



FOCUS FORWARD

2020 POCKET GUIDE
TO ETHANOL

THE POCKET GUIDE TO ETHANOL

is a quick reference of significant statistics for American-made fuel ethanol. It is a companion to the Renewable Fuels Association's more comprehensive 2020 Ethanol Industry Outlook, found online at <https://EthanolRFA.org/publications/outlook/>.

THE RFA has been the leading trade association for the U.S. ethanol industry for nearly 40 years. Our focus is on driving expanded demand for American-made renewable fuels and bio-products worldwide. Membership includes grain-based and advanced ethanol producers, the ethanol value chain, academia, and industry advocates.

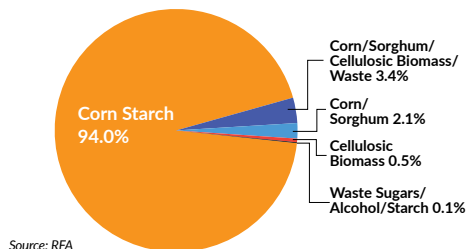


Geoff Cooper
RFA President & CEO

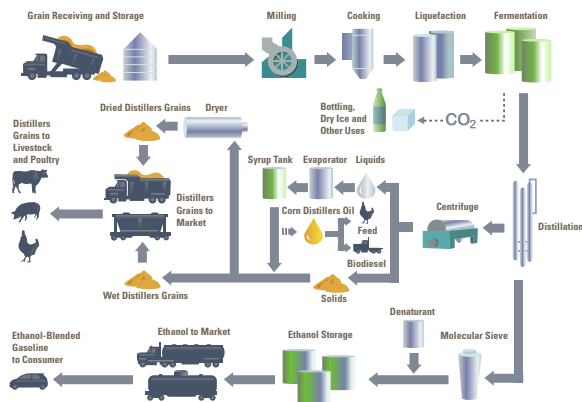
WHAT IS ETHANOL?

Ethanol is a renewable, biodegradable, high-octane and low-carbon motor fuel derived from the sugars, starches, and cellulosic matter found in plants. Most U.S. ethanol is made from corn and processed through dry milling.

U.S. Ethanol Production by Feedstock Type



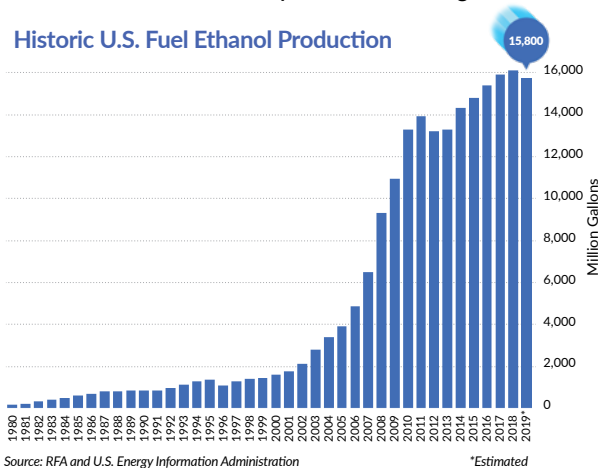
Dry Mill Ethanol Process



WHERE IS ETHANOL MADE?

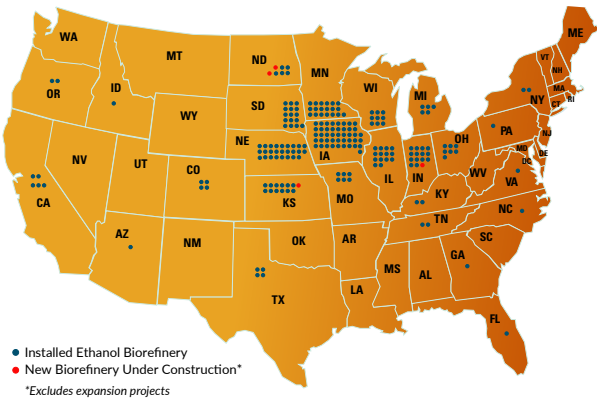
The United States led the world in ethanol production in 2019 with an estimated output of 15.8 billion gallons.

Historic U.S. Fuel Ethanol Production



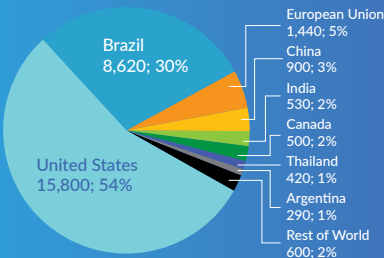
Twenty-six states are home to 205 biorefineries, although half of total nameplate capacity is found in Iowa, Nebraska, and Illinois alone.

U.S. Fuel Ethanol Biorefineries by State



2019 Global Fuel Ethanol Production by Country

(Country, million gallons, share of global production)



Source: RFA analysis of public and private data sources

Historical Biorefinery Count and Production Capacity

	Installed Ethanol Biorefineries	Total Installed Production Capacity (mg)	Average Capacity per Biorefinery (mg)
1999	50	1,799	36.0
2004	79	4,398	55.7
2009	191	13,028	68.2
2014	213	15,077	70.8
2019	205	16,964	82.8

Source: RFA

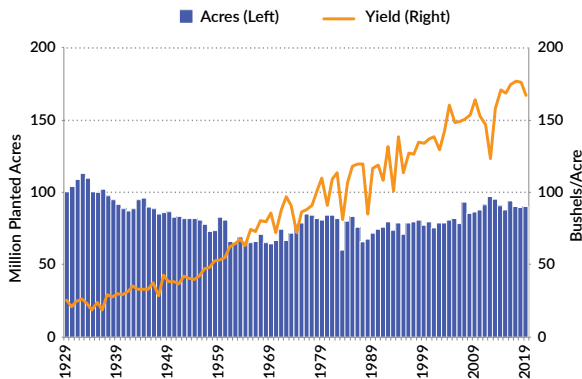
*As of December for each year specified



EFFICIENT PRODUCERS

American farmers are becoming more efficient at growing crops, harvesting a robust 168 bushels of corn per acre in 2019, for a total production of 13.7 billion bushels. Meanwhile, agricultural producers have been reducing per-bushel inputs like land, fertilizer, and water.

U.S. Corn Acreage and Average Yield



Source: RFA using U.S. Dept. of Agriculture data

Ethanol producers, too, have been making significant gains in yields and reducing energy inputs. Corn ethanol has a positive net energy balance: on average, dry mill biorefineries produce roughly 2.7 units of energy for every unit of fossil energy used to produce it. The most efficient plants edge closer to 4:1.

Energy production is not the only output at ethanol plants.

On average, 1 bushel of corn processed by a dry mill ethanol biorefinery produces:

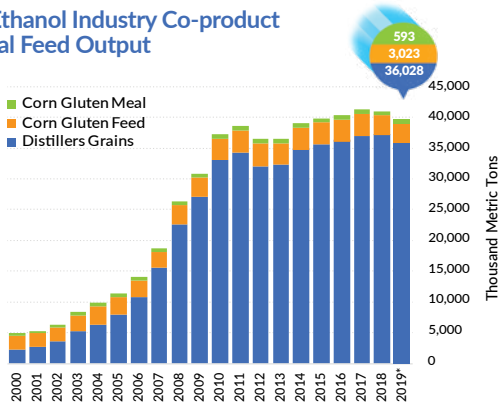
- 2.92 gallons of **denatured ethanol**
- 15.86 pounds of **distillers grains** animal feed (10% moisture)
- 0.80 pounds of **corn distillers oil** for biodiesel production & animal feed
- 16.5 pounds of **biogenic carbon dioxide** for food/beverage & industrial markets.



UNLOCKING NEW PRODUCTS

The U.S. ethanol industry generated 39.6 million metric tons of distillers grains and gluten feed/meal. These bio-products are valuable corn and soybean meal substitutes in animal rations around the world.

U.S. Ethanol Industry Co-product Animal Feed Output

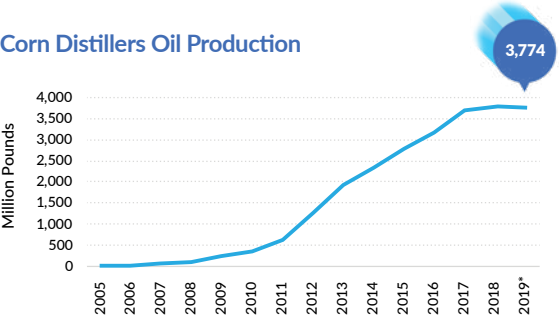


Source: RFA based on data from U.S. Dept. of Agriculture.
Note: All co-products converted to 10% moisture basis. *Estimated

Ethanol plants extracted 3.8 billion pounds of corn distillers oil—a nearly \$1 billion market underpinning the production of biodiesel and animal feed.

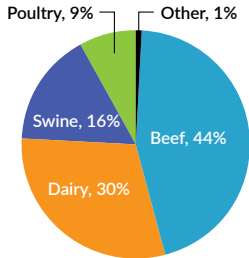


Corn Distillers Oil Production



Source: RFA based on U.S. Dept. of Agriculture data
*Estimated

Distillers Grains Consumption by Species



Source: Distillers grains marketing companies

Biorefineries captured 5.8 billion pounds of high-grade biogenic CO₂ for food/beverage and industrial markets. And, in a pivotal step toward fighting climate change, the industry is actively engaged in promoting the groundbreaking deployment of carbon capture and sequestration.

FOCUS ON THE RURAL ECONOMY

With trade policy decisions that hampered global crop marketing and bad weather wreaking havoc across the Corn Belt, 2019 was a year that many in rural America are glad to have in the rear-view mirror. This is why a flourishing ethanol industry remains of vital importance.



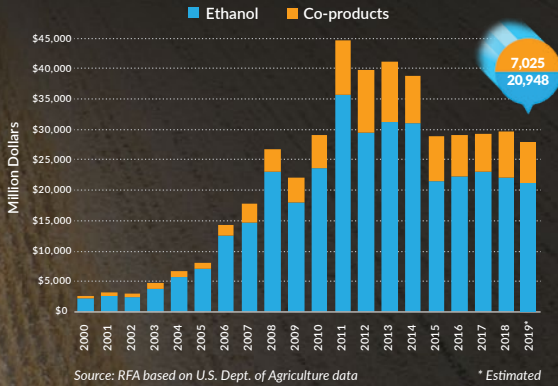
Ethanol's Value-Added Proposition

Based on average prices and product yields in 2019, a typical dry mill ethanol plant was adding roughly \$1.20 of additional value--or 31%--to every bushel of corn processed.

CORN COST PER BUSHEL \$3.90	VALUE OF OUTPUTS PER BUSHEL	
	Ethanol.....	\$3.82
	Distillers Grains.....	\$1.11
	Corn Distillers Oil.....	\$0.17
	TOTAL	\$5.10

The impact of this value-added proposition ripples throughout rural America in terms of higher tax revenues and GDP, as job creation and higher household incomes.

Gross Value of U.S. Ethanol Industry Output



- In 2019**, the production of 15.8 billion gallons of ethanol and 39.6 million metric tons of co-products and distillers oil had substantial economic impacts, including:
- **68,684** direct jobs
 - **280,327** indirect and induced jobs
 - **\$43 billion** contribution to GDP
 - **\$23.3 billion** in household income

Notably, 1 in 5 employees is a military veteran—triple the national average.

ENERGIZING GLOBAL MARKETS

The United States is the world leader in the export of ethanol. Shipments declined modestly in 2019 to an estimated 1.5 billion gallons, second only to the record 1.7 billion gallons shipped in 2018. This means one of every 10 gallons produced was shipped outside our borders, with half of exports destined for Brazil and North America.

TOP 5 Destinations for U.S. Ethanol in 2019

- Brazil
- Canada
- India
- South Korea
- Colombia



Source: RFA based on based on U.S. Dept. of Commerce & U.S. Census Bureau Jan.-Nov. data

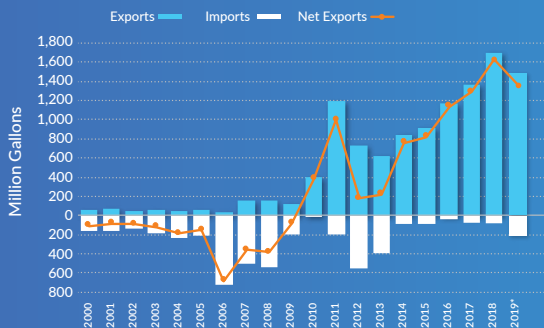
U.S. biorefineries satisfied growing domestic animal food needs while also exporting nearly one of every three tons of distillers grains produced, or 10.9 million metric tons. In 2019, four countries purchased half of all U.S. DDGS exports, while remaining volumes shipped to another 50 around the globe.

TOP 5 Destinations for U.S. Distillers Grains in 2019

- Mexico
- South Korea
- Vietnam
- Indonesia
- Turkey

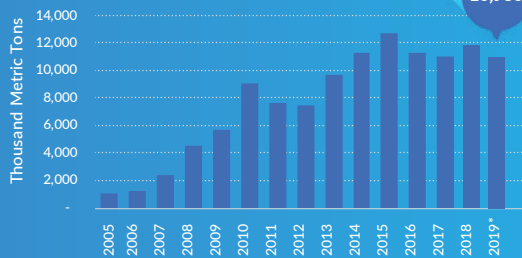
Source: RFA based on based on U.S. Dept. of Commerce & U.S. Census Bureau Jan.-Nov. data

U.S. Ethanol Exports and Imports

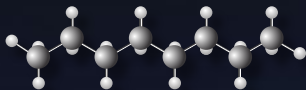


Source: RFA based on data from U.S. Dept. of Commerce & U.S. Census Bureau
*Estimated based on Jan.-Nov. 2019 data

U.S. Distillers Grains Exports



Source: RFA based on data from U.S. Dept. of Commerce & U.S. Census Bureau
*Estimated based on Jan.-Nov. 2019 data

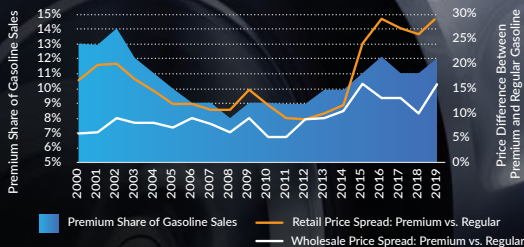


A CLEAN SOURCE FOR OCTANE

A fuel's octane rating is the measure of its ability to resist "knocking" in the engine, which is caused when the air/fuel mixture detonates prematurely during combustion. According to the U.S. Department of Energy, "Using a lower octane fuel than required can cause the engine to run poorly and can damage the engine and emissions control system over time. It may also void your warranty."

Automakers are increasingly using turbocharged, higher-compression engines requiring the use of high-octane gasoline. This higher demand has bumped the price spread between premium and regular gasoline in 2019 to the highest level in at least two decades.

Premium Gasoline: Share of Sales and Price Difference vs. Regular

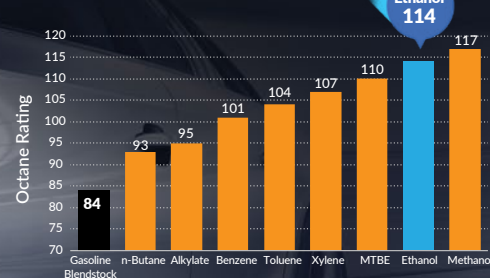


Source: RFA based on U.S. Energy Information Administration data

Ethanol is helping to hold down the cost of both regular and premium gasoline. According to a study by Dr. Philip K. Verleger, Jr., consumers saved an average of \$0.22/gallon from 2015-2018 as a result of the use of ethanol.

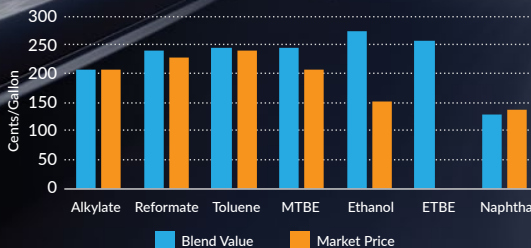
Ethanol has a blending octane rating of 114—the highest value of any major source. In 2019, ethanol traded at the largest discount to its blending value, retaining the title of the most cost-competitive source of octane in the world.

Blending Octane Ratings of Various Gasoline Octane Boosters



Source: U.S. Department of Energy

Octane Blending Value vs. Market Price

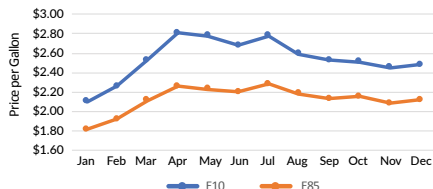


Source: Argus Media

FOCUSING BEYOND E10

Since its approval by EPA seven years ago, more than 10 billion trouble-free miles have been driven on E15. E15 typically has an octane rating of 88 and costs less than regular unleaded.

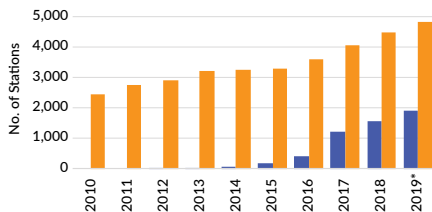
2019 National Average Retail Prices for E10 & E85



Source: RFA based on data from E85prices.com

In 2019, President Trump made good on his word and issued a rule allowing E15 to be sold year-round nationwide. As a result, E15 sales grew significantly, fueled by a 10% uptick in stations offering E15 and widespread automaker approval. As a result, E15 sales (about 450 million gallons) surpassed E85 sales (425 million gallons) for the first time. An expanding availability of E85 blender pumps was not enough to buoy significantly decreased flex fuel vehicle production and historically low RIN prices.

Expansion of U.S. Retail Stations Offering E15 and E85



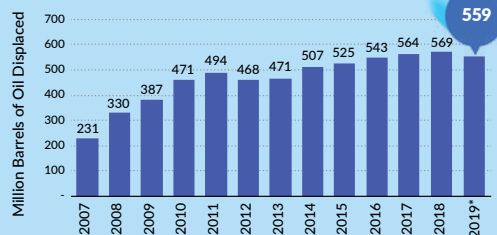
Source: RFA

*Estimated

A SECURE ENERGY SOURCE

Energy security remains an enduring concern, a reminder of which was provided by the September 2019 attacks on two key Saudi Arabian oil installations. Despite the recent expansion of U.S. oil production, the U.S. sent some \$35 billion—or \$275 per American household—to OPEC nations to pay for crude oil imports in 2019 alone. The addition of 15.8 billion gallons of ethanol to the U.S. fuel supply displaced 559 million barrels of oil. Without ethanol, U.S. import dependence would have been equivalent to 10% of petroleum demand.

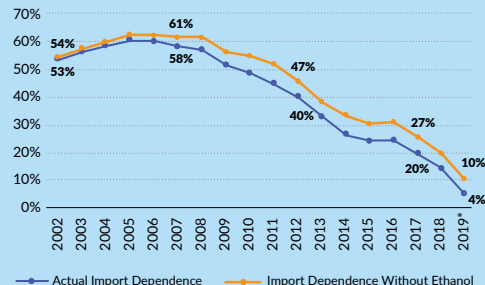
Historic Oil Import Displacement by Ethanol



Source: RFA based on U.S. Dept. of Energy data

*Estimated

U.S. Petroleum Net Import Dependence with and without Ethanol



Source: RFA based on U.S. Dept. of Energy data

*Estimated

LOW CARBON SOLUTION

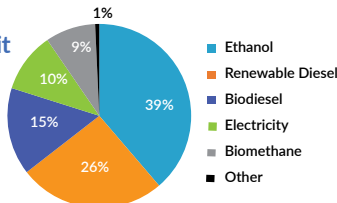
The Renewable Fuel Standard has been an important and effective policy for our climate, reducing CO₂-equivalent GHGs by an astounding 600 million metric tons over the last 15 years. That is the equivalent of removing about half of the cars on the road in America for one year or eliminating the annual emissions from 13 coalfired power plants.

In addition to reducing GHG emissions, ethanol is the best tool available to reduce tailpipe emissions of other harmful pollutants. Adding ethanol to gasoline reduces tailpipe emissions of the following pollutants, among others:

- **Carbon monoxide**, which can cause harmful health effects by reducing oxygen delivery to the body's organs.
- **Exhaust hydrocarbons**, which contribute to ozone, irritate the eyes, damage the lungs, and aggravate respiratory problems.
- **Air toxics like benzene**, which can cause cancer and reproductive effects or birth defects.
- **Fine particulate matter**, which can pass through the throat and nose and enter the lungs, causing serious health effects.

Corn ethanol from a typical dry mill has 35-50% lower GHG emissions than gasoline (this includes theoretical land use change emissions). As a result, the industry is responsible for 22 million metric tons of GHG reduction from California's transportation sector since 2011—more than any other low carbon fuel.

California LCFS Credit Percentage by Fuel, Q1 2011 - Q2 2019



Source: RFA using California Air Resources Board data

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