

Farm to Fuel

Ethanol's potential to change the world for the better was recognized long ago. In fact, Henry Ford and Alexander Graham Bell were among the first to realize that the sugars found in plants could easily and inexpensively be converted into clean-burning renewable fuel. Bell himself referred to ethanol as a "clean, beautiful, and efficient fuel" more than a century ago.

Today, more than 200 ethanol biorefineries are living up to the potential first identified by some of our nation's foremost inventors. Modern-day facilities use state-of-the-art technologies to produce ethanol and valuable coproducts from the starches and sugars found in grains, beverage and food waste, and cellulosic biomass, and American farmers themselves are often actively involved in many of these ethanol biorefineries through ownership or leadership roles. While corn is by far the predominant feedstock for ethanol, sorghum also is used, and biorefineries typically use about one-third of the nation's sorghum crop for ethanol production.

More than 91 percent of U.S. fuel ethanol is produced using the dry mill process, with the remaining amount coming from wet mills. The main difference between the two processes is in the initial treatment of the grain.

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

- 2.9 gallons of denatured fuel ethanol
- 15.1 pounds of distillers grains animal feed (10 percent moisture)
- 0.8 pounds of corn distillers oil
- 17 pounds of captured biogenic carbon dioxide*

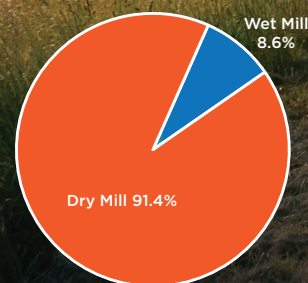
In 2021, ethanol biorefineries captured roughly 2.7 million tons of CO₂, which was used for dry ice production, bottling, food processing, and other uses.

*Source: RFA based on U.S. Dept. of Agriculture data
Approximately 25 percent of U.S. dry mills capture CO₂ from fermentation.

In **DRY MILLING**, the entire grain kernel is first ground into meal, then slurried with water to form a mash. Enzymes are added to the mash to convert starch to sugar. The mash is first cooked, then cooled and transferred to fermenters. Yeast is added and the conversion of sugar to alcohol begins. After fermentation, the resulting "beer" (not the kind you might drink) is separated from the remaining stillage. The ethanol is distilled and dehydrated, then blended with about 2 percent denaturant (such as gasoline) to render it undrinkable. 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 and corn distillers oil.

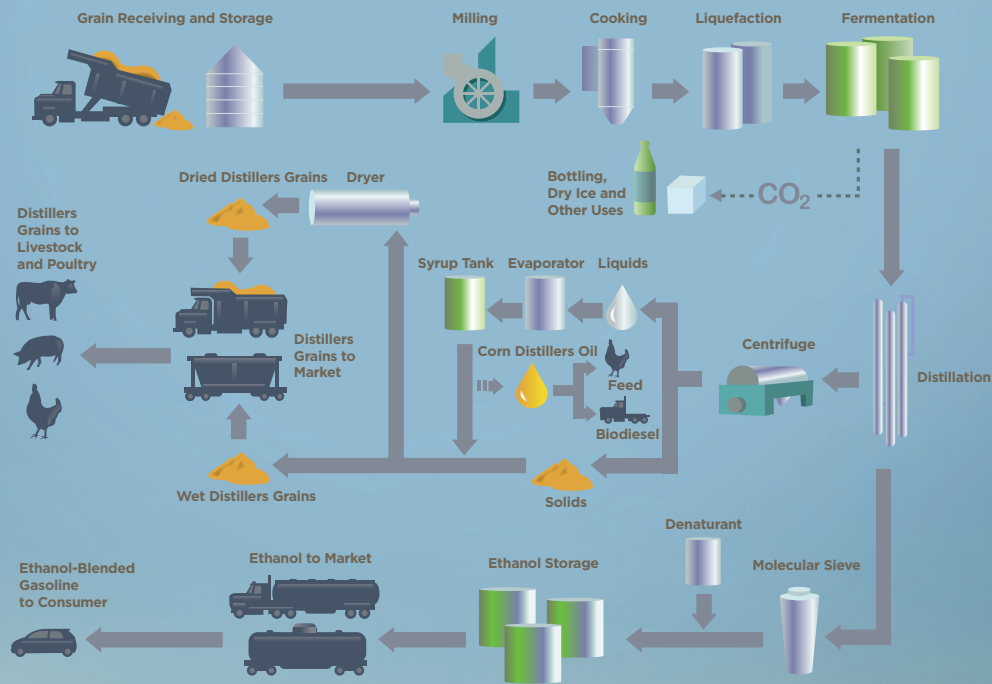
In **WET MILLING**, the grain is first separated into its basic components through soaking. After steeping, the slurry is processed through grinders to separate the corn germ. The remaining fiber, gluten and starch components are further segregated. The gluten component (protein) is filtered and dried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

U.S. ETHANOL PRODUCTION BY TECHNOLOGY TYPE



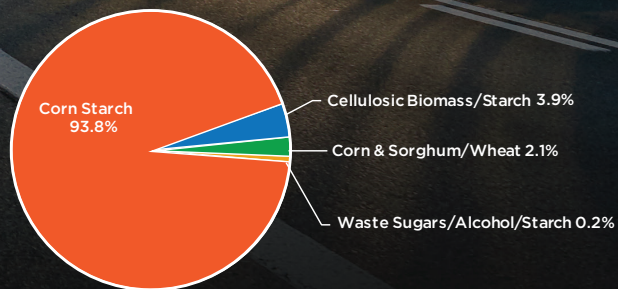
Source: RFA based on U.S. Dept. of Agriculture data

DRY MILL ETHANOL PROCESS



Source: RFA

U. S. ETHANOL PRODUCTION BY FEEDSTOCK TYPE



Source: RFA