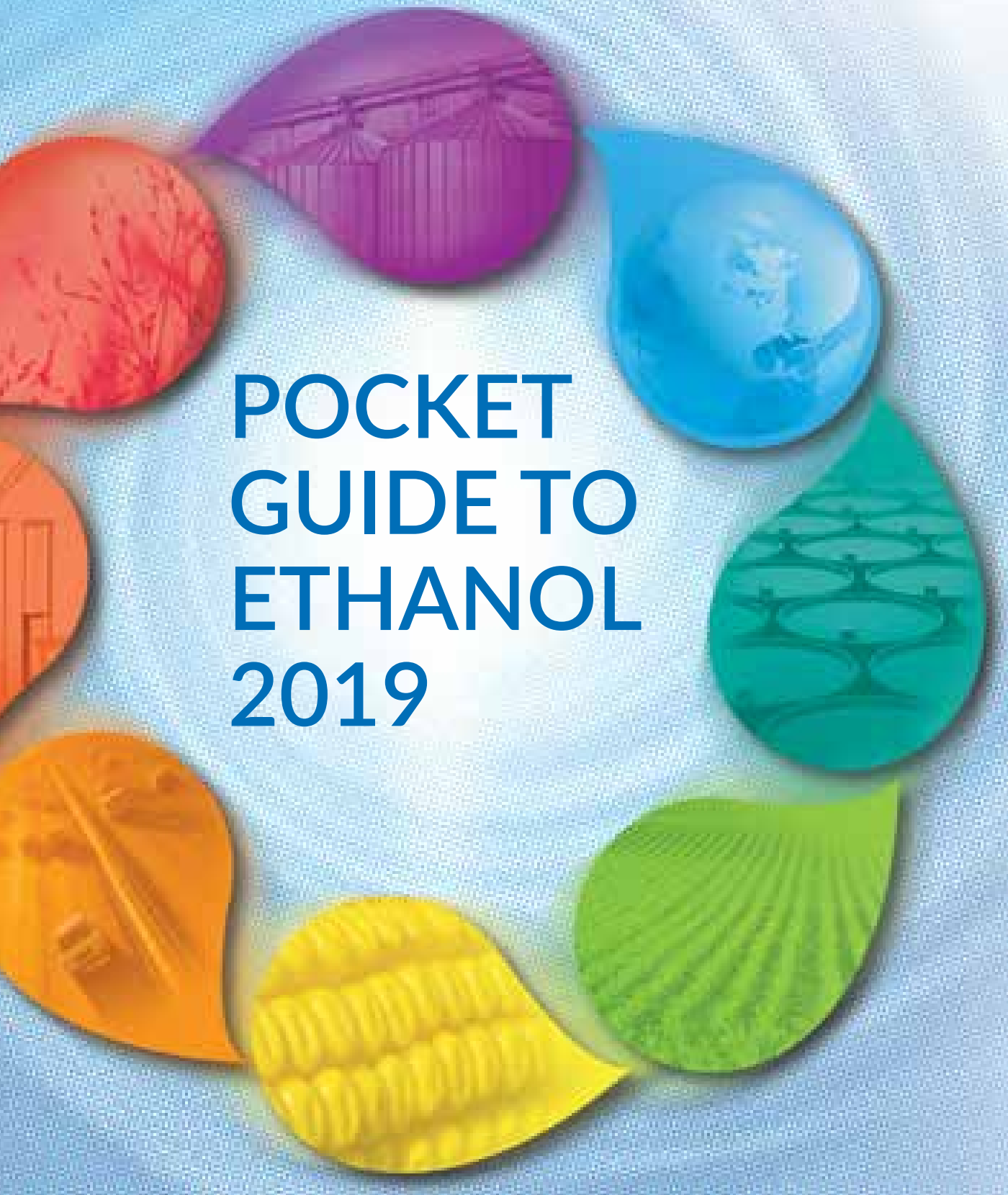
RFA RENEWABLE FUELS ASSOCIATION



POCKET GUIDE TO ETHANOL 2019

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 (RFA) more comprehensive *Annual Ethanol Industry Outlook* publication. Find both resources online at https://EthanolRFA.org/resources/publications.

RFA has been the leading trade association for America's fuel ethanol industry for nearly 40 years. Our focus is on advancing the development, production and use of ethanol and bio-products worldwide. RFA's membership includes grain-based and advanced ethanol producers, the ethanol value chain, academia, and industry advocates.

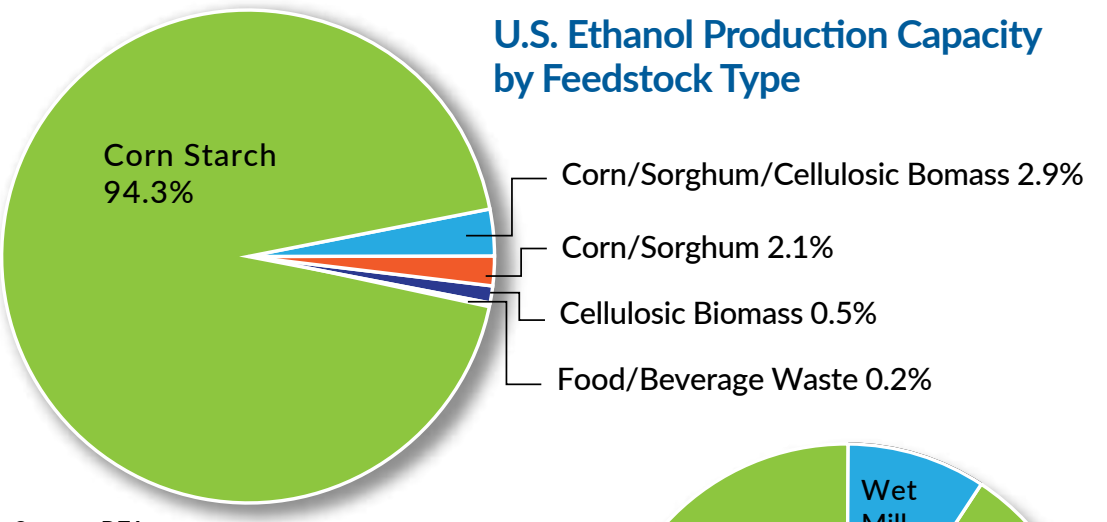
Geoff Cooper
RFA President & CEO

WHAT IS **ETHANOL?**

Ethanol is a biodegradable, high-octane motor fuel derived from the sugars, starches, and cellulosic matter found in plants. Most U.S. ethanol today is made from corn through the dry mill process. Corn production in 2018 neared record highs, but land dedicated to growing the feedstock has moved lower.

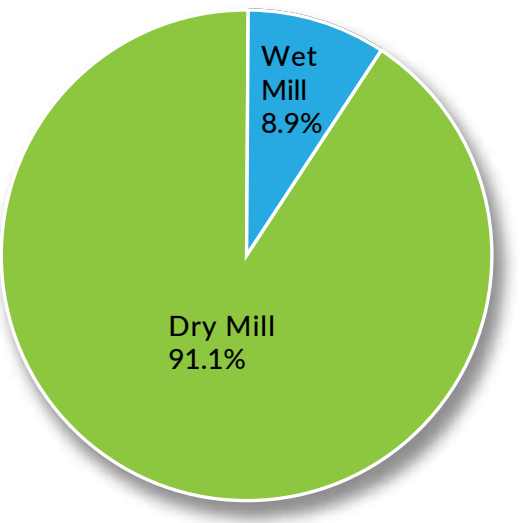
The industry continues to evolve with some plants adopting "bolt-on" technologies and integrating new process/refining technologies to capture more value-added co-products.

U.S. Ethanol Production Capacity by Feedstock Type



Source: RFA

U.S. Fuel Ethanol Production by Technology Type

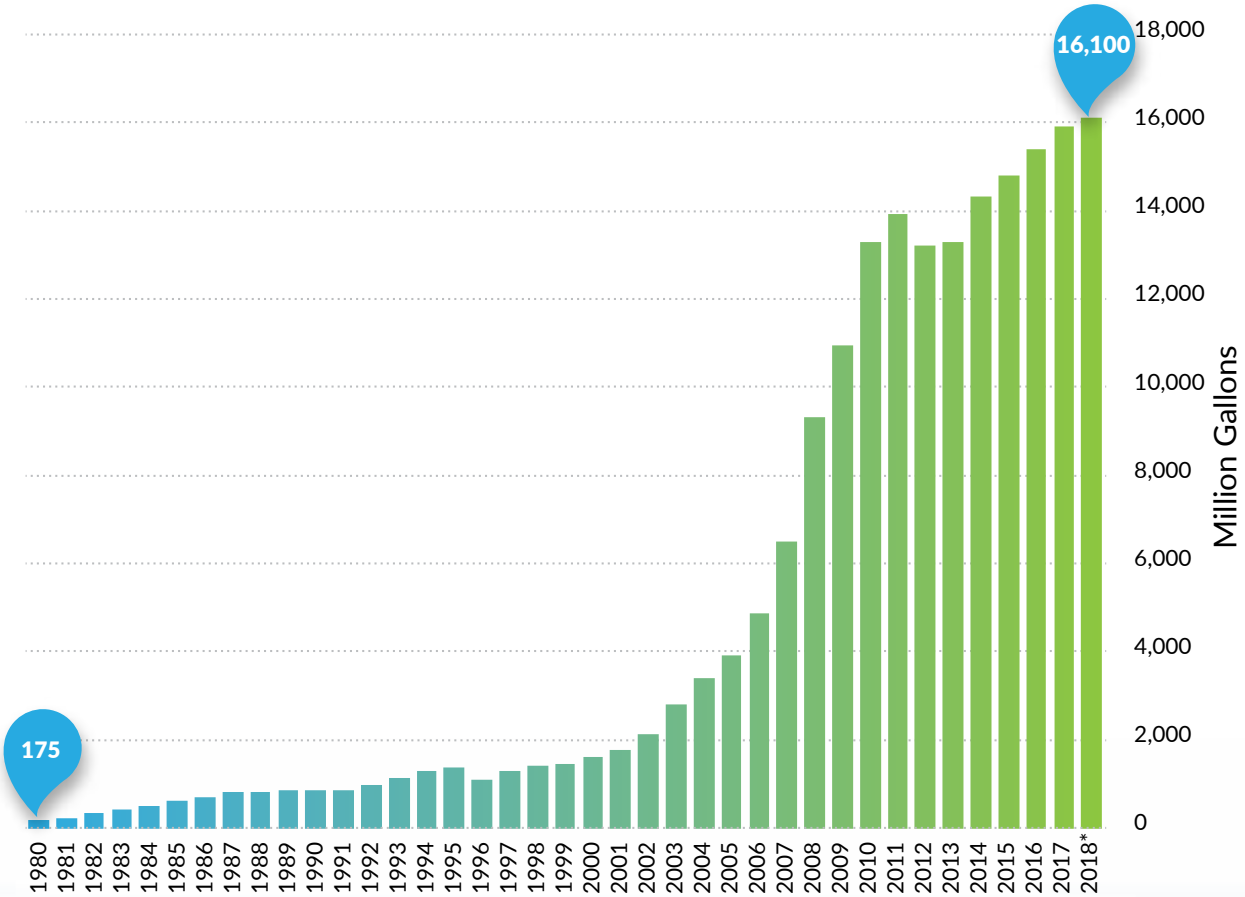


Source: RFA based on data from U.S. Dept. of Agriculture

POWERING FORWARD

The United States led the world in ethanol production in 2018 with a record output of 16.1 billion gallons. In fact, output was double the volume generated by Brazil—the world's second largest producer.

Historic U.S. Fuel Ethanol Production

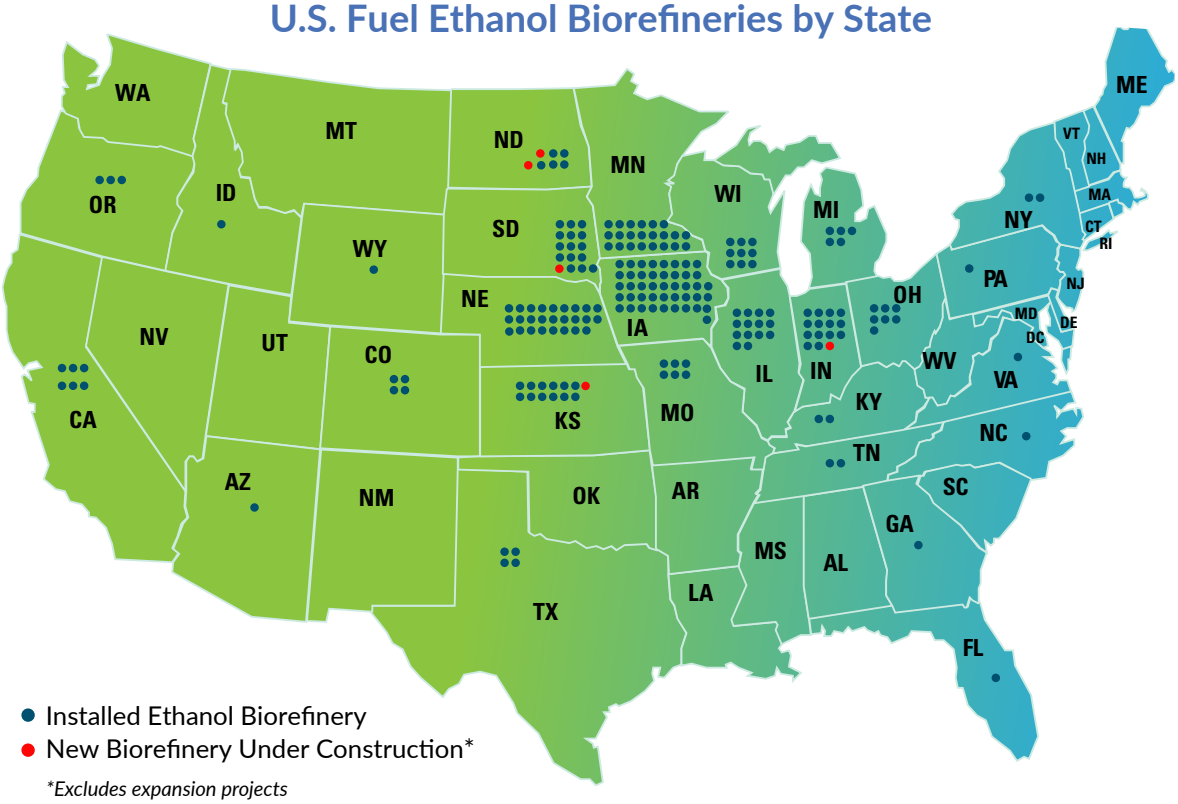


Source: RFA and U.S. Energy Information Administration

**Estimated*

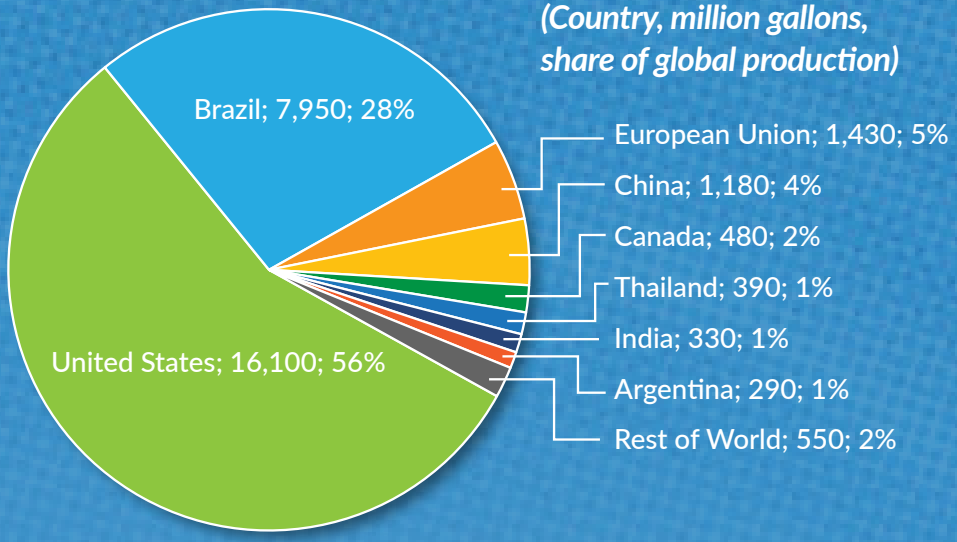
There are 210 ethanol biorefineries located in 27 states. Iowa, Nebraska, and Illinois account for half of production capacity.

U.S. Fuel Ethanol Biorefineries by State



*Excludes expansion projects

2018 Global Fuel Ethanol Production by Country

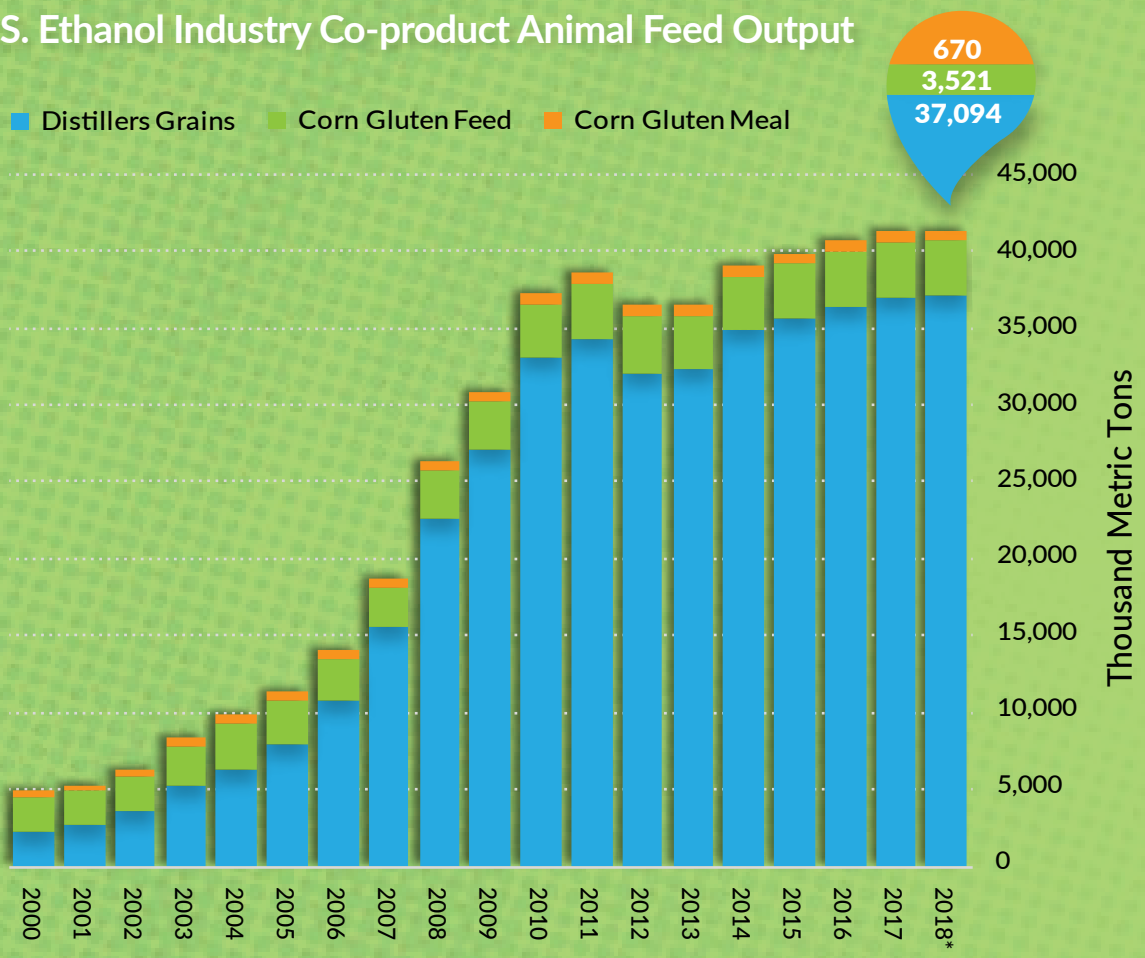


Source: RFA analysis of public and private data sources

POWERFUL NUTRITION

The ethanol industry generated a record 41.3 million metric tons of distillers grains and gluten feed/meal. These co-products are a consistent and cost-effective input for animal feed around the world.

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



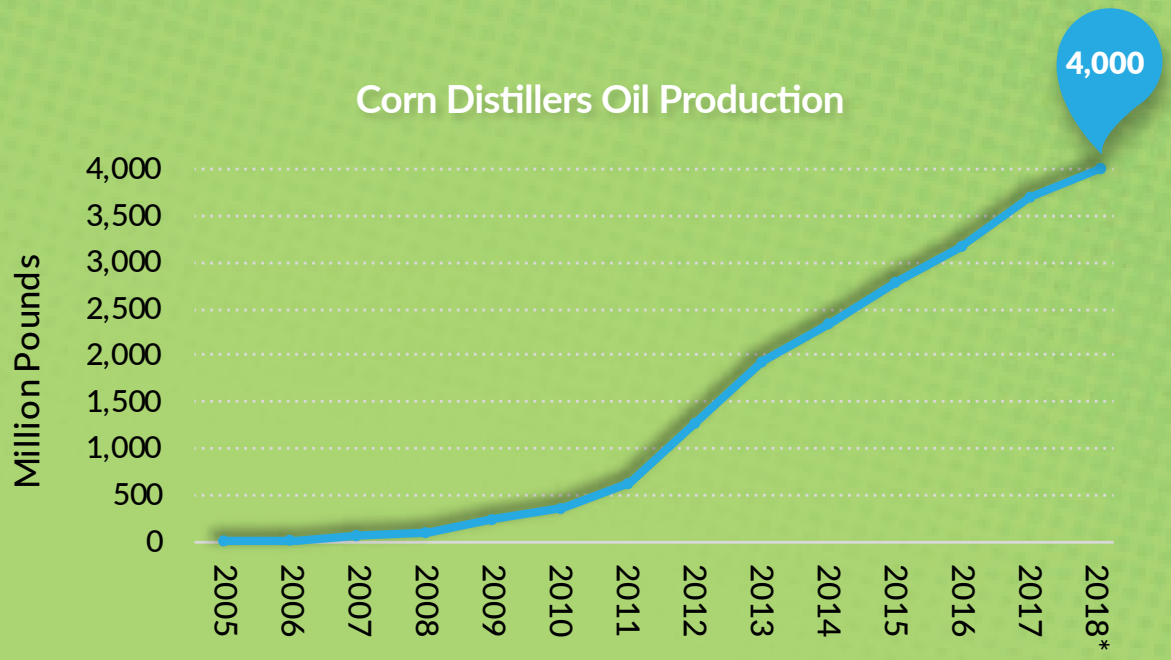
*Source: RFA and U.S. Dept. of Agriculture. Note: All co-products converted to 10% moisture basis *Estimated*

On average, 1 bushel of corn (56 pounds) processed by a dry mill ethanol biorefinery produces:

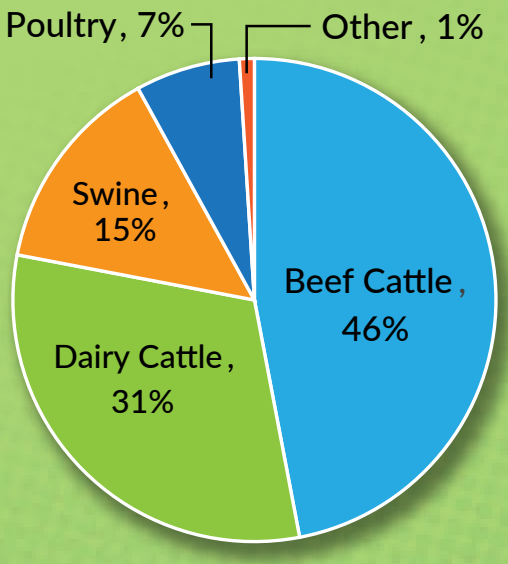
- **2.86 gallons of denatured fuel ethanol**
- **15.9 pounds of distillers grains animal feed (10% moisture)**
- **0.75 pounds of corn distillers oil**
- **16.5 pounds of biogenic carbon dioxide**

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

Biorefineries produced a record 4 billion pounds of corn distillers oil, used as a feed ingredient or biodiesel feedstock.



Distillers Grains Consumption by Specie



Source: Distillers grains marketing companies

ENERGIZING GLOBAL MARKETS

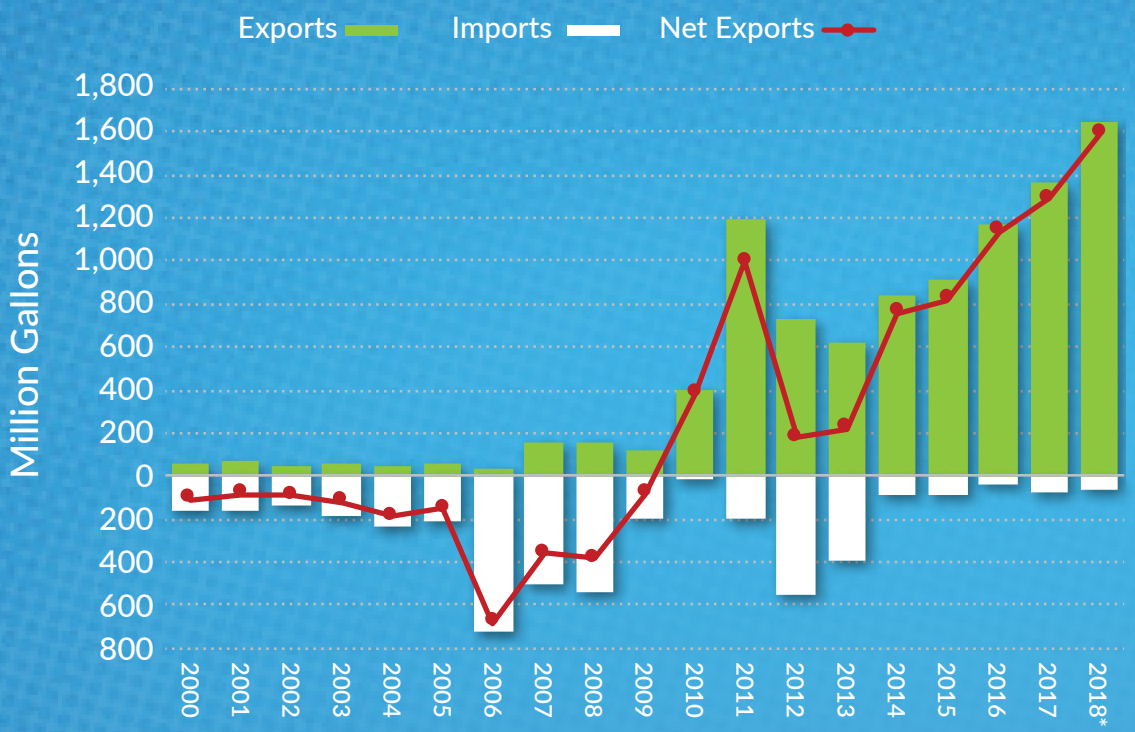
In 2018, U.S. ethanol exports swelled 20% to a new record high of 1.6 billion gallons worth an estimated $2.7 billion. This means 1 of every 10 gallons produced was shipped outside our borders, with half of exports destined for Brazil and Canada.

TOP 5 Destinations for U.S. Ethanol in 2018

1. Brazil
2. Canada
3. India
4. South Korea
5. Netherlands

Sources: U.S. Dept. of Commerce, U.S. Census Bureau, Foreign Trade Statistics **Based on Jan.-Sep. 2018*

U.S. Ethanol Exports and Imports



Sources: U.S. Dept. of Commerce, U.S. Census Bureau, Foreign Trade Statistics **Based on Jan.-Sep. 2018*

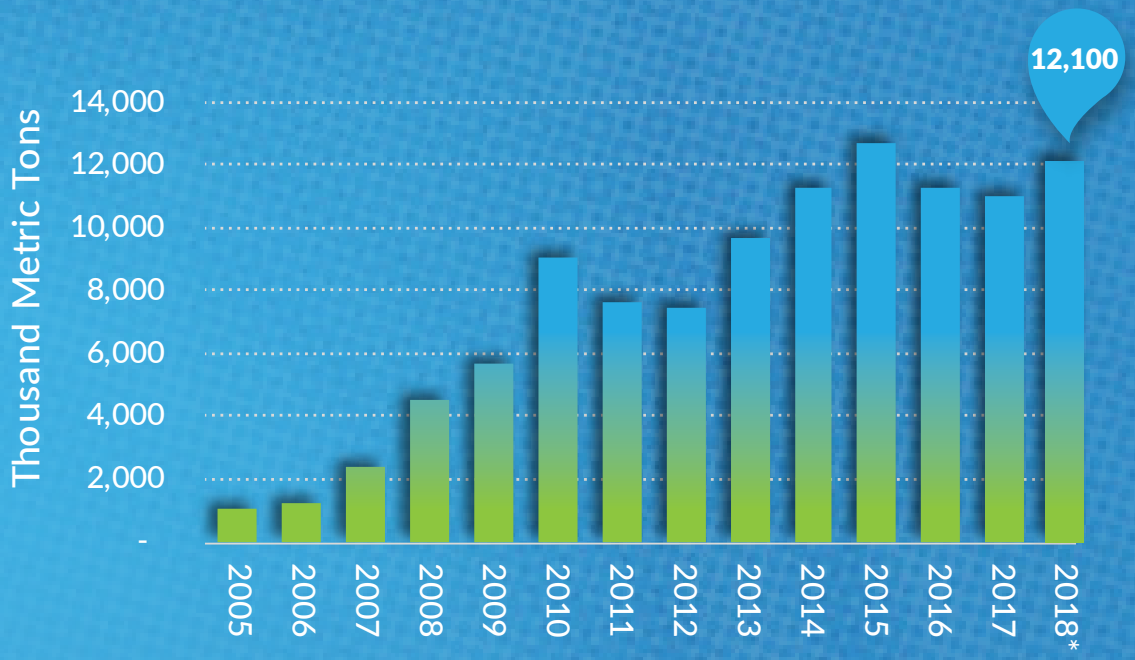
U.S. biorefineries satisfied growing domestic feed needs while also exporting nearly 1 of every 3 tons of distillers grains, or 12.1 million metric tons. In 2018, 4 countries purchased half of all U.S. DDGS exports while remaining volumes shipped to another 60 around the globe.

TOP 5 Destinations for U.S. Distillers Grains in 2018

- Mexico
- South Korea
- Turkey
- Vietnam
- Thailand

Sources: U.S. Dept. of Commerce, U.S. Census Bureau, Foreign Trade Statistics **Based on Jan.-Sep. 2018*

U.S. Distillers Grains Exports

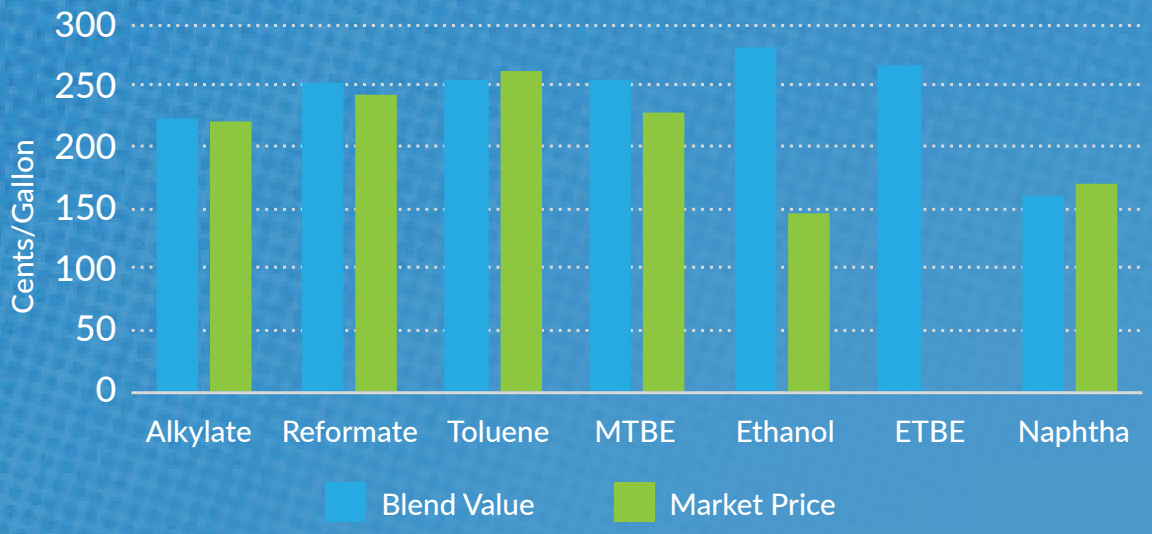


Sources: U.S. Dept. of Commerce, U.S. Census Bureau, Foreign Trade Statistics **Based on Jan.-Sep. 2018*

ETHANOL'S REFINERY POWER

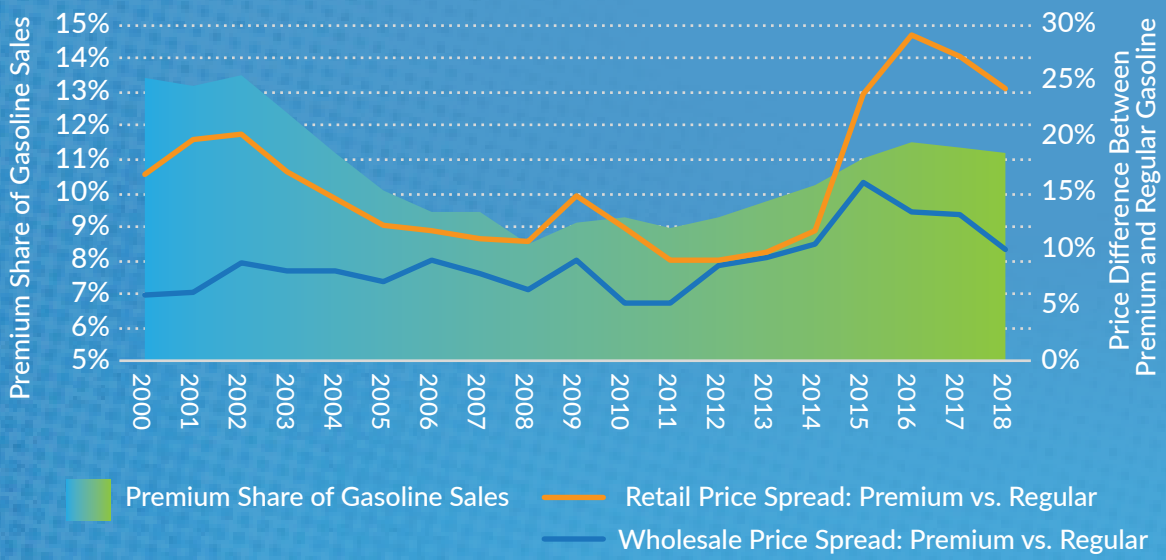
Ethanol is increasingly becoming a valuable octane source with an octane rating of 114. Most refiners add 10% ethanol to upgrade gasoline blendstock from 84 octane to 87 octane—the minimum allowable for "regular" grade gasoline.

Octane Blending Value vs Market Price



Source: Argus Media

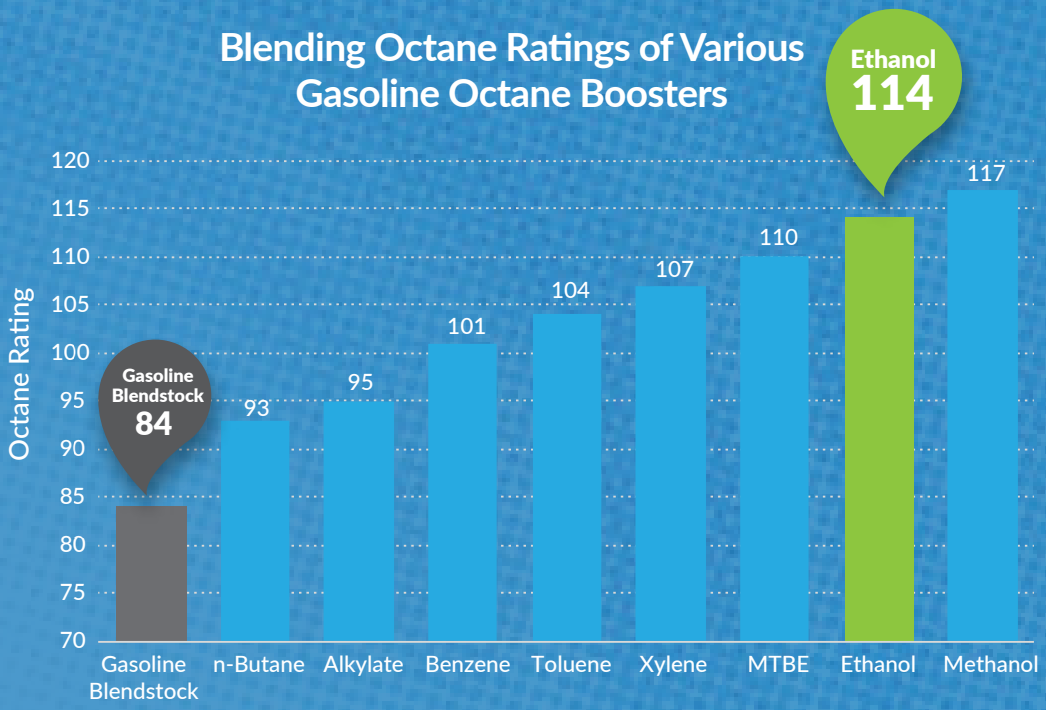
Premium Gasoline: Share of Sales and Price Difference vs. Regular



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

Ethanol blending has broken through the so-called "blend wall" and hit a record 10.75% blend rate in January 2018. However, demand destruction caused by EPA's "small refinery exemptions" dropped the average blend rate below 10% for much of the year.

Blending Octane Ratings of Various Gasoline Octane Boosters



Source: Department of Energy

Why is the Value of Octane Increasing?

CONSTRAINED SUPPLY

- **Increased volume of light tight oil (LTO) and condensate**
  Produces lower quality gasoline blendstock (more low-octane naptha)
- **Octane loss from tighter sulfur standards**
- **Refining industry slow to add octane-producing capacity**

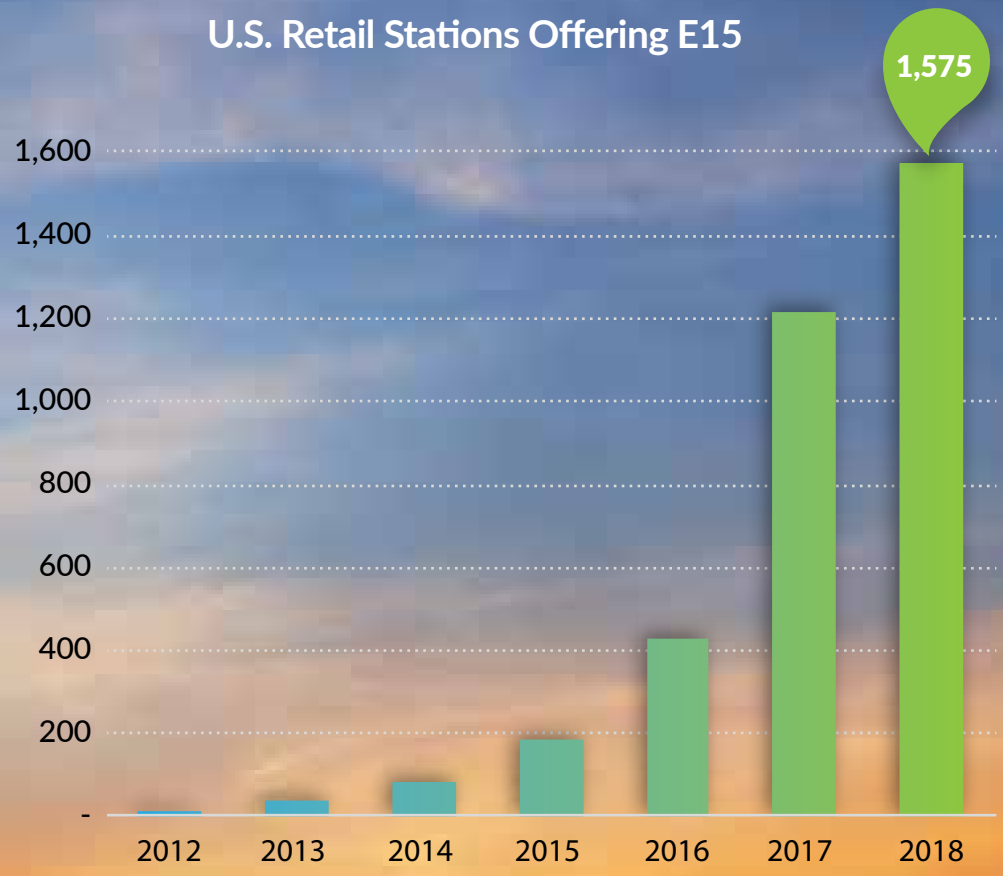
INCREASED DEMAND

- **Higher domestic demand for *all* gas grades**
- **Demand for premium is rising (as share of total)**
  Higher compression and turbo charging
- **Increased export demand for gasoline and high-octane blendstocks**

Source: EIA, MathPro Inc.

EMPOWERING E15

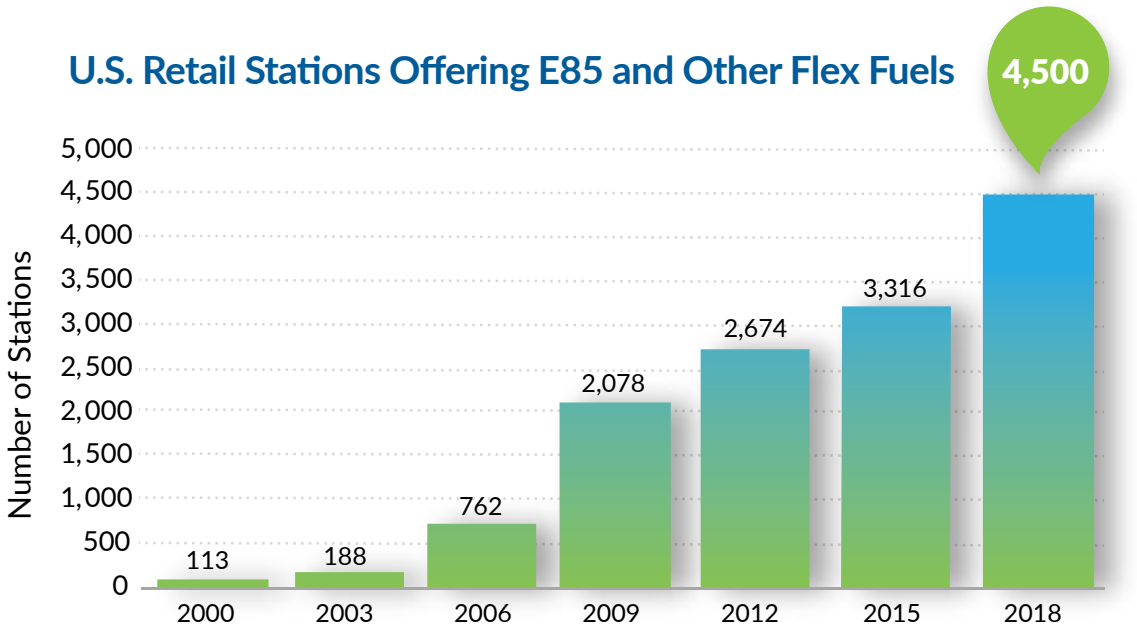
Since its approval by U.S. EPA, more than 5 billion trouble-free miles have been driven on E15. In 2018, access to E15 increased 33% as nearly 1,600 stations offered the fuel in 30 states. President Trump issued a directive to U.S. EPA to initiate a rulemaking allowing the year-round use of E15. If implemented, E15 sales could grow significantly in 2019, perhaps approaching 800 million gallons.



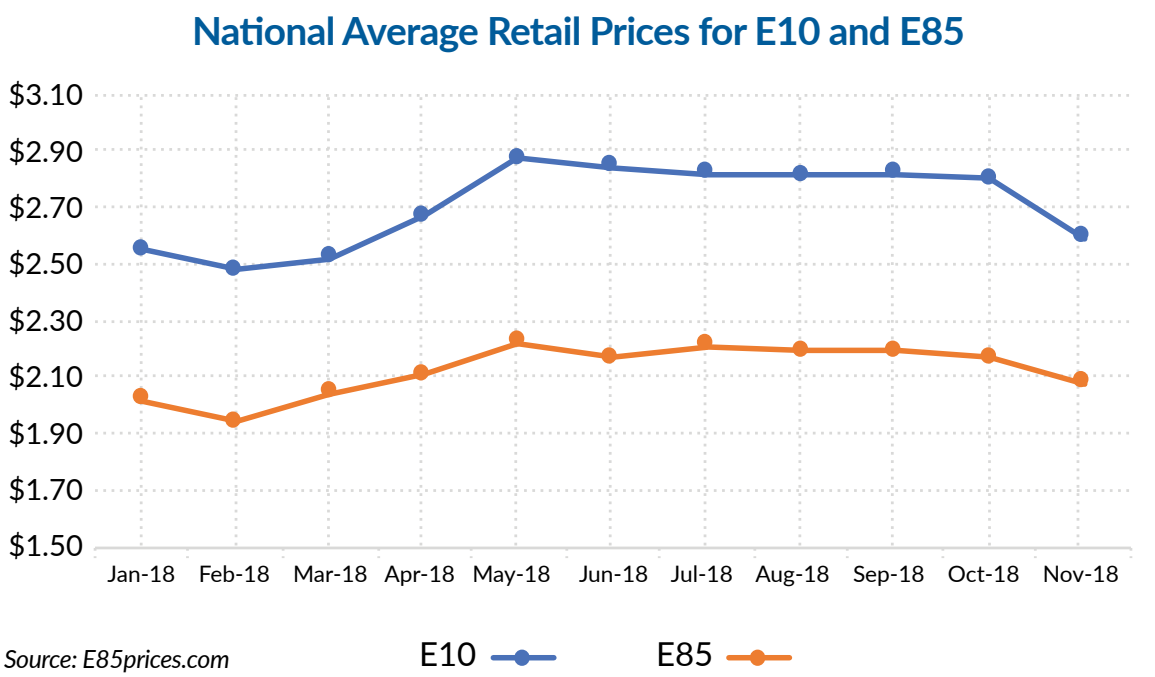
Source: RFA

FLEXING MUSCLE

Flex fuel consumption hit new heights in 2018. Nearly 1 of every 10 vehicles is a Flex Fuel Vehicle (FFV) approved to use Mid-Level Ethanol Blends (20-50% ethanol) and E85 (51-83% ethanol). Roughly 4,500 stations in 2,500 cities across America have blender pumps offering flex fuels.



Sources: RFA and U.S. Dept. of Energy

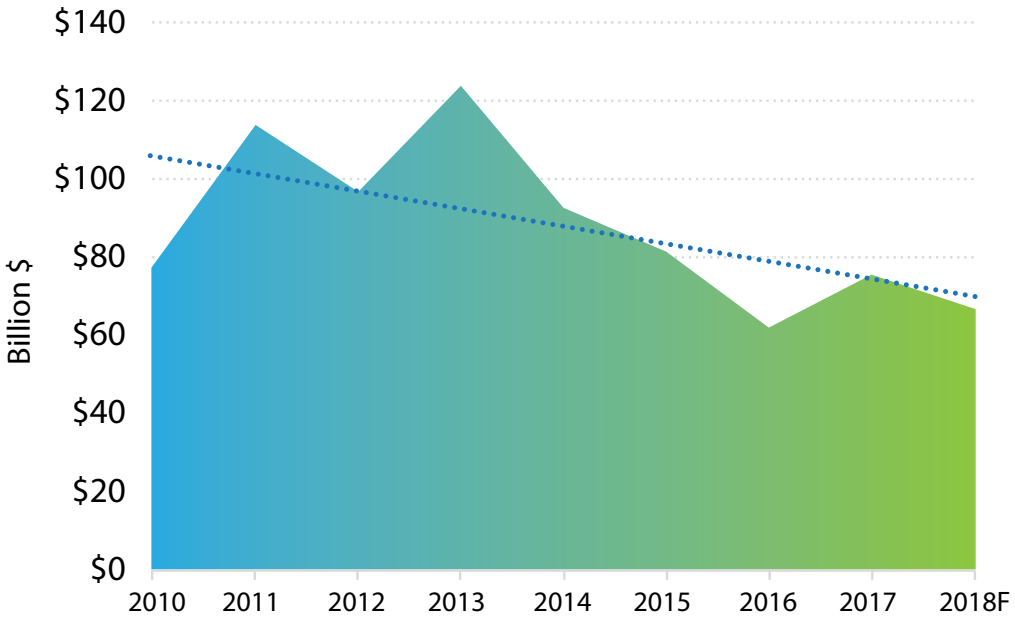


Source: E85prices.com

RENEWING THE RURAL ECONOMY

The U.S. ethanol industry provides a critically important market for corn and sorghum producers, a consistent low-cost feed source for livestock, bio-products for industrial uses, and feedstock for biodiesel.

U.S. Net Farm Income



Source: U.S. Dept. of Agriculture

Ethanol's Value-Added Proposition

Based on average prices and product yields in 2018, a typical dry mill ethanol plant was adding nearly $2 of additional value—or 55%—to every bushel of corn processed.

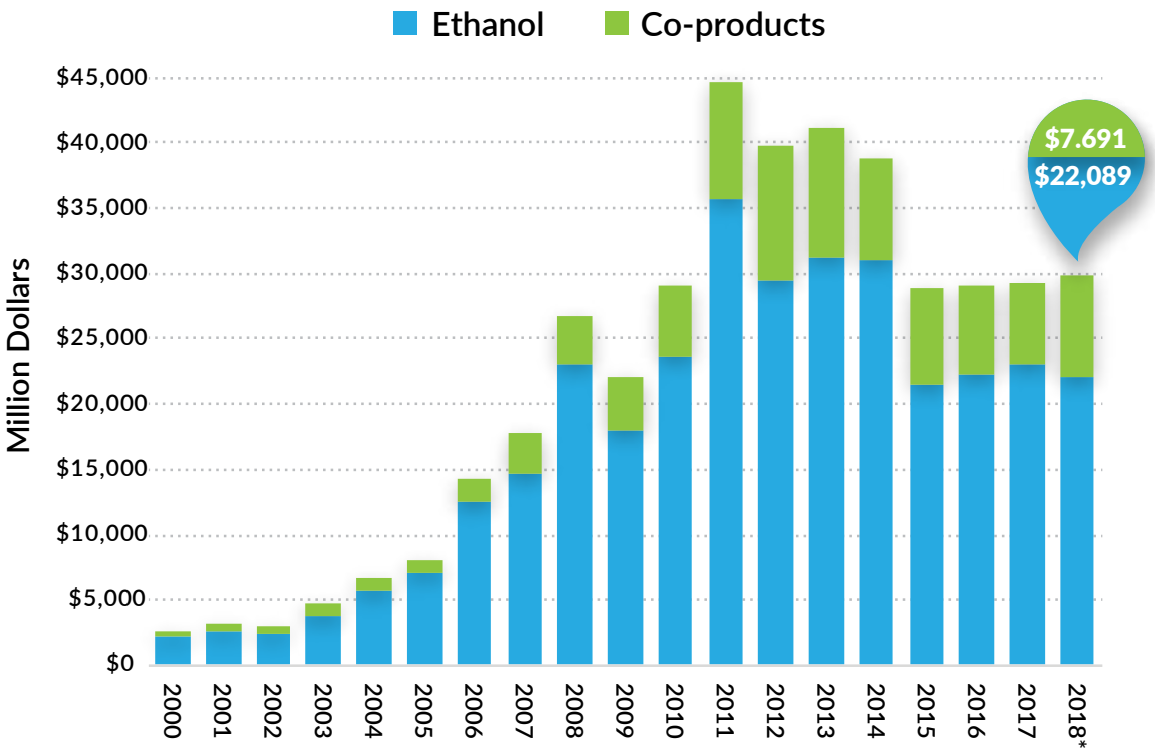
CORN COST PER BUSHEL
$3.35

VALUE OF OUTPUTS PER BUSHEL

Ethanol	$3.84
Distillers Grains	$1.16
Corn Distillers Oil	$0.19
TOTAL	**$5.19**

The ethanol industry yields tremendous economic impacts for the rural economy and America as a whole. And 1 in 4 employees is a military veteran—four times the national average.

Gross Value of U.S. Ethanol Industry Output



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

** Estimated*

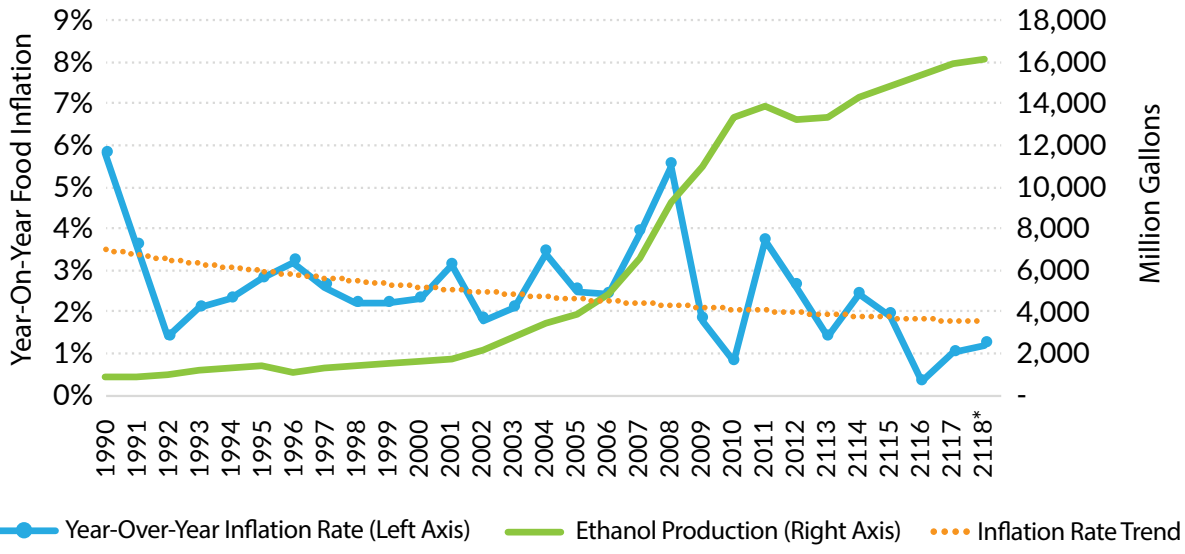
In 2018, the production of 16.1 billion gallons of ethanol and 43 million metric tons of co-products and distillers oil had substantial economic impacts, including:

- **71,367 direct jobs**
- **294,516 indirect and induced jobs**
- **$46 billion contribution to GDP**
- **$25 billion in household income**
- **$10 billion in tax revenue**

EMPOWERING CONSUMERS

In 2018, U.S. farmers harvested the second-largest corn crop ever. On a net basis, the U.S. ethanol industry used less than 3% of global grain supplies. More corn and co-products were available to livestock and poultry feeders than ever before. Meanwhile, average annual food inflation has averaged just 1.7% over this decade. The debunked "food vs. fuel" myth drifts another year further into the rearview mirror.

U.S. Food Price Inflation and Ethanol Production



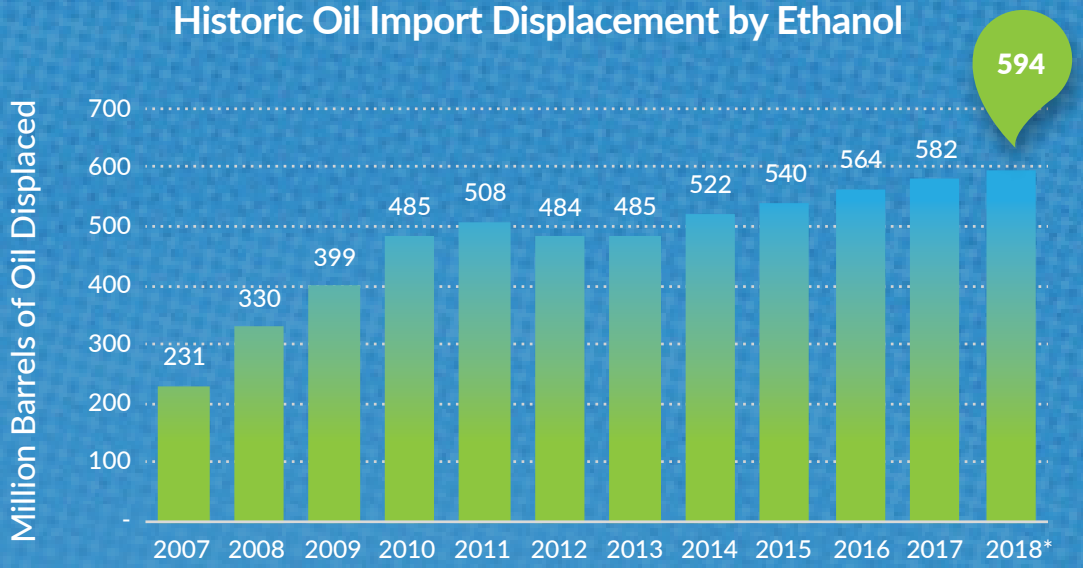
Source: U.S. Bureau of Labor Statistics and RFA

**Estimated*

POWERING ENERGY DOMINANCE

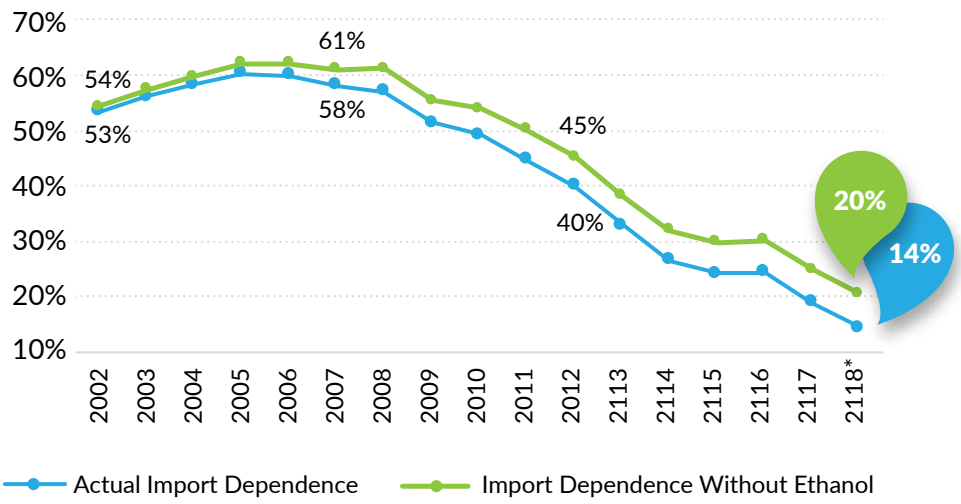
Energy security is one of the main drivers behind the RFS. In 2018, the addition of 16.1 billion gallons of ethanol to the U.S. fuel supply displaced an equivalent 550 million barrels of oil. Without the contribution of 16.1 billion gallons of ethanol, U.S. import dependence would have been equivalent to 20% 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

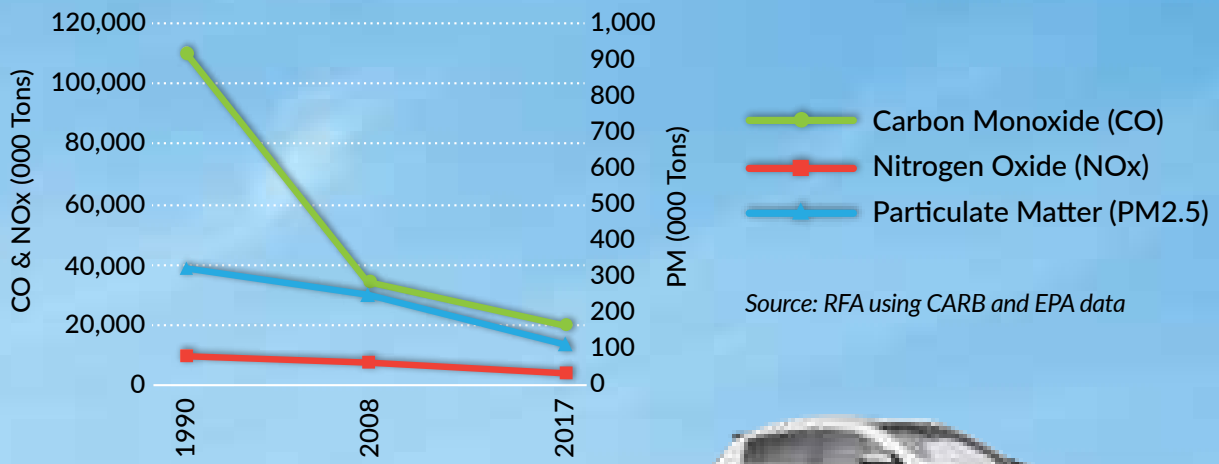


Source: RFA based on U.S. Dept. of Energy data **Estimated*

CLEARING THE AIR

Ethanol displaces hydrocarbon substances like aromatics in gasoline, helping to reduce emissions of air toxics along with particulate matter, carbon monoxide, nitrogen oxides, and exhaust hydrocarbons. These pollutants cause smog and ground-level ozone and adversely affect human health.

Emissions from All Highway Vehicles



Source: RFA using CARB and EPA data

Improvements Since Passage of the RFS2	2007	2018	% Change
GHG Emissions Avoided from using Ethanol *(million tons CO2e)*	12.7	55.0	+291%
Carbon Monoxide Concentration *(parts per million)*	1.91	1.34	-30%
Ozone Concentration *(parts per million)*	0.078	0.067	-13%
Coarse Particulate Matter Concentration *(micrograms per m3)*	71.83	69.82	-3%
Fine Particulate Matter Concentration *(micrograms per m3)*	11.93	8.02	-33%

Sources: U.S. Dept. of Energy and U.S. Environmental Protection Agency

Corn ethanol from a typical dry mill has 40-45% lower greenhouse gas (GHG) emissions than gasoline (this includes theoretical land use change emissions). As a result, the industry has contributed extensively to meeting California's Lower Carbon Fuel Standard.

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