

Biofuels

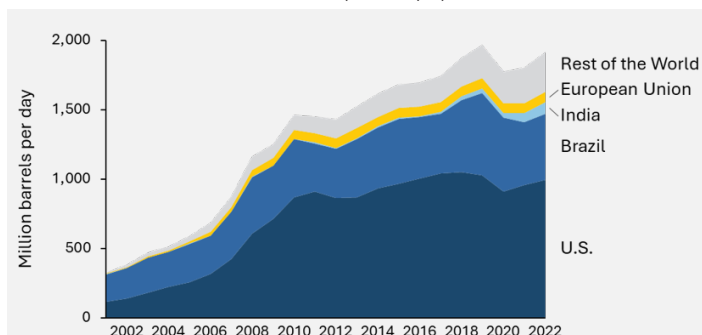
Biofuels, primarily ethanol, biodiesel, and renewable diesel,¹ are liquid fuels produced from biological sources, including plants, animal fat, and algae.² Ethanol is an alcohol with a long history of use in engines, dating back to 1826.³ The use of ethanol in the U.S. has expanded over time because of its combustion performance as well as desires for energy independence and lower environmental impact under Renewable Fuel Standards (RFS).³ Biodiesel and renewable diesel are two types of biofuels that can be used in diesel engines.¹ They are both produced from plant or animal fat feedstocks.^{4,5} Biodiesel is normally blended to 5% (B5) or 20% (B20) with fossil diesel and is not often used in pure (B100) form.⁶ Renewable diesel is not blended and can be used as a drop-in replacement for fossil diesel; most renewable diesel in the U.S. is used in California.¹ Biofuels can reduce energy and greenhouse gas emission intensities associated with transportation, but may have significant societal and environmental effects. Depending on demand, crop conditions, and technology, they may require significant increases in cropland area and irrigation water use, and can affect food prices.

Patterns of Use

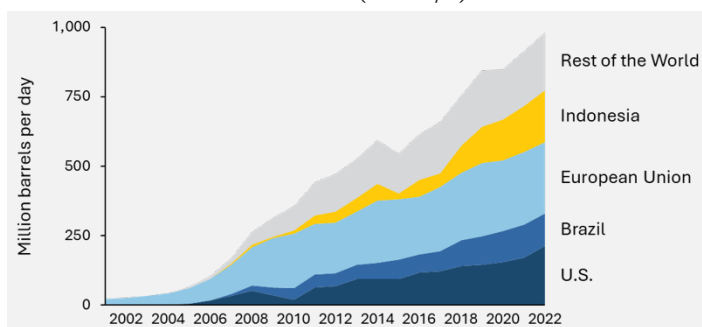
Production

- Ethanol, an alcohol blended with gasoline for vehicle fuel, is the most produced (82%) and used (75%) biofuel in the U.S.⁷
- The U.S. and Brazil produced 79% of global ethanol in 2024.⁸ 94% of U.S. ethanol is derived from corn,⁹ while Brazil uses sugarcane to produce ethanol.⁹

World Ethanol Production (M bbl/d)⁸

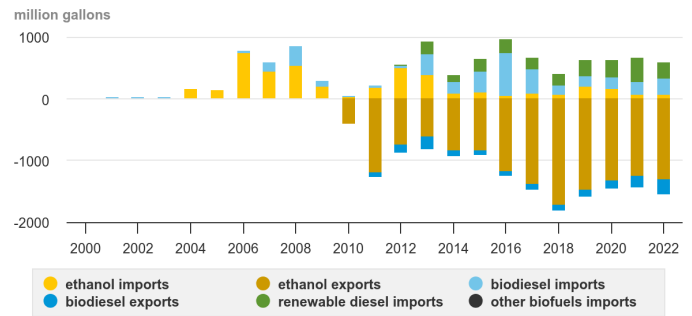


World Biodiesel Production (M bbl/d)⁸



Net Export Record for Biofuels⁵⁴

U.S. biofuels imports and exports by major type, 2000-2022

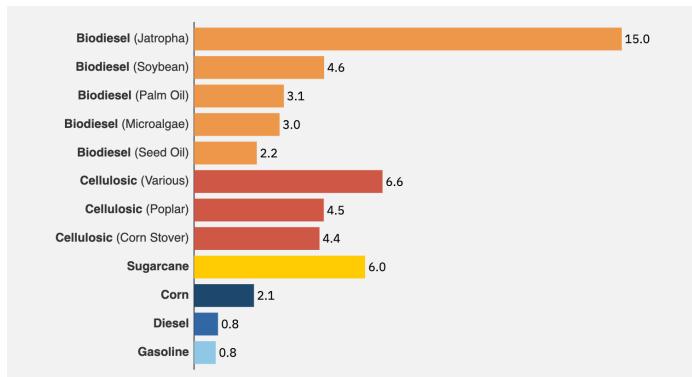


- In the 2024/25 season, 5.5B bushels of corn, 36% of the U.S. corn supply, were used as ethanol feedstock.¹⁰ U.S. ethanol production has plateaued, as producers have hit the 'blend wall', the limit of 10% ethanol that can be mixed into standard E10 gasoline.^{11,12,13} The U.S. has 191 ethanol refineries, with a total production capacity of 18,477 Mgal/yr.¹⁸
- Cellulosic ethanol is made from secondary sources like corn stalks, plant residue, waste wood chips, and switchgrass. Production is more difficult because cellulose does not break down into sugars easily.¹⁴ The U.S. has no commercial cellulosic ethanol production as of 2025, and international production has lagged expectations.¹⁵
- Biodiesel and renewable diesel accounted for 24% of U.S. biofuel production in 2024.⁸ Common U.S. feedstocks include soybean oil, corn oil, and recycled cooking oils.¹⁶ The U.S. has 48 biodiesel production plants, with a total production capacity of 1,986 Mgal/yr.¹⁹ The U.S. has 19 renewable diesel production plants, with a total capacity of 4,719 Mgal/yr.²⁰
- Algal biofuel is being researched, as it could potentially produce 10-100 times more fuel per acre than other crops.¹⁷
- Many biodiesel producers depend on federal tax credits and remain sensitive to feedstock (soybean oil) and energy (petroleum) prices. The Inflation Reduction Act (IRA) reinstated and extended several biofuel tax incentives through 2027, which were extended again through 2029.^{21,22,23}

Use and Demand

- Over 98% of U.S. gasoline contains ethanol,⁹ and 10% of U.S. vehicle fuel use (by volume) is ethanol.²⁴
- E85 (flex fuel) sells for less than regular gasoline but contains less energy per gal, reducing fuel economy by 15-27%.²⁵
- The U.S. is forecast to remain the largest producer and consumer of biofuel by 2030, with similar demand as 2024.²⁶
- Demand for biofuels is expected to grow significantly in major markets from 2024 to 2030: Brazil and Europe (30%), Indonesia (50%), and India (80%).²⁶ Biofuel demand is expected to grow by 18% globally from 2024 to 2030.²⁶
- The latest annual renewable fuel standard set by the U.S. EPA requires production of 27 Bgal of biofuels in 2027, a 31% increase from 2022.^{27,28}

Fuel Return on Fossil Energy Investment^{29,30,31,32}



- In 2024, ethanol prices dropped 25% while biodiesel and renewable diesel prices fell over 35% from 2022 levels, primarily a result of lower feedstock costs, with price declines for sugar (-10%), corn (-35%), and vegetable oils (-30%).⁵³

Lifecycle Impact

Energy

- The Fossil Energy Ratio (FER) is the ratio of energy output to nonrenewable energy inputs.²⁹ Gasoline has a FER of 0.8 (1.2 Btu of fossil fuel needed per 1 Btu at the pump).³³ Ethanol's FER is about 1.5, though highly efficient corn regions like Iowa and Minnesota achieve FERs near 4.³⁴
- From 1990-2006, soybean biodiesel's FER improved from 3.2 to 5.5,³⁵ while ethanol transitioned from an energy sink to net energy gain, largely through reduced fertilizer inputs for corn production.³⁴ In comparison, petrodiesel has a FER of 0.83.³⁶

Greenhouse Gases (GHGs)

- Globally, biofuels replaced 2M barrels of oil equivalent per day in 2022, 4% of the global transportation sector oil demand.³⁷ GHG emissions from corn ethanol average 39% lower than gasoline, and NG-fueled refineries achieve a 43% reduction.³⁸
- B20 (20% biodiesel, 80% petroleum diesel), a common U.S. blend,³⁹ reduces CO₂ emissions by 15% compared to petroleum diesel, while B100 (pure biodiesel) reduces emissions by 74%.⁴⁰
- Biodiesel CO₂ emissions are assumed to be reabsorbed by new feedstock growth,⁴¹ so tailpipe CO₂ emissions from biofuels are excluded from emissions calculations.⁴²
- Increased U.S. biofuel production may increase global GHG emissions due to indirect land use changes, where higher crop prices motivate farmers elsewhere to convert non-cropland to cropland, releasing stored carbon.⁴³

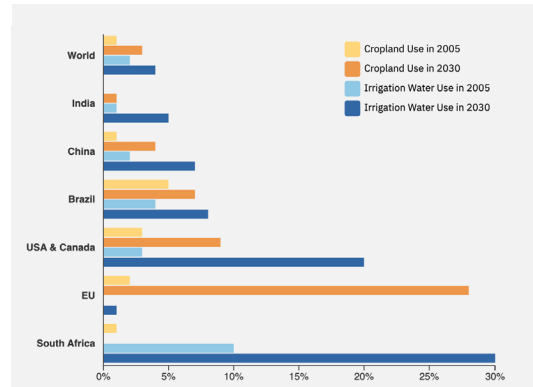
Other Impacts

- Land use change resulting from an increase in biofuel demand in the E.U. has been estimated to increase global corn and wheat prices 1-2% and vegetable oil prices by around 10%.⁴⁴
- Bioethanol requires an area the size of Mississippi to produce

4% of U.S. transportation fuel.⁴⁵

- Large corn producers disproportionately capture government incentives, making small scale farmers, who are more likely to be non-white, less profitable.⁴⁵
- Biofuel refineries output volatile organic compounds (VOCs) and ozone into the air, which can cause respiratory issues for nearby residents.⁴⁵
- Water intensity is generally higher for biofuels than fossil fuels but is extremely variable.⁴⁷ The average use of surface and groundwater for ethanol and biodiesel production in Europe is

Cropland and Irrigation for Biofuels, 2005 & 2030⁴⁶



than fossil alternatives.⁴⁸

- Feedstock irrigation accounts for over 80% of water used in corn-ethanol production in most U.S. states.⁴⁹
- Ethanol feedstock demand was estimated to increase U.S. corn prices by 22% to 34% in 2024.^{8,12}

Solutions and Sustainable Actions

- U.S. ethanol producers, blenders, and resellers have been supported by tax incentives, some of which were extended in 2022 by the IRA and then further extended through 2029.^{21,22,50} Producers can qualify for up to \$1/gal of non-aviation fuel and \$1.75/gal of aviation fuel.⁵⁰
- Fuel content standards are one policy option to encourage biofuel use. Regular gasoline sold in Brazil is required to contain 27% ethanol.⁵¹
- Strategies to reduce the carbon intensity of corn ethanol production include adoption of precision agriculture systems, retention of soil carbon, use of alternative energy, and increased demand for ethanol production co-products.⁵²
- Public transportation, carpooling, biking, and telecommuting are excellent ways to reduce transportation energy use and related impacts. See [Personal Transportation Factsheet](#).