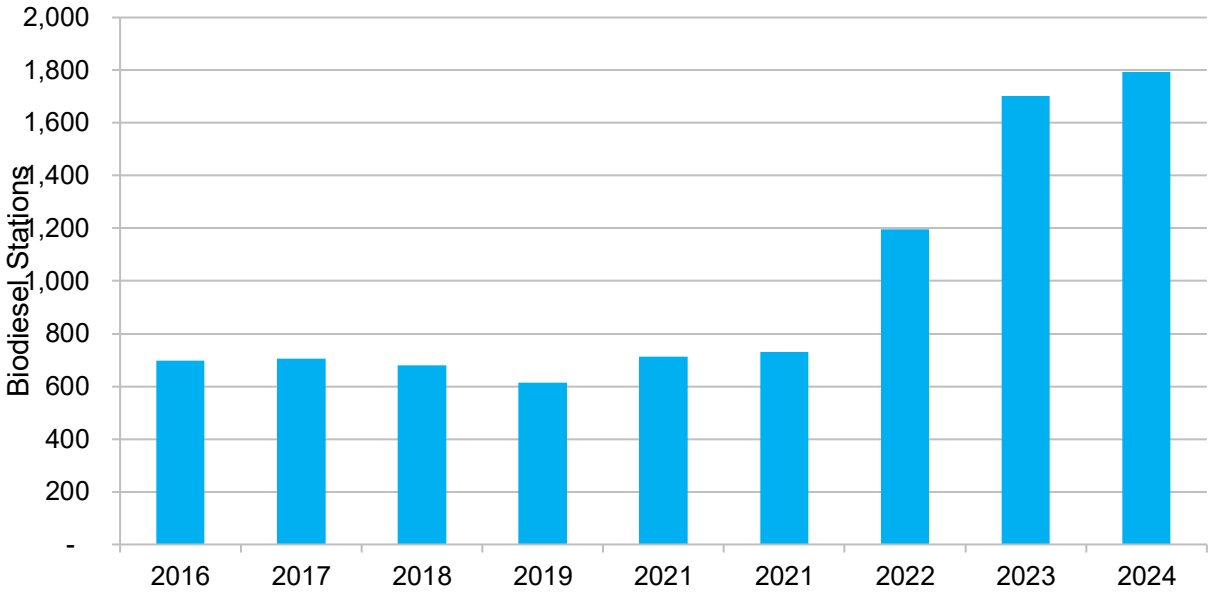

Figure 22. U.S. biodiesel refueling stations.

Source: Alternative Fuels Data Center (2025b)

2.6.6 End Use

Existing diesel vehicles can use B5 without any modifications to vehicles or infrastructure. As of 2024, 31 out of 33 major on-road vehicle manufacturers support the use of B20 in at least some of their vehicles.[10] Biodiesel is also used in off-road applications such as farm equipment and in backup generators. Biodiesel has also seen an increase in use as a marine fuel in recent years, with numerous vessel operators and ports trialing the use of B100 in place of heavy fuel oil (see Section 2.9).

Biodiesel use in the home heating oil market has been increasing in recent years. In 2023, commercial and residential heating accounted for nearly 5% of total U.S. biodiesel consumption, up from roughly 1% a decade earlier (EIA 2025p). The home heating oil market is concentrated in the Northeast. Biodiesel blended with home heating oil is marketed as Bioheat fuel by the National Oilheat Research Alliance.[11] B20 can be used in standard home heating oil equipment.

2.7 Ethanol

Ethanol is a widely used biofuel made predominantly from corn. Ethanol has a long history of use in the United States, dating back to the introduction of motor vehicles. As a domestically produced biofuel, ethanol provides jobs in rural areas. The ethanol market has expanded to be the largest (by joule) alternative fuel in the United States due to both market factors and policies

[10] Clean Fuels Alliance America original equipment manufacturer information: cleanfuels.org/wp-content/uploads/OEM-Support-Summary_Sept-2025.pdf.
[11] The National Oilheat Research Alliance provides details on renewable fuels for home heating oil: noraweb.org.

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(Johnson et al. 2021). Today, ethanol consumption is driven by both octane requirements and the RFS. Pipelines ship a variety of gasoline and gasoline blendstocks to meet demand, which varies regionally. Many of these products are sub-octane, meaning they have a lower octane than is required for sale to consumers at a station. Ethanol has a higher octane number than gasoline, and refiners provide a gasoline blendstock that, when blended with ethanol, will meet octane specifications necessary for vehicle performance needs. Ethanol is delivered to terminals or blenders by railcar, tanker truck, or barge, and it is then blended with gasoline and delivered by truck to stations.

In the United States, 98% of gasoline sold contains ethanol, and nearly all ethanol is sold as E10 (Alternative Fuels Data Center 2025a). Another long-available blend is E85, which can be used in flexible-fuel vehicles. E15 is approved for use in model year 2001 and newer vehicles, which represent 97% of the light-duty gasoline vehicle market.[12] The blend rate of ethanol with gasoline reached 10.4% in 2024—this means that the market expanded beyond E10 with sales of E15 and E85 (RFA 2025b). In states without a reformulated gasoline market, E15 typically cannot be sold in summer months due to a waiver needed for Reid vapor pressure. However, an ongoing EPA emergency fuel waiver has allowed sales of E15 nationwide year-round in 2022 and 2023 (EPA 2025c). Eight Midwestern states received approval from EPA to remove the 1-pound-per-square-inch Reid vapor pressure waiver for summer gasoline containing E10, allowing for year-round sales effective April 28, 2025.[13]

2.7.1 Production, Consumption, and Capacity

Most ethanol is produced using dry-mill technology (92%); a small number of larger plants use a wet-milling process (8%) (RFA 2025b). Dry milling is a process that grinds corn grain into flour and ferments only the starch component into ethanol with coproducts of distillers grains (an animal feed coproduct) and carbon dioxide. Wet-mill plants primarily produce corn grain sweeteners, along with ethanol and several other coproducts (such as corn oil and starch).

Figure 23 highlights 2024 ethanol production and consumption of more than 16 billion gallons and 14 billion gallons, respectively (EIA 2025j). Exports account for the difference in production and consumption. Figure 24 shows cellulosic ethanol production including a large increase in 2024, a result of EPA using a new ASTM test method to quantify the pre- and post-fermentation cellulosic content (Primrose 2025). Since 2021, all cellulosic ethanol production is from bolt-on technology at existing conventional ethanol plants, which extracts the corn fiber byproduct for processing into ethanol. Adding cellulosic ethanol conversion technology to existing corn ethanol plants allows these facilities to diversify their portfolios.

As of January 2025, there were 191 fuel ethanol plants with an installed capacity of about 18.5 billion gallons (Figure 25 and Figure 26). There are plants in 21 states, with the majority in the Midwest (Figure 18) (EIA 2025d). Plant ownership is not consolidated—there are approximately 114 ownership organizations. The four top producers account for 39% of installed capacity and 32% of plants: POET (34 plants, 3 billion gallons), Valero (12 plants, 1.6 billion gallons), Archer

[12] The National Laboratory of the Rockies purchases vehicle registration data from Experian and compared the total number of vehicles versus model year 2001 and newer: www.experian.com/automotive/auto-vehicle-data.
[13] 40 CFR Part 1090: www.federalregister.gov/documents/2024/02/29/2024-04023/request-from-states-for-removal-of-gasoline-volatility-waiver.

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Daniels Midland (7 plants, 1.6 billion gallons), and Green Plains (10 plants, 903 million gallons) (RFA 2025b).

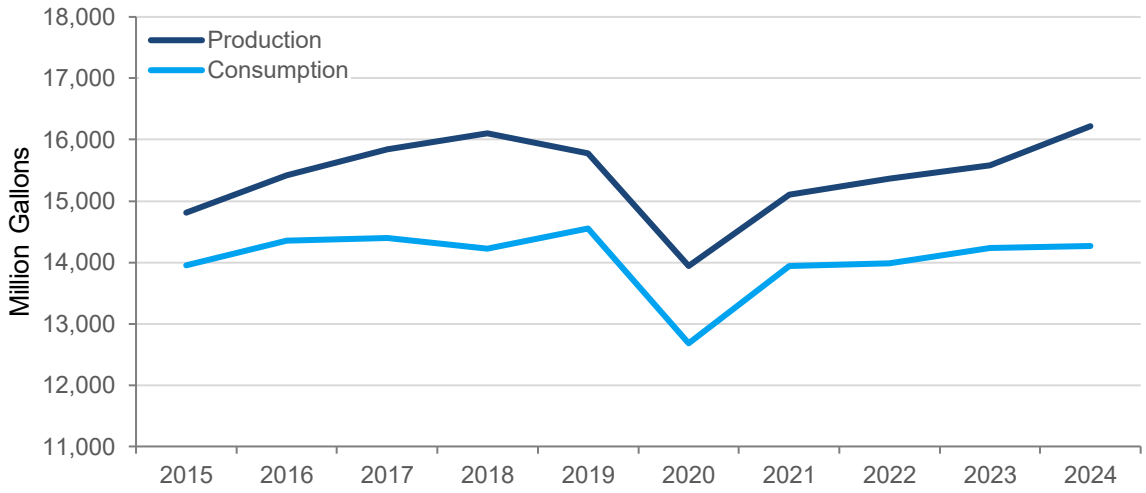

Figure 23. U.S. ethanol production and consumption.

Source: EIA (2025j)

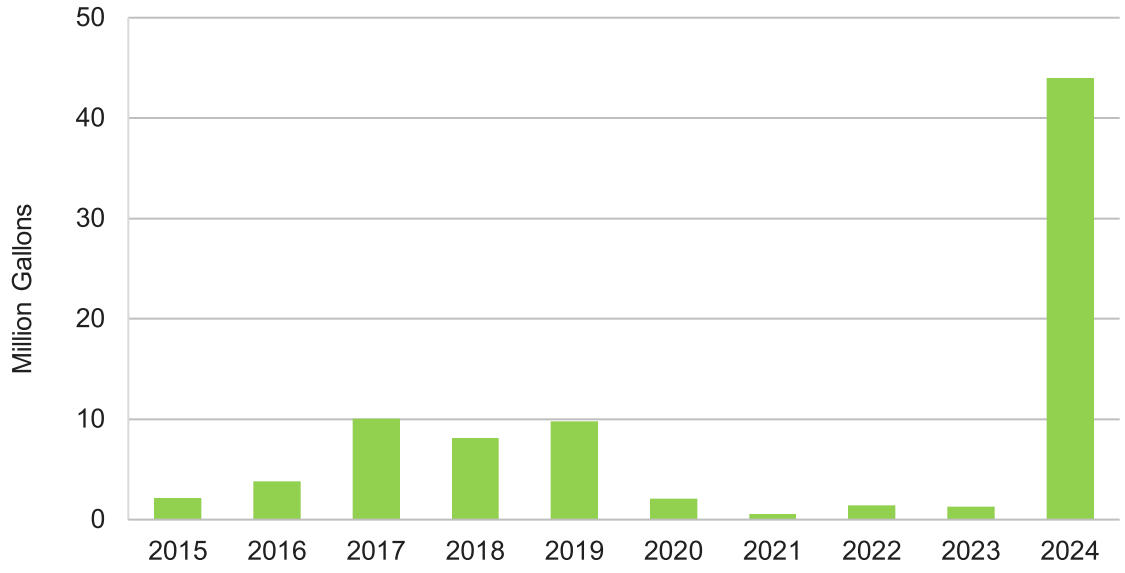

Figure 24. U.S. cellulosic ethanol production.

Source: EPA (2025d)

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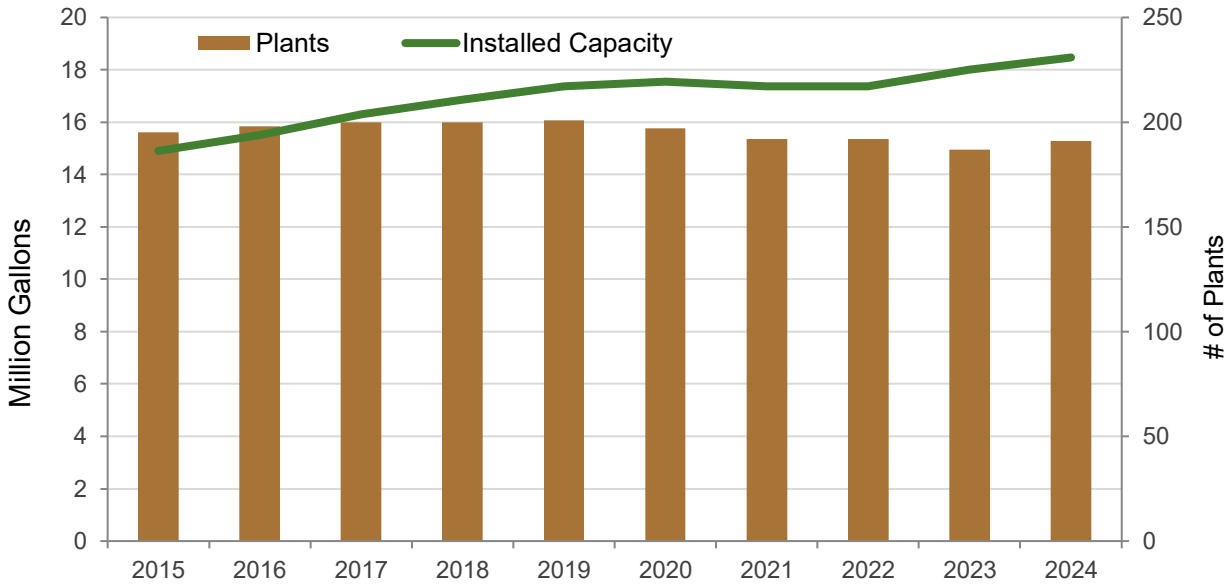

Figure 25. U.S. ethanol plants and capacity as of Jan. 1, 2025.

Source: EIA (2025d)

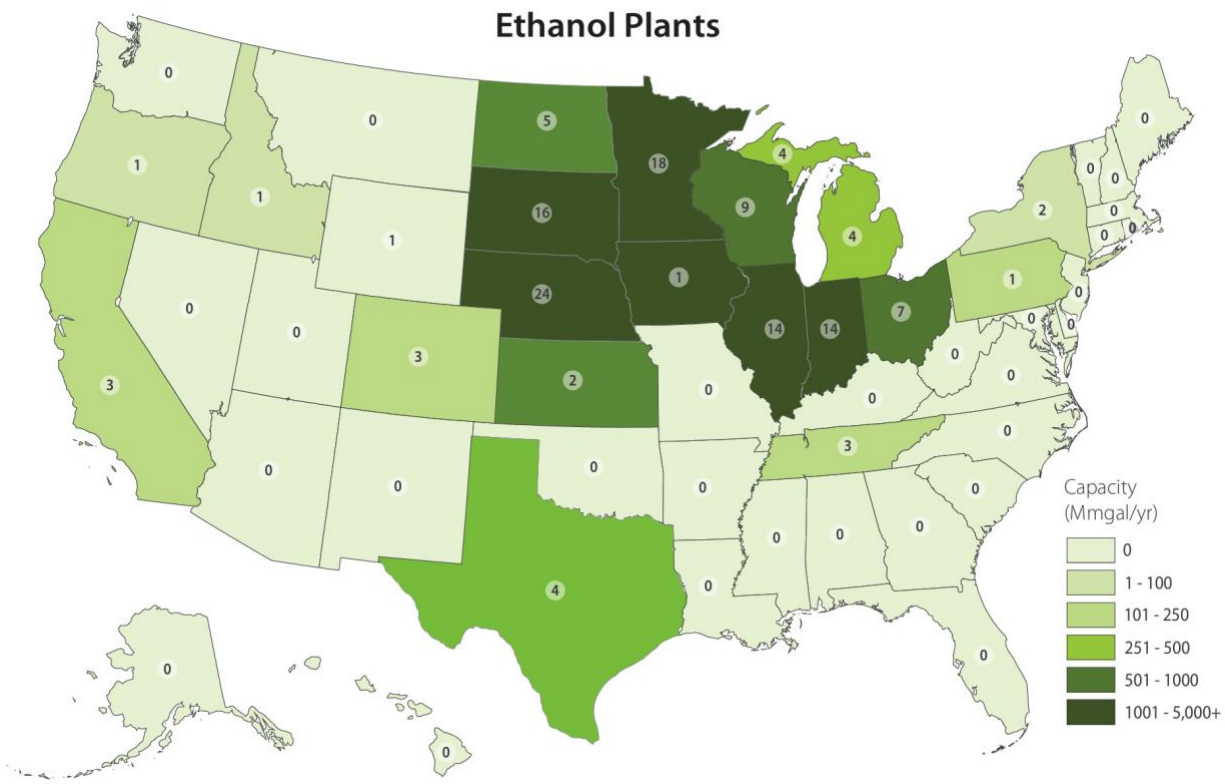

Figure 26. Ethanol plants by state, January 2023.

Source: EIA (2025d)

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2.7.2 Prices and Production Cost

The primary drivers of ethanol prices are the cost of corn and the gasoline prices, for which ethanol serves as a substitute product. Figure 27 compares ethanol and gasoline futures prices with corn prices.

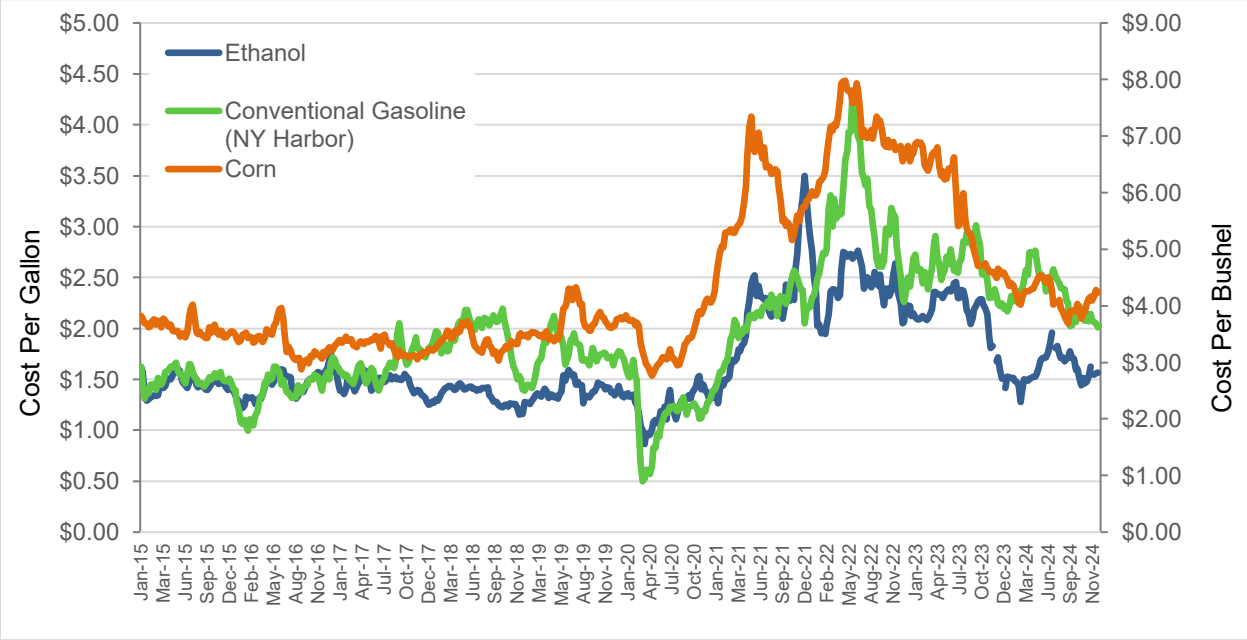

Figure 27. U.S. corn, ethanol, and gasoline prices.

Sources: Ethanol and corn grain: Johans (2025); gasoline: EIA (2025f). Ethanol and gasoline are price per gallon, not energy equivalent.

A model created by Iowa State University was used to estimate the production cost for a typical northern Iowa natural-gas-fired ethanol plant with an annual capacity of 100 million gallons. The plant represents similar facilities built around 2007 in Iowa but may not be representative of plants in other regions (Hofstrand 2025b). The estimated production cost varied from $1.58/gal to $3.45/gal between 2015 and 2024, and corn accounted for 71% of production costs over the past 10 years (Figure 28) (Hofstrand 2025a).

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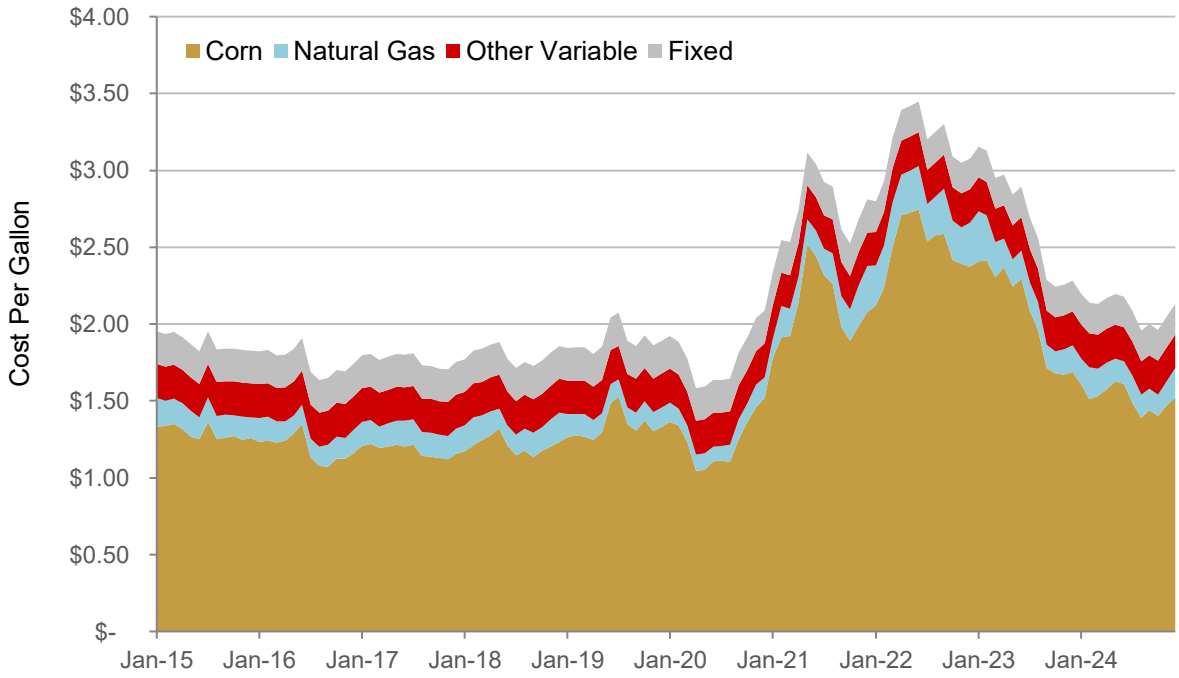

Figure 28. U.S. corn grain ethanol production cost trends.

Source: Hofstrand (2025b)

The largest ethanol markets are located on the East and West coasts of the United States, outside of the primary corn production region. Most ethanol produced in the Midwest and is shipped by mostly commonly by trains and also by barge to other regions. Ethanol is not shipped by pipeline due to fuel properties. Ethanol prices are typically lowest in the Midwest and increase as a function of transportation costs when shipped to other domestic markets.

2.7.3 Coproducts Overview

Fuel ethanol coproducts include distillers grains,[14] corn gluten meal/feed, corn oil, and carbon dioxide. The gross value of coproducts was $8.4 billion in 2024. Corn grain is approximately two-thirds starch, which is converted into ethanol and carbon dioxide; the remaining is converted into distillers grains and corn oil. Distillers grains are the highest-volume coproduct and are sold as livestock feed, and about one-third is exported to more than 50 countries (Figure 29). The top three export markets in 2024 were Mexico (21%), South Korea (13%), and Indonesia (8%) (RFA 2025b).

About 90% of ethanol plants have dry fractionation technology at the front end of their plant to extract nonedible corn oil at a rate of about 0.9 pounds per bushel, which is used as a feedstock for biodiesel/renewable diesel plants or in animal feed (RFA 2025b). Figure 30 shows 2024 corn oil production of 2.3 million tons and carbon capture of 2.7 million tons (RFA 2025d). Thirty percent of dry-mill ethanol plants capture carbon dioxide—those closer to cities sell carbon dioxide for use in pharmaceutical and food products (RFA 2025b). The ethanol industry is

[14] Distillers grains are sold in variations of two forms: wet distillers grains and dried distillers grains. Wet distillers grains have a short shelf life and are generally delivered to livestock operations within driving distance of ethanol plants. Dried distillers grains have a much longer shelf life and can be delivered to livestock operations throughout the country and exported.

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considering various carbon capture technologies, as they qualify for the amended 45Q incentive of $85/metric ton under the One Big Beautiful Bill Act.

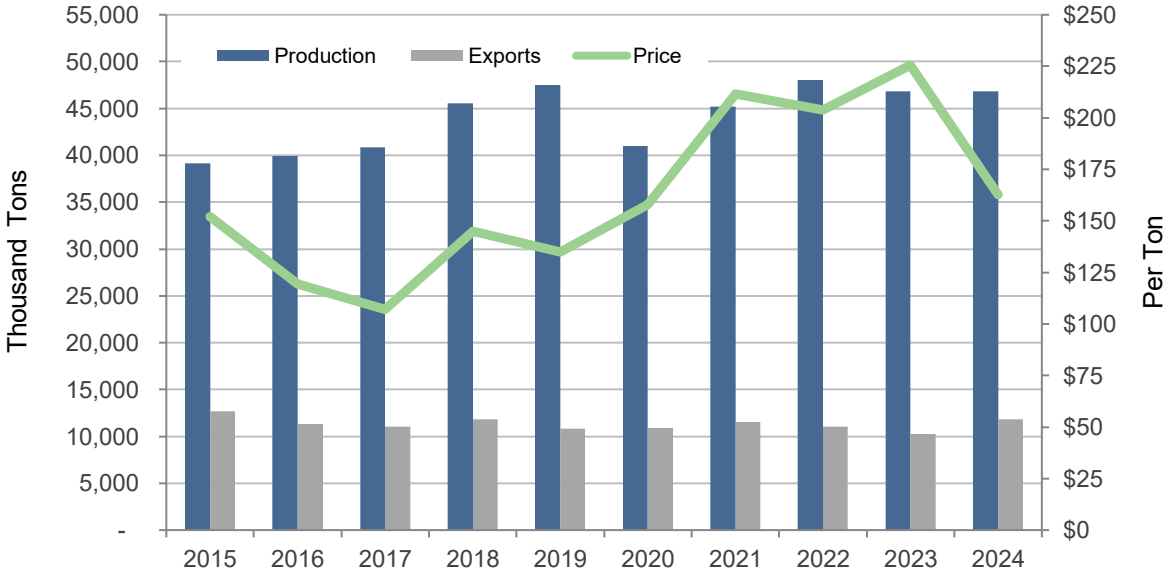

Figure 29. U.S. starch ethanol distillers grains production, trade, and price.

Sources: Production: RFA (2025d); exports: USDA Economic Research Service (2025); prices at production facilities (annual average of prices at production facilities in Iowa, Illinois, Nebraska, South Dakota, and Wisconsin): Johans (2025)

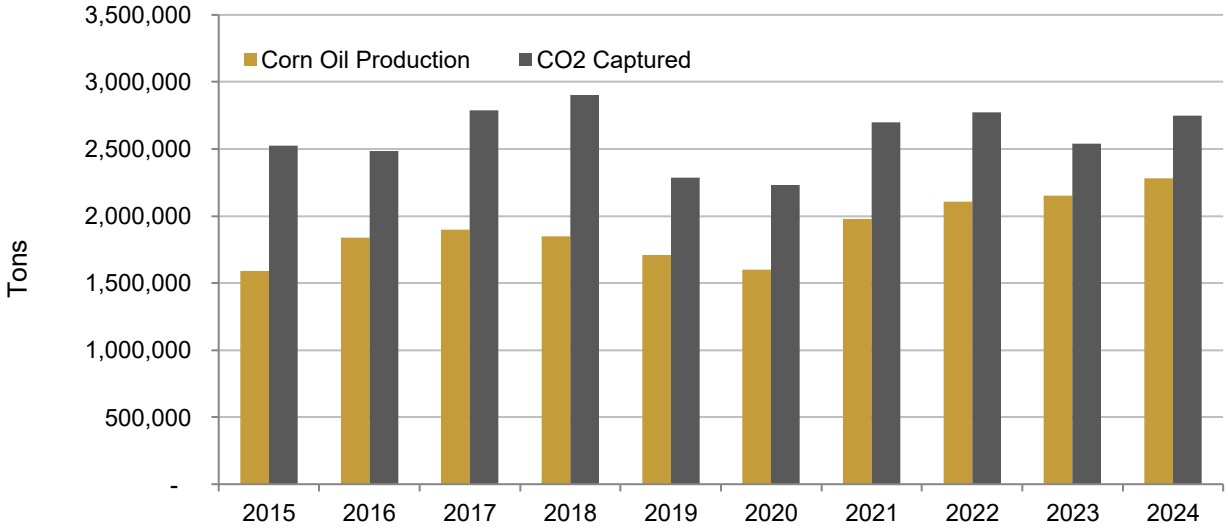

Figure 30. U.S. starch ethanol corn distillers oil and carbon dioxide captured.

Source: RFA (2025d)

2.7.4 Ethanol Trade

Ethanol is both imported and exported as a function of demand or biofuel use requirements in other nations (Figure 31). The United States is the world leader in ethanol production, accounting for 52% of 2024 world production (RFA 2025a). Imports dropped to an all-time low at 3.5

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million gallons, all from Brazil (RFA 2025b). The United States exported 1.94 billion gallons valued at $4.2 billion in 2024, which was nearly 12% of domestic production (EIA 2025r; RFA 2025b). Exports were to 45 nations, and the United States' three largest trading partners were Canada (37%), the United Kingdom (12%), and the European Union (10%) (EIA 2025r).

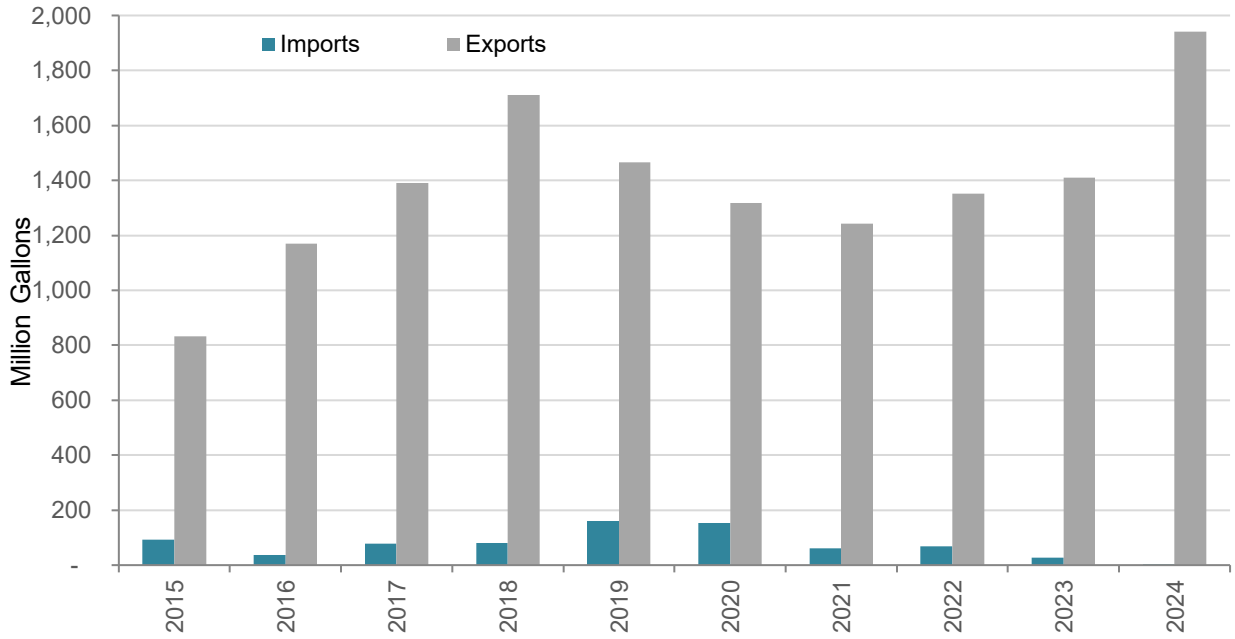

Figure 31. U.S. ethanol imports and exports.

Source: EIA (2025t, 2025r)

2.7.5 Infrastructure

Regulations have long accommodated the use of E10 in existing infrastructure. Blends above E10 require approvals and some specialized equipment to meet the patchwork of regulations that cover refueling infrastructure (Section 2.6.5).

Stations interested in selling ethanol blends can refer to Clean Cities' *Handbook for Handling, Storing, and Dispensing E85 and Other Ethanol-Gasoline Blends*, which explains requirements for selling ethanol blends and provides lists of compatible and UL-listed equipment (DOE 2016).[15]

As of the end of 2024, E85 was available at 4,717 stations in 43 states (Figure 32) (Alternative Fuels Data Center 2025c). As of July 2025, there were 4,300 stations in 34 states selling E15 (Growth Energy 2025). USDA's Higher Blends Infrastructure Incentive Program has offered $500 million in grant funding to terminals and stations offering E15 and E85 in recent years (USDA 2025).

[15] The handbook provides lists of compatible tanks, pipes, and associated underground storage tank equipment, as well as UL-listed dispensers and hanging hardware.

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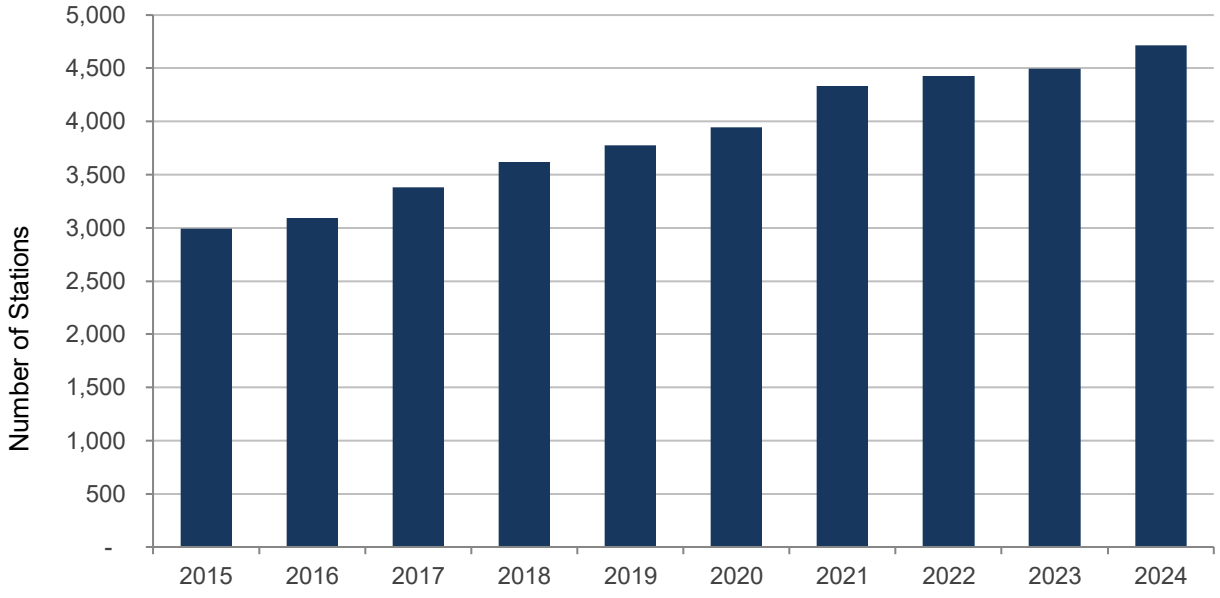

Figure 32. U.S. E85 stations.

Source: Alternative Fuels Data Center (2025c)

2.7.6 End Use

All 264 million U.S.-registered light-duty gasoline vehicles can operate on E10. Model year 2001 and newer light-duty trucks and vehicles are approved by EPA to operate on E15 (EPA 2026). At the end of 2024, 97% of the gasoline light-duty truck and vehicle population was model year 2001 and newer.[16]

Flexible-fuel vehicles can operate on any gasoline-ethanol blended fuel between E0 and E85, and there were nearly 20 million flexible-fuel vehicles on U.S. roads at the end of 2024. There were 42 models from six manufacturers in model year 2017, but only four models offered from two manufacturers in model year 2023. The reason for the decline was a change to the National Highway Traffic Safety Administration's Corporate Average Fuel Economy standards, in which auto manufacturers receive a credit for flexible-fuel vehicles sold. For model year 2020 and beyond, auto manufacturers must demonstrate that the vehicle is using E85 to obtain credits, which has led to a steep decline in the availability of flexible-fuel vehicles.

2.8 Renewable Natural Gas

RNG, or biomethane, is a pipeline-quality gas that is interchangeable with conventional natural gas and thus can be used in natural gas vehicles and other applications. RNG is essentially biogas (the gaseous product of the decomposition of organic matter, composed primarily of methane, carbon dioxide, and other trace compounds) that has been processed to purity standards. Like conventional natural gas, RNG can be used as a transportation fuel in the form of compressed natural gas or liquefied natural gas. RNG qualifies as a cellulosic biofuel under the RFS and is currently the main contributor to this fuel category (EPA 2025d). In 2024, there were 411 operating RNG facilities with capacity of 113 TBtu (Guidehouse 2024).

[16] Derived registration counts by the National Laboratory of the Rockies, Experian Information Solutions.

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Biogas is produced from landfill biogas, agricultural wastes (including crop waste and manure), food waste, and wastewater treatment plants through a biochemical process (e.g., anaerobic digestion) or thermochemical means (e.g., gasification). With minor cleanup (e.g., siloxane removal), most biogas is used to generate electricity and heat. To fuel vehicles, biogas must be processed to a higher purity standard. This process is called conditioning or upgrading and involves the removal of water, carbon dioxide, hydrogen sulfide, and other trace elements. The resulting RNG has a higher content of methane than raw biogas, which makes it comparable to conventional natural gas and thus a suitable energy source in applications that require pipeline-quality gas.

In general, RNG is sold via book-and-claim in the United States; facilities that are close enough to the end user for a direct connection are far less common. Book-and-claim systems decouple the physical gas from its environmental attributes, allowing the attributes to be verified and transferred via certificates, without the need for the specific gas molecules to reach the buyer. This decoupling allows for greater flexibility in end users and uses and provides RNG producers with much larger markets (RNG Coalition 2023).

RNG's contribution to the economy includes an estimated 55,000 jobs and $7.2 billion to gross domestic product. In 2024, for every 1 TBtu of RNG generated, 314 jobs were created in the United States (Guidehouse 2024). RNG systems offer socioeconomic benefits, including generating revenue streams and boosting local economies. Along with generating revenues from wastes through the sale of renewable energy products, outputs from biogas systems can offer avoided costs of waste management, on-site electricity, heat, and transportation fuel.

2.8.1 Renewable Natural Gas Production and Potential

The EPA reports that more than 882 million RINs of compressed RNG, about 82.6 million RINs of liquefied RNG, and about 8.6 million RINs of unspecified RNG were consumed in 2024 (EPA 2025d). One RIN is equal to one ethanol-equivalent gallon and RNG receives D3 celluosic RINs. Figure 33 shows the increase in RNG production over the past 10 years due to a combination of more production facilities coming online and increased production at existing plants. The combined 2024 volume corresponds to about 973 million gallons of ethanol equivalent, or roughly 74.8 TBtu. RNG accounted for 86% of the fuel used in on-road natural gas vehicles in 2024 (The Transport Project 2025).

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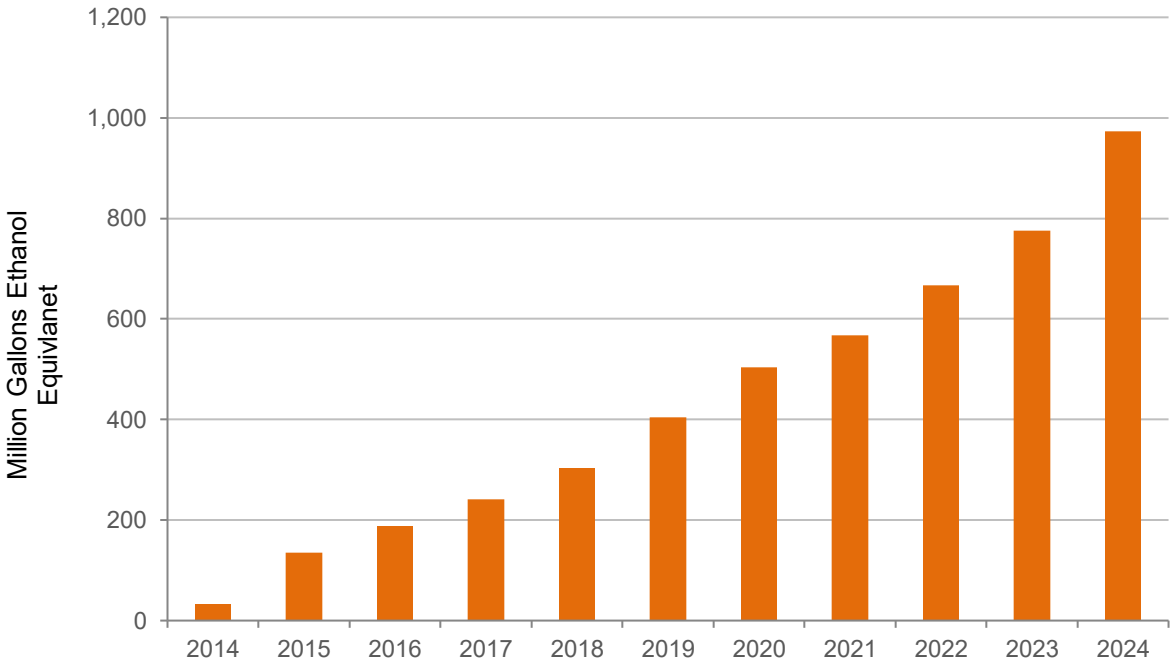

Figure 33. U.S. estimated RNG consumption.

Source: EPA (2025d)

A study funded by the American Gas Foundation evaluated low (10% of available biomass) and high (23% of available biomass) resource utilization scenarios for biogas to RNG through 2050. They estimate that anaerobic digestion potential is 672–3,951 TBtu/yr, and the potential from thermal gasification is between 955 and 12,415 TBtu/yr (American Gas Foundation 2025). Both scenarios assume availability of energy crops that has yet to occur.

Table 5. U.S. 2040 RNG Potential.

Source: American Gas Foundation (2025)

Source	2050 Low Scenario Potential	2050 High Scenario Potential
	TBtu/yr	
Landfill gas	410	1,334
Animal manure	213	2,373
Wastewater	28	97
Food waste	21	147
Anaerobic digestion subtotal	**672**	**3,951**
Agricultural residue	328	2,185
Forestry and forest residue	107	715
Energy crops	345	7,331
Municipal solid waste	175	2,184
Thermal gasification subtotal	**955**	**12,415**
Total	**1,627**	**16,366**

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2.8.2 Other Uses for Renewable Natural Gas

Natural gas utilities are increasingly adding RNG to their pipeline mix to reduce carbon emissions. By the end of 2023, RNG projects produced an estimated 108 TBtu (Argonne National Laboratory 2025). While the majority of RNG is used for transportation, a portion is also used by utilities or private entities. Additional uses being investigated in the United States and abroad include as a direct substitute for liquefied natural gas as a maritime fuel, and as a feedstock to produce SAF via gas-to-liquids pathways (e.g., SkyNRG's Project Wigeon [SkyNRG n.d.]).

2.9 Marine and Rail Biofuels

The International Organization for Standardization 8217:2024 specification for marine fuels was adopted in 2024 enabling the use of up to B100 in nearly every grade of marine fuel applications (both distillates and residual fuel). Marine biofuel feedstocks under consideration include forestry and agricultural residues; energy crops; waste oils, fats, and greases; manure; sewage sludge; landfill gas; algae; and municipal solid wastes. Biofuels accounted for about 1% of global marine fuel use in 2024 based on fuel sampling representative of 65 million metric tons (Bee 2025).

Multiple marine biofuels are being considered, and a multi-fuel future is anticipated. Drop-in fuels would require minimal changes prior to use in existing engines and infrastructure. These include namely renewable diesel and biodiesel, with bio-crude and bio-oil also being investigated. Liquefied RNG, referred to in the maritime industry as bio-liquefied natural gas, is also considered a drop-in substitute for liquefied natural gas within the existing natural gas fleet. Emerging non-drop-in fuels include bio-methanol and lignin-alcohol mixes. Additional non-biofuels being investigated include other varieties of methanol (namely e-methanol), ammonia, and hydrogen. Presently, most U.S. ports are not equipped to supply alternative fuels like biofuels, and a readily available supply chain is still developing (DOE 2024b).

Significant progress has been made in the bunkering and use of marine biofuels through various trails and voyages, demonstrating the viability of biofuels in the maritime sector. In the United States, renewable diesel, biodiesel, and bio-liquefied natural gas have seen successful deployment (Maritime Logistics Professionals 2021; Diesel Direct 2025; Kosmajac 2025; Scania 2025). Additionally, Oak Ridge National Laboratory is actively testing the use of advanced biofuels such as fast pyrolysis and hydrothermal liquefaction biointermediates in marine engines, with preparations to move from laboratory testing to sea trials by 2027 (Bioenergy Technologies Office 2024). Internationally, successful trials and voyages using B100, renewable diesel, bio-methanol, and bio-liquefied natural gas further illustrate biofuel momentum within the maritime industry.

While current biofuel prices are generally higher than fossil marine fuels (e.g., $967–$1,157 per metric ton for biofuels compared to $700 for marine gas oil in 2019), they are projected to decrease by 36%–43% between 2022 and 2040. Strategies to lower costs include utilizing waste feedstocks, improving logistics, coprocessing with fossil fuels, and developing high-value coproducts (DOE 2024b).In 2023, biofuels accounted for 6.1% of Union Pacific's fuel use (Luczak 2024). CSX conducted testing of B20 in 10 locomotives in 2023 (CSX 2023), and

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BNSF started testing B20 80% renewable diesel blends in 2022, which continued in 2024 (BNSF Railway 2024).

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3 Biopower

Biomass power, or biopower, is the use of biomass resources to generate electricity. There are five major types of biopower generation technologies: combustion, co-firing, gasification, anaerobic digestion, and pyrolysis. Combustion is used by most biopower plants today—bioenergy feedstock is burned directly to produce steam that turns an electricity-generating turbine (International Renewable Energy Agency 2012). The steam could also be used for industrial processes or to heat buildings in combined heat and power facilities. Co-firing power plants substitute solid biomass for a portion of the other primary fuel in use. In gasification systems, solid biomass is heated in a restricted supply of air to produce an energy-rich gas that can fuel steam generators, combustion turbines, combined-cycle technologies, or fuel cells. Anaerobic digestion is a biological process in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products of anaerobic digestion is biogas, composed primarily of methane, carbon dioxide, and other trace compounds. The methane is usually burned in a boiler to produce steam for electricity generation or for industrial processes, but it could also power microturbines and gas engines and feed fuel cells. Pyrolysis involves the chemical decomposition of organic materials at elevated temperatures in the absence of oxygen to produce liquid, gas, and char. The resulting pyrolysis oil can be used in traditional power generation and heating applications with minor modifications.

There are also modular bioenergy systems, which are biomass energy systems (e.g., combined heat and power, anaerobic digestion, and gasification) at small scale used in off-grid, distributed-generation applications. Combustion, combined heat and power, anaerobic digestion, and low-percentage co-firing are mature, commercially available technologies, whereas commercial gasification and pyrolysis are in earlier stages of development, demonstration, and deployment.

Biomass electricity generation accounts for nearly 5.2% of all utility-scale renewable energy generated in the United States and about 1.1% of total U.S. electricity generation (EIA 2025e, 2025g). Both installed biopower capacity and generation have been declining over the past 5 years (Figure 34). In 2024 there were 442 biopower plants, and the top five states with the largest biopower generation capacity were Virginia, California, Florida, Georgia, and Alabama (EIA 2025i).

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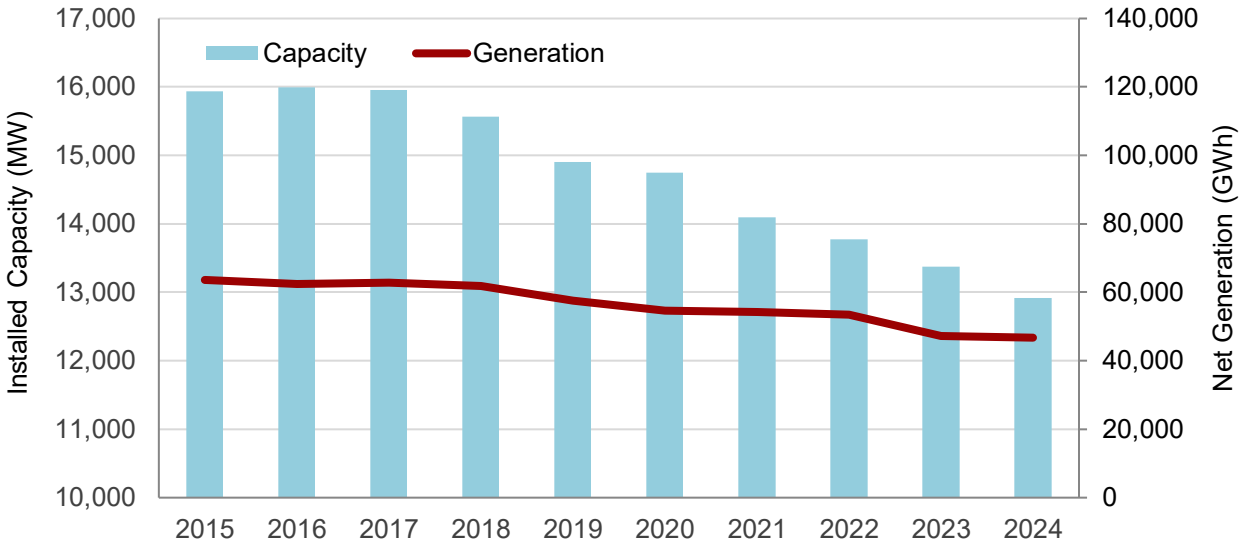

Figure 34. U.S. biopower capacity and generation.

GWh = gigawatt-hour; MW = megawatt

Source: EIA (2025i, 2025n)

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4 Biochemicals and Bioproducts

Biochemicals and bioproducts are two broad categories used to classify products produced from biomass feedstocks. Conventional bioproducts, including building material, pulp and paper, and forest products, have long been available. Emerging bioproducts as a focus of R&D include biochemicals, bioplastics, and bioadhesives. Bioproducts derived from bioresources can be used to produce fuels, chemicals, and plastics. Many biochemical and bioproduct manufacturers currently treat their production and pricing information as confidential because they pursue competitive advantages within this emerging market sector.

The industrial sector is a key enabler for providing the energy and end-use products that use crude oil, natural gas, coal, and biomass to provide basic raw materials for producing the chemicals that are intermediates to most commercial and household products used worldwide. The petrochemical industry has been impacted by energy trends, increasing population, and global economic growth that have led to supply chain imbalances that could potentially lead to increased uncertainty and future investment decisions. Regardless, the petrochemical industry in North America is expected to increase in the next 5 years, driving the production of building block chemicals. With the increasing energy demand and use of end products, the chemical industry has become increasingly vigilant about using alternative non-fossil feedstocks to meet supply chain demand.

Production of bioproducts can (1) enable the production of bioenergy feedstocks as coproducts to improve the economics of the primary fuel product in an integrated biorefinery (Biddy, Scarlata, and Kinchin 2016) or (2) enable industrial learning to develop technologies and processes essential to the long-term production of biofuels and bioenergy. This study assessed a broad range of chemicals and their production from alternative feedstock sources to increase the deployment and scale up the production of these chemicals. The future potential for the 12 selected chemicals along with key drivers and challenges associated with moving toward production of the selected chemicals were evaluted. Furthermore, the study evaluated the impacts of scaling up these technologies on accelerating the production of biofuels.

A 2023 report commissioned by the USDA BioPreferred Program (Golden et al. 2024) provides an analysis of specific bio-based segments within the U.S. economy. The report evaluates agriculture and forestry, biorefining, bio-based chemicals, enzymes, bioplastic bottles and packaging, forest products, and textiles as the seven major bio-based product industries contributing to the U.S. economy. It specifically excludes contributions to the economy from energy, livestock, food, feed, and pharmaceuticals. The report stated that in 2023, U.S. bio-based products accounted for 3.9 million jobs and a $489 billion contribution to the economy (Golden et al. 2024).

Historically, federal incentives and policies have focused on biofuels; however, recent investments under several federal programs are investing in biochemicals and bioproducts (The

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White House 2022). Iowa, Minnesota, and Nebraska also offer bioproducts production tax credits.[17]

Within this context, this report considers four types of biochemicals and bioproducts: wood pellets, platform and intermediate biochemicals, lignin, and biochar.

4.1 Wood Pellets

Wood pellets are made from compacted sawdust or other residue streams of the wood harvesting and processing industries, including, for example, the milling of lumber or manufacture of wood products (World Forest Industries 2023). Chipping, shredding, and milling are typical first-process steps to create a uniform, dough-like material that is fed through a press containing holes of a uniform size. The pressure of the press causes the temperature of the wood to increase greatly, causing the wood's natural lignin to plasticize slightly, forming a natural binder that holds the pellet together as it cools (Walker et al. 2010). The main advantages of pelletizing are the creation of consistent physical and chemical characteristics, including an improvement of the feedstock's homogeneity, quality, flowability, bulk, and energy density.

As of December 2024, there were 94 wood pellet plants in the United States with a total annual capacity of 13.4 million tons employing 2,438 people. A number of different feedstocks are used to produce pellets. In 2024, 15.7 million tons of feedstock were used (Figure 35) to produce approximately 10.5 million tons of wood pellets. Woody feedstock prices ranged between $24 and $39 per ton, and feedstock types used to produce wood pellets include other residuals (41%), roundwood/pulpwood (24%), sawmill residuals (16%), and wood product manufacturing residuals (19%) (Figure 35). Production is concentrated in the South (~85%) due to the availability of feedstocks and proximity for export to European Union nations (EIA 2025i).

In 2024, 10.7 million tons of wood pellets were produced and 8.9 million (83%) were exported (Figure 36 (EIA 2025i).[18] The key market driver for exports is bioenergy policies across northwestern Europe. In 2024, the top exports markets were the United Kingdom (70%), Japan (10%), and the Netherlands (7%) (Krueger 2025). The average domestic and export prices were $220.69 and $195.37 per ton, respectively (EIA 2025i).

[17] For more information on the Iowa Renewable Chemicals Production Tax Credit, visit www.iowaeconomicdevelopment.com/RenewableChem. For more information on the Minnesota Renewable Chemical Production Incentive Program, visit www.mda.state.mn.us/environment-sustainability/renewable-chemical-production-incentive-program. For more information on Nebraska's Chemical Production Tax Credit Act, visit opportunity.nebraska.gov/programs/incentives/renewable-chemical-production/.

[18] USDA reports 2024 exports of 10 million metric tonnes; the report uses EIA data to be consistent with the source for all wood pellet data. (Krueger 2025).

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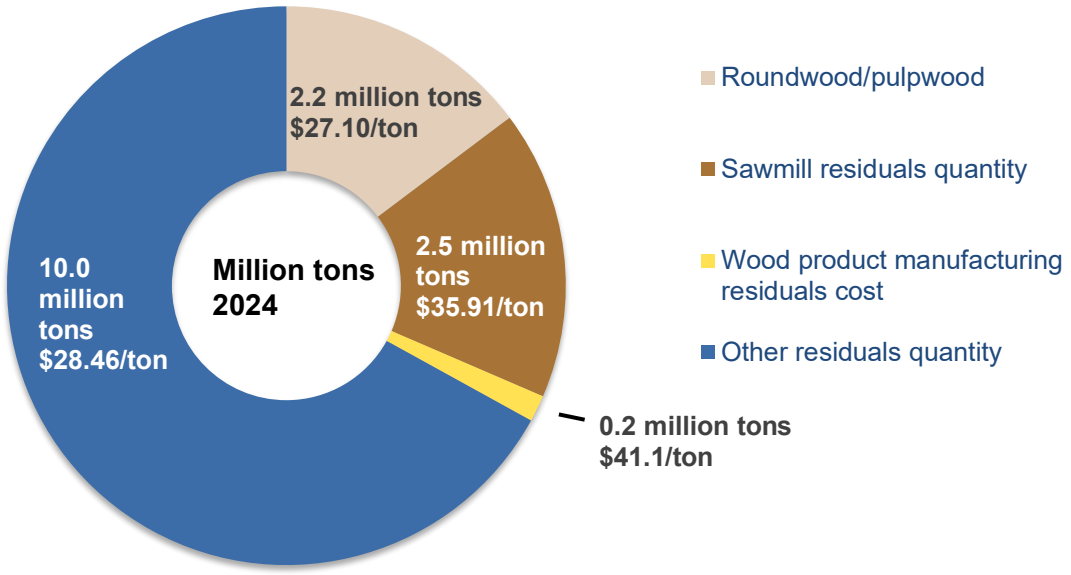

Figure 35. U.S. wood pellet feedstock usage and prices in 2022.

Source: EIA (2025c)

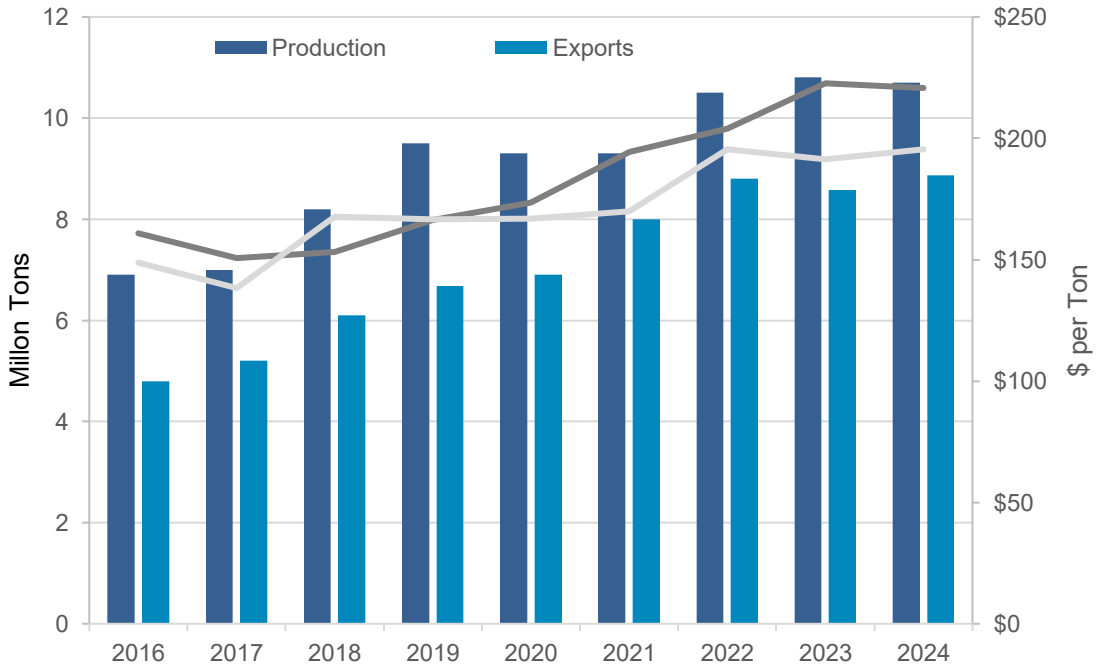

Figure 36. U.S. annual production, exports, and prices of wood pellets.

Source: EIA (2025i)

4.2 Platform and Intermediate Biochemicals

The biochemicals market is an emerging and immature market; thus, market production volumes and prices are unavailable. A nationally accepted system for certifying and tracking production volumes (similar to RINs for biofuels) and competitive market pricing for many biochemicals do not yet exist. Examples of manufacturers producing platform and intermediate chemicals include

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DuPont Tate and Lyle's 1,3-propanediol facility in Tennessee, AGAE Technologies' biosurfactant facility in Oregon, and NatureWorks' polylactic acid facility in Nebraska (DOE 2015). Commercial production of biochemicals is developing to seek out cost advantages (relative to traditional petrochemical production routes), greenhouse gas emissions reductions, and U.S. independence from foreign oil. Additionally, these facilities are stimulating the biomass feedstock supply chain for future producers of biofuels and bioproducts.

Two important reports on chemical analysis include *Chemical Bandwidth Study Exergy Analysis: A Powerful Tool for Identifying Process Inefficiencies in the U.S. Chemical Industry* (Ozokwelu, Porcelli, and Akinjiola 2006) and *Bandwidth Study on Energy Use and Potential Energy Saving Opportunities in U.S. Chemical Manufacturing* (Brueske, Kramer, and Fisher 2015). The 2006 study relied on extensive software simulations to identify the quality of energy consumed in manufacturing chemicals and the amount of energy that could be recovered. The 2015 study compared diverse industrial, academic, and governmental consumption data to analyses of reported plant energy consumption data in the Manufacturing Energy Consumption Survey conducted by the EIA for data year 2010. Additionally, the 2015 study expanded the number of chemical products studied from 44 to 74 and updated energy consumption and production values to 2010.

4.3 Lignin

Lignin is an aromatic heteropolymer that constitutes between 15% and 30% of the mass of plants, making it the second most abundant terrestrial biopolymer behind cellulose and the only large-volume renewable resource composed of aromatics (Ragauskas et al. 2014).

Lignin extraction from biomass is an essential process step prior to ethanol production in both cellulosic biorefineries and the pulp and paper industry. High extents of lignin extraction can be attained, leaving behind relatively pristine carbohydrate pulps suitable for downstream conversion (Humbird et al. 2011). Research progress in lignin valorization (conversion) into saleable products has comparably lagged behind carbohydrate conversion technologies due to the difficulty of further targeted upgrading of extracted lignin. The recalcitrance arises due to the generation of reactive intermediates via the cleavage of labile aryl ether bonds during extraction, which subsequently react to form new C-C bonds. These new linkages are difficult to cleave, making the resulting lignin resistant to further upgrading (Kim et al. 2011). Markets for condensed lignins include dispersants and adhesives, among others, but less than 2% of generated lignin is estimated to be sold as these coproducts, with the majority being burned for process heat in the pulp and paper industry (Bajwa et al. 2019).

Lignin valorization to fuels and chemicals has substantial potential to improve both the economic and environmental viability of biorefineries (Davis et al. 2018; Corona et al. 2018). Aside from fuels, lignin can be converted into high-value products such as polymers, pharmaceuticals, and other fine chemicals (Sun et al. 2018; Afanasenko et al. 2024; Wu, De bruyn, and Barta 2023).

4.4 Biochar

Biochar is a solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment. Biochar, in the form of a charcoal, can be used as a soil amendment and thus represents an avenue for greenhouse gas mitigation by contributing to carbon

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sequestration when applied to soils (Hofstrand 2010). Because pyrolysis is one of the conversion pathways used to produce biofuels, biochar can be produced as a coproduct with biofuels produced via pyrolysis.[19] While the process for producing biochar is similar to that used for producing fossil-based charcoal, the primary use of charcoal is as a fuel for the production of heat, thus differentiating charcoal as a product from biochar based on application (International Biochar Initiative 2015).

The pyrolysis process is the thermal decomposition of organic materials in an oxygen-free environment at about 300°C to 600°C. This process converts biomass into biochar, pyrolysis gas, and bio-oil products. During pyrolysis, the lignocellulosic components (cellulose, hemicellulose, and lignin) go through different stages, including depolymerization, fragmentation, and cross-linking, resulting in a variety of products. The solid and liquid products comprise the char and bio-oil, and gaseous products are pyrolysis gas (C_1–C_2 hydrocarbons), carbon dioxide, and carbon monoxide. The biochar yield depends on operational conditions, including temperature, residence time, heating rate, and pressure, among which temperature is the main parameter. Increasing temperature leads to a decrease in biochar yield and an increase in pyrolysis gas. However, higher temperature also leads to higher stable carbon in biochar, which is a desirable property if long-term carbon sequestration in biochar and soil is the driving factor for the production and application of biochar from biomass.

Pyrolysis can be classified as either fast or slow pyrolysis depending on the heating rate, temperature, residence time, and pressure. Fast pyrolysis has a high heating rate (>100°C/second and liquefies solid biomass into bio-oil, which can be converted to fuel products. In slow pyrolysis the rate of heating is low (e.g., around 1°C/second), which produces more biochar than other coproducts, such as pyrolysis gas. It should be noted that the small amount of bio-oil produced during slow pyrolysis is different from the energy-rich bio-oil from fast pyrolysis (Brown, Wright, and Brown 2011). In practice, condensable liquids or bio-oil from slow pyrolysis are not expected to be recovered as coproducts; these liquids are typically burned with pyrolysis gas for process energy.

Biochar production is assumed to be co-located with a corn starch ethanol plant and employs slow pyrolysis conversion using corn stover as feedstock. The bolt-on slow pyrolysis process is energy self-sufficient and generates extra pyrolysis gas. One of the options for using the extra pyrolysis gas could be the displacement of natural gas with pyrolysis gas to meet process heat demand at the corn starch ethanol facility. This strategy could help reduce the carbon intensity of corn ethanol production in addition to the carbon sequestered in biochar when applied to cropland.

A study by Thengane et al. (2021) investigated the cost, market, and barriers of commercial-scale biochar production and application in California using locally available agricultural and forestry biomass. Given the large variations in feedstock cost as well as differences in technology and capacity, the study found that biochar production cost in California could range from $200 to $1,000 per U.S. ton, with an average of around $400 per U.S. ton for most

[19] Pyrolysis oil is sold in the Northeastern United States as renewable heating oil, which could enable the production of biochar as a coproduct for sale as a bioproduct (Butcher 2015).

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producers. Detailed techno-economic analyses for commercial-scale biochar production via slow pyrolysis using corn stover are scarce.

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Appendix A. U.S. Environmental Protection Agency Renewable Identification Number Data

Table A-1. 2022 Renewable Identification Number Generation.

Source: EPA (2025d)

Fuel	Equivalence Value	Cellulosic Biofuel (D3)		Biomass-Based Diesel (D4)		Advanced Biofuel (D5)		Renewable Fuel (D6)		Cellulosic Diesel (D7)	
		RINs	Volume (gal)	RINs	Volume (gal)	RINs	Volume (gal)	RINs	Volume (gal)	RINs	Volume (gal)
Ethanol	1	43,714,475	43,714,475			28,685,489	28,685,489	14,879,187,703	14,879,187,703		
Liquid propane gas	1.1					1,022,782	929,082				
Biodiesel	1.5			3,119,775,469	2,079,829,5i0						
Naphtha	1.4, 1.5					94,873,780	929,802				
Heating oil	1.6			157,995	98,746	4,449,630	2,781,013				
Renewable jet fuel	1.6			178,987,792	111,864,983						
Renewable gasoline								3,930,434	2,620,288		
Non-ester renewable diesel	1.6, 1.7			5,905,934,921	3,504,984,865	114,700,322	67,470,770				
Cellulosic heating oil	Equivalence value application required									283,259	283,259
Renewable compressed natural gas	n/a	880,960,893	880,960,893			114,700,322	114,700,322				
Renewable liquefied natural gas	n/a	82,642,184	82,642,184								
Renewable natural gas	n/a	9,820,158	9,820,158								

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