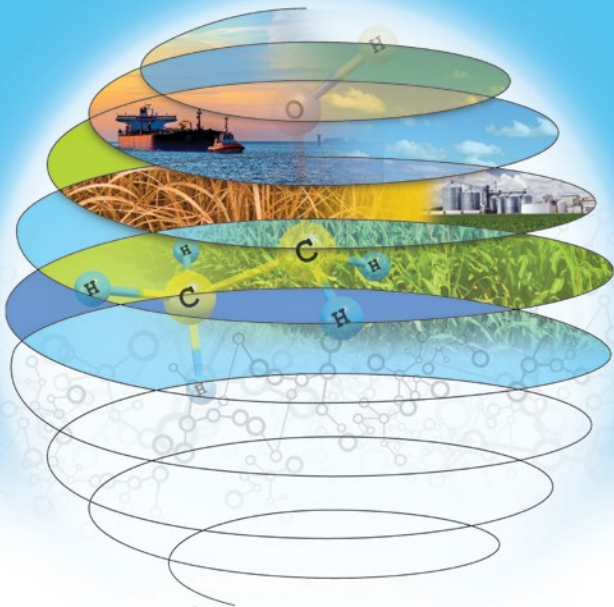


Pocket Guide to ETHANOL 2015



ETHANOL BASICS

Ethanol is a biodegradable, high-octane motor fuel derived from the sugars, starches, and cellulosic matter found in plants. It has been used as a fuel or additive since the days of Henry Ford's Model T. Virtually every gallon of gasoline consumed in the United States today contains fuel ethanol.

Ethanol is part of our nation's solution to reducing our dependency on fossil fuels, lowering fuel prices, creating domestic jobs, boosting the farm economy, and cleaning our environment.

Today, more than 200 biorefineries in 29 states have the capacity to produce more than 15 billion gallons (bg) of ethanol. And we've just gotten started, as new plants are coming online that utilize the next generation of feedstocks and technologies to make cellulosic ethanol.

How is Ethanol Made?

There are two primary ethanol production processes: wet milling and dry milling. Roughly 90% of the industry today uses the dry mill process, while the remaining 10% are wet mills.

In dry milling, the entire corn kernel is first ground into "meal." The meal is slurried with water to form a "mash." Enzymes are added to the mash to convert the starch to sugar. The mash is cooked, then cooled and transferred to fermenters. Yeast is added and the conversion of sugar to ethanol begins. After fermentation, the resulting "beer" is separated from the remaining "stillage." The ethanol is then distilled and dehydrated. The ethanol is then blended with about 2% denaturant (such as gasoline) to render it undrinkable and exempt from beverage alcohol tax. It is then ready for shipment. The stillage is sent through a centrifuge that

separates the solids from the solubles. These co-products eventually become distillers grains (a nutritious livestock feed), as well as corn distillers oil (a feed ingredient and feedstock for biodiesel production).

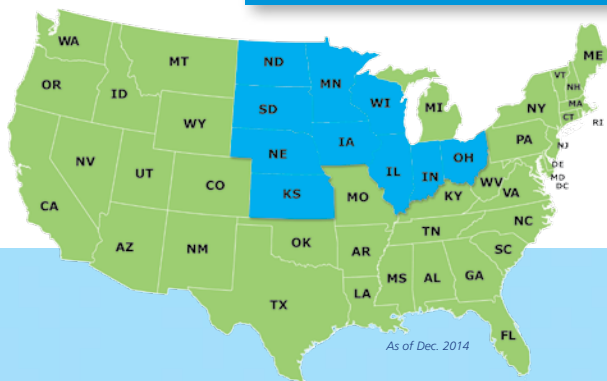
In wet milling, the grain is first separated into its component parts through soaking. After steeping, the slurry is processed through grinders to separate the corn germ. The remaining fiber, gluten and starch components are further segregated. The gluten component (protein) is filtered and dried to produce animal feed. The remaining starch can then be fermented into ethanol, using a process very similar to the dry mill process.

Key U.S. Ethanol Industry Stats (as of Jan. 2015)

Installed Plants	213
Plants in Operation	198
Total Production Capacity (per year)	15.08 billion gals.
Capacity in Operation (per year)	14.58 billion gals.
Plants Under Construction/Expansion	3
Capacity Under Construction/Expansion (per year)	100 million gals.
States with Ethanol Plants	29

- 1 bushel of corn (56 lbs.) = 2.8 gals. of ethanol, 16.5 lbs. of livestock feed, 0.6 lb. of corn distillers oil
- 1 gal. of ethanol contains 76,300 BTUs, or 81.5 megajoules
- Ethanol is blended in more than 97% of gasoline in the U.S. today
- In 2014, ethanol accounted for 10% of the U.S. gasoline supply
- More than 98% of the ethanol produced in 2014 was made from corn
- The first three commercial-scale cellulosic ethanol facilities began production in 2014

TOP 10 ETHANOL-PRODUCING STATES



Historic Ethanol Production (billion gallons)

2014	14.30*
2013	13.29
2012	13.22
2011	13.93
2010	13.30
2009	10.94
2008	9.31
2007	6.52
2006	4.88
2005	3.90

*Estimated



Ethanol's Economic Impacts

The ethanol industry continues to have a profoundly positive impact on the economic health of states across the country.

The production of 14.3 bg of ethanol in 2014 created:

- 83,949 direct jobs
- 295,265 indirect and induced jobs
- \$53 billion in gross domestic product
- \$27 billion in household income
- \$10.3 billion in tax revenue

In addition to jobs at ethanol plants, the industry directly or indirectly supports the following jobs:

- Corn and grain sorghum farming
- Agricultural machinery production
- Seed, fertilizer and crop protection
- Grain handling and storage
- Trucking and rail transportation

- Enzyme and yeast production
- Legal and accounting services

Workers in the ethanol industry are well compensated, highly educated and enjoy what they do.

- 46% of workers earn \$75,000 or more annually
- 45% earn \$40,000-\$74,999 annually
- 55% are college graduates
- 30% have college experience or vocational/technical training
- 68% are "satisfied" or "extremely satisfied" with their jobs

Global Ethanol Trade

The U.S. ethanol industry has evolved into a global leader in both the production and trade of renewable fuel.

- The U.S. is the world's leading ethanol producer, generating more than twice as much ethanol as Brazil—the No. 2 producer.
- The U.S. industry was responsible for nearly 60% of global ethanol output in 2014.
- The U.S. exported 836 million gallons of ethanol in 2014—the second-highest on record.
- Canada was the leading market for U.S. exports, accounting for more than 40% of total shipments.
- Brazil emerged as the No. 2 market, receiving 13% of U.S. exports.
- The United Arab Emirates, Philippines, and South Korea were other leading markets.
- Despite the European Union's tariff against U.S. ethanol, about 50 million gallons were shipped to European countries in 2014.
- The U.S. imported approximately 80 million gallons of ethanol in 2014, most of which came from Brazil.



Ethanol's Impact on the Agriculture Economy

Growth in ethanol production has enhanced the value of agriculture products, stimulated investment in new technologies and expanded economic opportunities for America's farm families.



- 2010-2014 has been the most profitable 5-year period in the history of U.S. agriculture
- The value of U.S. crops hit \$194 billion in 2014, down slightly from the past three years, but still the fourth-highest ever. The value of livestock hit a record \$209 billion in 2014.
- Farm equity and the value of farm assets both hit new records in 2014.

Ethanol has helped transform the once-stagnating grain sector into an economically vibrant and demand-driven marketplace.

- From 1997 to 2006, corn prices were below the cost of production. Thus, farmers were reliant on government payments to offset losses.
- From 2007-2013, corn prices were above the cost of production, meaning farmers earned their income from the market—not the taxpayer.
- Unfortunately, corn prices in many areas fell close to—or below—cost of production in 2014, as EPA's proposal to slash the RFS artificially constrained demand for the 2014 record crop.

Ethanol and Energy Security

U.S. dependence on imported petroleum is falling to depths not seen since the early 1990s—and growth in ethanol is a primary reason.

- Petroleum (crude and products) import dependence peaked at 60% in 2005, but was just 28% in 2014.
- Petroleum import dependence would have been 35% without 14.3 bg of ethanol in 2014.
- Ethanol production in 2014 displaced an amount of gasoline refined from 512 million barrels of crude oil—more than the amount of oil imported annually from Saudi Arabia.

Growing supplies of ethanol have helped reduce prices at the pump for U.S. consumers.

- Consumers pay \$0.50-\$1.50 per gallon less for gasoline because of ethanol, according to Philip K. Verleger, former economic advisor to Presidents Ford and Carter.
- Ethanol remains the lowest cost—and cleanest—source of octane available on the world market.



The Renewable Fuel Standard (RFS)

Congress adopted the RFS in 2005 and expanded it in 2007. The program requires oil companies to blend increasing volumes of renewable fuels with gasoline and diesel, culminating with 36 bg in 2022.

By any measure, the RFS has been an unmitigated success. It has reduced dependence on imported petroleum, stimulated investment in new technologies, lowered gasoline prices, created jobs and economic opportunity across rural America, and reduced greenhouse gas emissions from transportation fuels.



Oil companies view this rapid shift in the marketplace as a serious threat to their century-old monopoly on America's gas tanks. As a result, they have mounted a campaign to repeal the RFS and halt the evolution of the fuels market—just as it is getting started.

Moving forward, the RFS requires oil companies to use more renewable fuel than can be consumed as E10. Oil companies say the E10 “blend wall” prevents them from meeting the RFS requirements. But, legal and viable options—such as E15 and E85—exist for refiners to break through the self-inflicted barrier.

Cellulosic Ethanol



The dream of commercial-scale cellulosic ethanol production became a reality in 2014, ushering in a new era of low carbon biofuels and silencing critics who claimed “phantom fuels” would never materialize.

In September, POET-DSM opened Project Liberty, a 20 million gallon per year (mgpy) facility in Emmetsburg, Iowa.

Less than a week later, Quad County Corn Processors in Galva, Iowa, unveiled its “bolt-on” process that converts corn kernel fiber into 2 mgpy of cellulosic ethanol.

In October, Abengoa raised the curtain on its biorefinery in Hugoton, Kansas. The facility will generate 25 mgpy of cellulosic ethanol, as well as 21 megawatts of electricity.

As 2015 began, DuPont was putting the finishing touches on its 30 mgpy cellulosic ethanol facility in Nevada, Iowa.

Cellulosic ethanol projects that are under development will use a variety of feedstocks, including:

- Agricultural residues like corn cobs and stover, wheat straw, or soybean stubble
- Purpose-grown energy crops like algae, miscanthus, switchgrass, energy cane, and poplar
- Forestry residues and wood processing waste
- Organic matter in municipal solid waste
- Municipal yard and vegetative waste
- Food and citrus processing waste

E15, Ethanol Flex Fuels, and Renewable Super Premium

Girded by the RFS and favorable economics, demand for ethanol blends above E10 is growing.

Key facts on E15:

- E15 is offered at 100 stations in 16 states (Jan. 2015).
- More than 100 million trouble-free miles have been driven on E15 since its introduction.
- There have been no reported cases of “engine damage” or misfueling.
- E15 is approved by EPA for use in about 85% of today’s automotive fleet.

- Nearly 70% of new cars sold in 2015 will be explicitly warranted for the use of E15 by the manufacturers.
- E15 offers a higher octane fuel blend typically at a lower price than E10.



Key facts on Ethanol Flex Fuels:

- Ethanol flex fuels, including E85, contain 51-83% ethanol.
- More than 3,200 stations across the country sell E85 today.
- E85 is approved for use only in flex-fueled vehicles (FFVs).
- There are nearly 18 million FFVs on the road today, representing about 8% of the overall fleet.
- Roughly 25% of new cars sold in 2015 will be FFV capable.
- E85 was often priced \$0.80-1.00 per gallon below gasoline for much of 2014.

Key facts on Renewable Super Premium (RSP):

- RSP is a high-octane fuel blend that can contain elevated levels of ethanol (20-40%).
- These blends are sold today from roughly 300 blender pumps in states across the Midwest.
- RSP typically offers much higher octane than regular gasoline and can overcome the “mileage penalty” when used in optimized engines.
- Automakers have suggested high-octane RSP, when paired with advanced engine technology, could help meet stringent fuel economy and emissions standards in the future.

Ethanol Co-Products

Ethanol plants produce more than fuel—they also make a huge contribution to the global animal feed market.

- One-third of every 56-pound corn bushel processed by an ethanol plant returns to the feed market as distillers grains, distillers oil, corn gluten feed, or gluten meal.
- Ethanol production utilizes only the starch in the grain; the remaining protein, fat and fiber return to animal feed.
- Feed co-products are consumed by beef and dairy cattle, swine, poultry, and even fish.
- The ethanol industry produced roughly 39 million metric tons of animal feed in 2014.
- About 30% of the distillers grains produced in 2014 were exported to more than 50 countries.
- About 85% of dry mill ethanol plants are now producing corn distillers oil as well—a product used as an animal feed ingredient or biodiesel feedstock.



The Food vs. Fuel Debate

Ethanol opponents suggest using grain to make biofuel creates a “food vs. fuel” dilemma and increases food prices. The truth is, the industry produces both fuel AND food, and there is no evidence that ethanol adversely affects food prices.

- More grain is available for food and feed use worldwide today than at any time in history.
- On a net basis, the U.S. ethanol industry will use just 3% of global grain supplies.
- Corn prices in 2014/15 are lower than they were when the RFS2 was signed into law in 2007.
- Corn is a minor ingredient in retail food items. When corn prices are \$4 per bushel, there is just 5 cents worth of corn in a box of corn flakes.
- Food prices have increased more slowly since passage of the first RFS in 2005. From 1980 to 2004, food price inflation averaged 3.5% per year. Since 2005, food inflation has averaged 2.8% annually.



- Only 17 cents of every dollar spent on food pays for the value of the farm products in the groceries. The remaining 83 cents pays for labor, packaging, energy, and other costs.
- According to the World Bank, “most of the food price increases are accounted for by crude oil prices.”

Ethanol and the Environment

Innovation and new technology have revolutionized the agriculture industry and reduced the environmental impacts associated with producing corn and other biofuel feedstocks.

- U.S. farmers produced a record corn crop of 14.22 billion bushels in 2014.
- The 2014 crop was 3% larger than the previous record and 32% bigger than the drought-ravaged crop of 2012.
- Average yield per acre continues to trend upward. Farmers produced a record average of 171 bushels per acre in 2014, double the typical yield from just 40 years ago.

Growers are producing more corn using less land, fertilizer and water.

- U.S. planted crop acreage continues to trend downward. Average crop acreage was 361 million in the 1930s and 342 million in the 1980s. By comparison, acreage has averaged just 322 million since 2009.
- Nitrogen fertilizer use is down 29% per bushel since 1985. Phosphate and potash use are down 36% and 49%, respectively.



Contrary to the rhetoric of biofuel opponents, corn production for ethanol is not leading to increased deforestation or hypoxia.

- Deforestation in the Amazon has steadily fallen since 2004, hitting the second lowest point on record in 2014.
- The hypoxic zone in the Gulf of Mexico has gotten smaller since 2001 – it was nearly 40% smaller in 2014 than in 2001.

Ethanol's Energy Efficiency

Few—if any—manufacturing sectors can boast the same record of efficiency, technology adoptions and innovation as the U.S. ethanol industry. Over the past 20 years, the industry has dramatically reduced the energy and environmental impacts of producing ethanol.

- The average ethanol plant uses just 23,862 BTU of natural gas energy to produce a gallon of ethanol that contains 77,300 BTU. Natural gas usage by ethanol plants has fallen 36% since 1995.
- Electricity use by ethanol plants has fallen 38% since 1995.
- Average consumptive water use is just 2.7 gallons of water per gallon of ethanol produced. That compares with 8-10 gallons of water needed to produce a gallon of gasoline from tar sands.
- Water use is down 53% since 1998.
- Producers are squeezing more ethanol out of every bushel. Today, the average ethanol plant gets 2.82 gallons per bushel, compared to 2.51 gallons in 1994.
- Corn ethanol reduces GHG emissions by 34% compared to petroleum—even when hypothetical land use change emissions are included.
- Without indirect emissions, average corn ethanol decreases GHG emissions by 44%.
- The use of 14.3 bg of ethanol in 2014 reduced GHG emissions by 40 million metric tons—equivalent to removing 8.4 million cars from the road for an entire year.
- Every 1 BTU of energy invested in corn ethanol production results in the output of 2.3 BTUs of usable energy.

About the RFA

RFA is the leading trade association for America's ethanol industry. Its mission is to advance the development, production, and use of fuel ethanol by strengthening America's ethanol industry and raising awareness about benefits of renewable fuels. RFA's 300 members are working to help America become cleaner, safer, more energy independent and economically secure.

Every day, the RFA works hard to provide timely and comprehensive industry information to its members and consumers on numerous issues including legislative and regulatory, technical and research, and market development. RFA's expertise is showcased in its constantly updated industry statistics, scientific analysis, industry best practices, and ethanol standards and specifications. RFA's success is driven by its active and engaged members who serve on committees like the Technical Committee, Environmental Compliance Committee, Co-products Committee, the Plant & Employee Safety Committee, and more important, participate fully on the Board of Directors.

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