

# How an ethanol plant works

Here are the basic steps in an industry that's still evolving

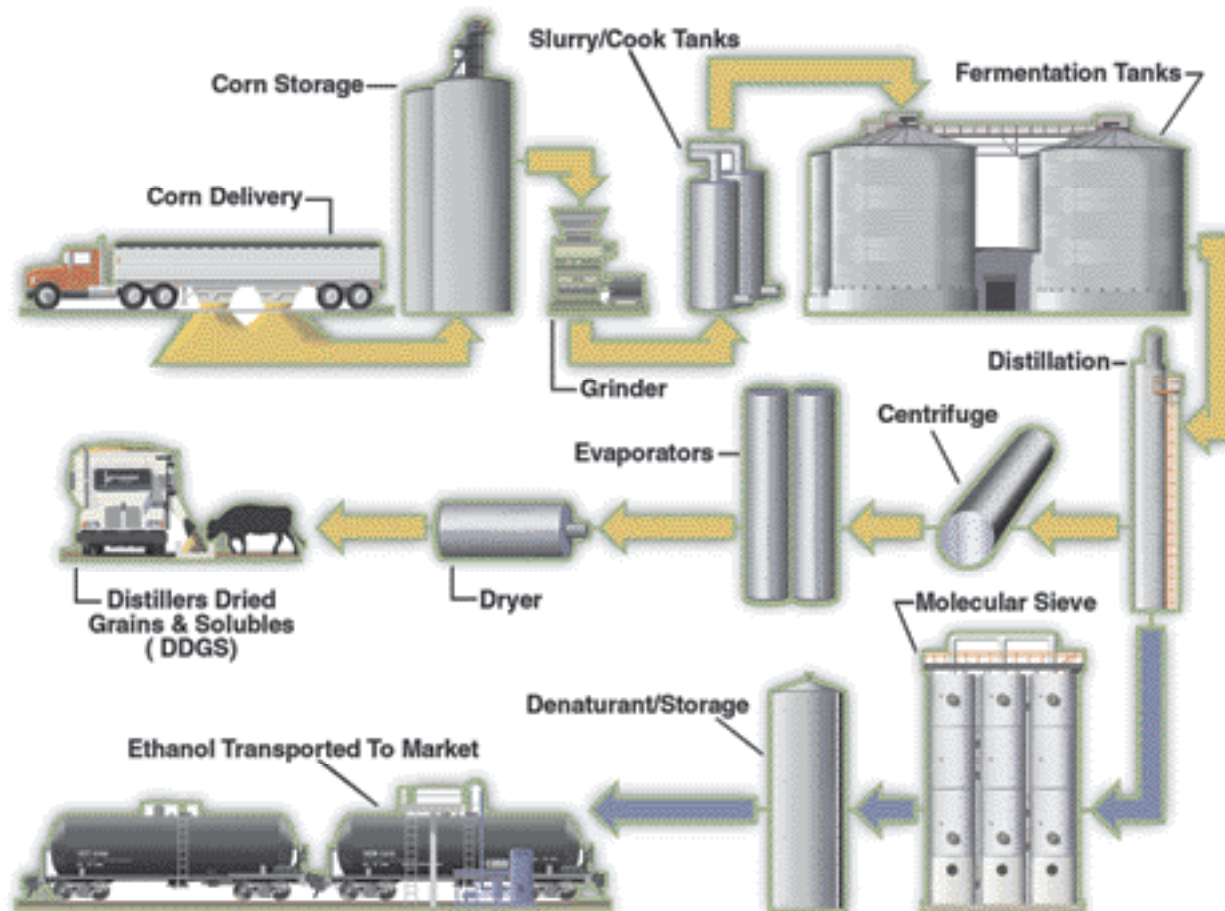


Illustration: Paul Bridgford

An ethanol plant is a biological and industrial process. Besides this production flow, a modern plant recycles some water, recaptures much of its heat, and scrubs emissions from exhaust. Trucks deliver grain and ship out DDGS. Railcars are filled with ethanol that has double the energy used to make it.

**M**aking ethanol is a lot like farming. Ethanol plants grow yeast, a fungus that has waste products of carbon dioxide and alcohol.

"The main part of the process is a living organism. It is alive. It's like growing a crop," says Scott Kohl, a researcher with ICM, Inc. in Colwich, Kansas, an ethanol plant designing and engineering firm.

When today's ethanol industry began, ethanol was made in wet milling plants that also turn out corn oil, starch, syrup, and gluten meal for livestock feed. Wet mills soak grain in water and acid to help separate

corn kernels' germ and endosperm.

Today, nearly all new ethanol plants are dry mills, which cost less to build and run. They grind corn into a flour that is used to make two products: ethanol and livestock feed. Dry mills also make carbon dioxide, but only a few have found markets such as soda bottling plants.

### A brief tour of a dry mill

Dry milling is getting more sophisticated. The Broin Companies of Sioux Falls, South Dakota, are starting to use fractionation, which mechanically mills corn into fiber, germ, and endosperm before mak-

ing ethanol. This allows a plant to make more high-value products such as corn oil.

Most dry mills still use the conventional process illustrated above.

The front end resembles a small grain elevator, where trucks dump corn into temporary storage. It might hold a 10-day supply of corn. From there corn is conveyed to hammer mills where it is ground into a fine meal.

The meal, with a consistency of corn meal, is conveyed into three or four slurry/cook tanks, where the process of breaking starch into sugar begins. Water, heat, and en-

## One-stop shopping

zymes are added to the meal, creating a slurry. In some plants more enzymes are added to complete the breakdown to sugar, but most now finish that process during fermentation, Kohl says.

This first cooking usually takes place at about 185°F., but newer enzymes will work at lower temperatures. Not shown in the chart are boilers that provide this heat and steam for cooking, fermenting, and distillation. Most run on natural gas, but as its cost rises, new plants are being built to run on coal, even methane from manure.

"Over the last 10 to 15 years, energy conservation has significantly improved," Kohl says.

Ten years ago, it took up to 60,000 Btu's to make a gallon of ethanol. Today it's about 35,000. Most of the savings is from recapturing heat to use in several steps of production.

### Into the biological heart

Next, the wet mixture called mash is pumped into fermentation tanks where yeast is added. Keeping yeast-producing ethanol is both art and science. There is a risk of bacterial infection, which lowers production. Urea may be added for nitrogen, which is food for the yeast. If all goes well, in 40 to 55 hours at 90°F., the yeast makes a beer that is up to 16% to 17% alcohol by volume. The chart shows three 730,000-gallon fermentation tanks and a larger tank, called a beer well, that sends beer to the distillation columns.

### Extracting the alcohol

Distillation does two things. It separates alcohol from most of the water and diverts the rest of the water and solids, called stillage, into a process to make distillers' grains.

Distillation columns use alcohol's lower boiling point, 178.4°F., to separate it from water, which boils at 212°F. The beer is heated between 178°F. and 212°F. As this gas rises to the top of the column, liquid with a higher percentage of alcohol condenses. The liquid is passed to the next column, where an even higher percentage of alcohol condenses out. The last distillation column yields 190 proof (or 95%) alcohol.

After distillation, alcohol passes to molecular sieves, columns that

Farmers investing in today's ethanol industry rely heavily on plant designers and builders.

"I'd say 90% of the plants have been a turnkey plant," says Jeremy Wilhelm, an agribusiness loan officer with Farm Credit Services of America. And of those, most are built by two firms, says Shane Frahm, another lender at the bank.

At least 60% of dry mill plants have been built by Fagen, Inc. ([www.fageninc.com](http://www.fageninc.com)) of Granite Falls, Minnesota, Frahm says. It often teams up with Kansas plant designer, ICM, Inc. ([www.icminc.com](http://www.icminc.com)),

which is working with about two thirds of new plants under construction. Broin Companies ([www.broin.com](http://www.broin.com)) of Sioux Falls, South Dakota, has designed and built most of the rest.

These companies will also run plants at start-up, or even permanently, as well as train staff. Some are involved in marketing plant products. And they're heavily involved in promoting ethanol.

Other players include Delta-T Corporation ([www.deltatcorp.com](http://www.deltatcorp.com)) and the German firm, Lurgi PSI ([www.lurgipsi.com](http://www.lurgipsi.com)).

are filled with BB-size zeolite balls. Each has microscopic holes big enough for water molecules but too small for larger alcohol molecules. Heat and pressure force water into the balls. Pure alcohol is removed. When the balls fill up with water, it's removed in a vacuum.

### Making livestock feed

Stillage, with a consistency of noodle soup, flows from the bottom of the distillation columns to a centrifuge, which makes wet cake that looks like steaming, bright yellow sawdust and can be balled up in your hand. The centrifuge also spins out a mix of water and 7% solids called solubles. Evaporators thicken the solubles to the consistency of maple syrup. Most plants

add solubles back into the wet cake. Then it's dried to about 10% moisture and sold as distillers' dry grains and solubles (DDGS), which are used for livestock feed.

If a plant can sell the wet cake without drying, it can cut the energy needed for ethanol production to under 25,000 Btu's per gallon, a big cost savings, Kohl says. But at 65% moisture, it must be used in about a week by nearby feedlots. Some plants now sell modified wet cake at 50% moisture, which keeps about a month. DDGS last a year.

Ethanol plants run year-round, 24 hours a day but must be shut down at least twice a year for maintenance. A lot can go wrong. "There's just a ton of moving parts," Kohl says. "As a plant ages, they can break." □



At this plant, distillation columns are on the left, molecular sieves in the center, and fermentation tanks are behind the shed at right.