Pocket Guide to Ethanol 2014
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 fuel additive since the days of Henry Ford’s Model T. Today, virtually every gallon of gasoline consumed in the United States contains fuel ethanol, typically at a blend rate of 10%.

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.

Over the past 30 years, a robust ethanol industry has emerged in the United States. Today, more than 200 corn ethanol plants in states across the nation have the capacity to produce approximately 15 billion gallons of clean-burning renewable fuel. And we’ve just gotten started, as new plants are being built that will utilize the next generation of feedstocks and technologies to make cellulosic ethanol.
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 flour or “meal.” The meal is slurried with water to form a “mash.” Enzymes are added to the mash to convert the starch to dextrose, a simple sugar. The mash is processed in a cooker, then cooled and transferred to fermenters. Yeast is added and the conversion of sugar to ethanol begins. After fermentation, the resulting “beer” is transferred to distillation columns where the ethanol is separated from the remaining “stillage.” The ethanol is concentrated using distillation and then is dehydrated. The ethanol is then blended with about 2.5% denaturant (such as natural 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 coarse grain from the solubles. These co-products eventually become distillers grains, a high quality, nutritious livestock feed.

In **wet milling**, the grain is soaked in water and dilute sulfurous acid to separate the grain into its component parts. After steeping, the slurry is processed through a series of 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. 2014)

U.S. Ethanol Production Facts
• 1 bushel of corn (56 lbs.) = 2.8 gallons of ethanol and 17-18 pounds of livestock feed
• 1 gallon of ethanol contains 76,300 BTUs
• Ethanol is blended in more than 96% of gasoline in the U.S. today
• In 2013, ethanol accounted for 10% of the U.S. gasoline supply
• More than 98% of the ethanol produced in 2013 was made from corn
• Five out of the seven plants under construction or expanding will use cellulosic or waste feedstocks

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<th>Key U.S. Ethanol Industry Stats (as of Jan. 2014)</th>
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<td>Operational Plants</td>
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<td>Plants in Operation</td>
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<td>Total Production Capacity (per year)</td>
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<td>Capacity Under Construction/Expansion (per year)</td>
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<td>States with Ethanol Plants</td>
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Historic Ethanol Production (billion gallons)

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<tr>
<th>Year</th>
<th>Production</th>
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<tbody>
<tr>
<td>2013</td>
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<td>2012</td>
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<td>2011</td>
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<td>2006</td>
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<td>2005</td>
<td>3.90</td>
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<td>2004</td>
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*Estimated

Top 10 Ethanol-Producing States

As of Dec. 2013
Amidst the slow recovery from the Great Recession, the ethanol industry continues to have a profoundly positive impact on the economic health of states across the country.

The production of 13.3 billion gallons of ethanol in 2013 created:
- 86,504 direct jobs
- 300,277 indirect and induced jobs
- $44 billion in gross domestic product
- $31 billion in household income
- $8.3 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 products
- Grain handling and storage
- Trucking and rail transportation
- Enzyme and yeast production
- Natural gas 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
- 96% have health insurance
- 92% have retirement plans
- 55% are college graduates
- Another 30% have college experience or earned vocational/technical training
- 68% are “satisfied” or “extremely satisfied” with their jobs
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.

- The value of U.S. livestock surged to a record of $182 billion in 2013.
- Net farm income hit a record of $131 billion in 2013—more than double the amount in 2009.
- Farm equity and the value of farm assets also hit new highs in 2013.

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.
- Since 2007, corn prices have been above the cost of production, meaning farmers are earning their income from the market—not the taxpayer.
- Government payments to corn growers have fallen from nearly $9 billion in 2006 to less than $2 billion in 2013.
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 35% in 2013.
- Petroleum import dependence would have been 41% without 13.3 billion gallons of ethanol in 2013.
- Ethanol production in 2013 displaced an amount of gasoline refined from 462 million barrels of crude oil—that’s the equivalent of U.S. oil imports from Venezuela and Iraq combined.
- Due to the emergence of ethanol, the U.S. imports virtually no finished gasoline today.

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

- Consumers paid $0.50-$1.50 per gallon less for gasoline in 2013 because of ethanol, according to Philip K. Verleger, a renowned economist and former advisor to Presidents Ford and Carter.
- Economists at Iowa State University and the University of Wisconsin similarly found that ethanol reduced gas prices by an average of $1.09 per gallon in 2012.
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 less than 3% of global grain supplies.
- Corn prices in early 2014 are lower than they were when the expanded RFS was signed into law in 2007.
- Corn is a minor ingredient in retail food items. When corn prices are $4.40 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 price inflation has averaged 2.9% annually.
- Only 12 cents of every dollar spent on food pays for the value of the farm products in the groceries. The remaining 88 cents pays for labor, packaging, energy, and other costs.
- According to World Bank, “most of the food price increases are accounted for by crude oil prices.”
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 billion gallons 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, Big Oil has mounted an unrelenting 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. Big Oil says the E10 “blend wall” prevents them from meeting the RFS requirements. But, legal and viable options—such as E15, E85 and mid-level blends—exist for refiners to break through the self-inflicted “blend wall.”
Girded by the RFS, demand for E15, E85, and mid-level blends (MLBs) is growing rapidly.

Key facts on E15:
- E15 is offered at 70 stations in 12 states (Jan. 2014).
- More than 50 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 for use in 80% of today’s automotive fleet—or four out of every five cars on the road.
- More than 60% of new cars sold in 2014 will be explicitly warranted for the use of E15 by the manufacturers.
Key facts on E85:

- E85 is the highest octane fuel on the market, offering an octane rating of 105.
- 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 16 million FFVs on the road today, representing about 7% of the overall fleet.
- Roughly 25% of new cars sold in 2014 will be FFV capable.
- E85 demand hit record levels in 2013 as a result of RFS requirements and favorable blending economics.
- E85 was often priced $1 or more per gallon below gasoline in the summer of 2013.

Key facts on MLBs:

- MLBs are sold from roughly 300 blender pumps in states across the Midwest.
- E20, E30 and E40 are the most popular MLBs.
- MLBs are approved for use only in FFVs.
- Automakers have suggested a high-octane MLB paired with advanced engine technology could help them meet increasingly stringent fuel economy and emissions standards in the future.
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, 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 36 million metric tons of animal feed in 2013.
- That’s enough feed to produce 45 billion hamburgers—six patties for every person on the planet.
- About 25% of the distillers grains produced in 2013 were exported to roughly 50 countries around the world.
- About 75% of dry mill ethanol plants are now producing distillers corn oil as well—a product used to make biodiesel or as an animal feed ingredient.
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 twice as much ethanol as Brazil—the No. 2 producer.
- The U.S. industry was responsible for nearly 60% of global ethanol output in 2013.
- The U.S. exported approximately 630 million gallons of ethanol in 2013—down slightly from the past two years, but the third-highest on record.
- Canada was the leading market for U.S. exports, accounting for 54% of total shipments.
- The Philippines emerged as the No. 2 market, receiving 9% of U.S. exports.
- The United Arab Emirates, Brazil, Mexico and Peru were other leading markets.
- Exports to the European Union dropped significantly in 2013 because of the EU’s punitive tariff against U.S. ethanol.
- The U.S. imported approximately 425 million gallons of ethanol in 2013, most of which came from Brazil for the purposes of compliance with the California LCFS and RFS advanced biofuel standard.
Innovation and new technology have revolutionized the agriculture industry and reduced the environmental impacts associated with producing corn and other biofuel feedstocks.

- Despite a late planting season and challenging conditions in some areas, U.S. farmers produced a record corn crop of 13.93 billion bushels in 2013.
- The 2013 crop was 7% larger than the previous record and 30% bigger than the drought-ravaged crop of 2012.
- Average yield per acre continues to trend upward. Farmers produced an average of 159 bushels per acre in 2013, roughly double the typical yield from just 40 years ago.

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

- Deforestation in the Amazon has steadily fallen since 2004, hitting the lowest point on record in 2012.
- The hypoxic “Dead Zone” in the Gulf of Mexico has steadily gotten smaller since 2001. In 2012, the hypoxic zone was the smallest it had been in 12 years.
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 77,600 BTU. Natural gas usage by ethanol plants has fallen 36% since 1994.
- Electricity use by ethanol plants has fallen 38% since 1994.
- Average consumptive water use is just 2.7 gallons of water per gallon of ethanol produced. That compares 8-10 gallons of water needed to produce a gallon of gasoline from tar sands.
- Water use is down 53% since 1998.
- Meanwhile, 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.

These efficiency enhancements have led to an improved energy balance and reduced lifecycle carbon impacts for ethanol.

- Today’s corn ethanol reduces GHG emissions by 34% compared to petroleum—even when hypothetical land use change emissions are included.
- The use of 13.3 billion gallons of ethanol in 2013 reduced GHG emissions by 38 million metric tons—equivalent to removing 8 million cars from the road.
- Every 1 BTU of energy invested in the corn ethanol production process results in the production of 2.3 BTUs of usable energy in the form of fuel ethanol.
While today’s corn ethanol industry has served as the foundation of the vibrant U.S. biofuels sector, the first wave of commercial cellulosic ethanol plants is on the cusp of beginning production.

- One commercial-scale plant, INEOS Bio in Florida, is already in operation. The facility uses vegetative waste and municipal waste to produce up to 8 million gallons of ethanol per year.
- Three additional commercial plants are expected to begin production in 2014:
  - Abengoa Bioenergy in Hugoton, KS, will use agriculture residues and dedicated energy crops to produce up to 25 million gallons per year.
  - DuPont Cellulosic Ethanol in Nevada, IA, will use corn stover to generate up to 30 million gallons per year.
  - POET/DSM in Emmetsburg, IA, will use corn crop residue to produce up to 20 million gallons per year.
- While these facilities are on the leading edge, other projects will follow closely behind. Cellulosic biofuel facilities are in various stages of development in 20 states.

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 miscanthus, switchgrass and energy cane
- Forestry residues and wood processing waste
- Organic matter in municipal solid waste
- Municipal yard and vegetative waste
- Food and citrus processing waste
- Algae
- Fast-growing trees like poplar
Ethanol—a colorless, renewable alcohol fuel processed from starches, sugars, and cellulosic plant material.

Cellulose—an organic compound that is the structural component of cell walls for plants. Cellulosic materials, such as wood chips and corn stalks, are an emerging feedstock for ethanol production.

E10—(10% ethanol, 90% gasoline) the most common ethanol-blended fuel on the market today. Nearly every gallon of gasoline sold in the United States today contains 10% ethanol.

E15—(15% ethanol, 85% gasoline) this ethanol-blended fuel has been approved by the U.S. Environmental Protection Agency (EPA) for light duty vehicles model year 2001 and newer, and all flex-fuel vehicles (FFVs).

Mid-Level Ethanol Blends (MLBs)—commonly sold in Blender Pumps, these fuel blends are typically comprised of 20-40% ethanol.

E85—(70-85% ethanol, 15-30% gasoline) this high-level ethanol blend is the most renewable liquid fuel available on the market today and can be used by flex-fuel vehicles (FFVs).

Blender Pumps—gasoline dispensers that allow station owners to offer multiple ethanol/gasoline blends from E10 to E85, and provide consumers a choice in what fuel they put in their tank.

Distillers Grains (DGs)—the nutrient-rich livestock feed co-product of ethanol production from grain sources. DG is often dried and combined with syrup to form distillers dried grains with solubles (DDGS), but can also be sold in wet form (WDG).

Flex-Fuel Vehicle (FFV)—a vehicle that has been slightly modified to operate on ethanol blends up to 85% (E85).

Renewable Fuel Standard (RFS)—Federal program that requires oil refiners and blenders to use increasing amounts of various renewable fuels. Culminates in the required consumption of 36 billion gallons of renewable fuels in 2022.
RFA is the leading trade association for America’s ethanol industry. Its mission is to advance the development, production, and use of ethanol fuel 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.