



# Ethanol Production in Minnesota

Air Quality/General/#1.20/October 2002

Ethanol (also known as ethyl alcohol or grain alcohol) is a clear, colorless liquid made by fermenting and distilling material, usually some sort of plant, most commonly corn. One bushel of corn produces between two and three gallons of ethanol.

In recent years, ethanol has been used primarily as an “oxygenate” for gasoline—in other words, ethanol adds oxygen to gasoline, which allows the gasoline to burn more completely. Gasoline that burns completely pollutes the air less. Other gasoline additives serve the same purpose, but many are not good for the environment.

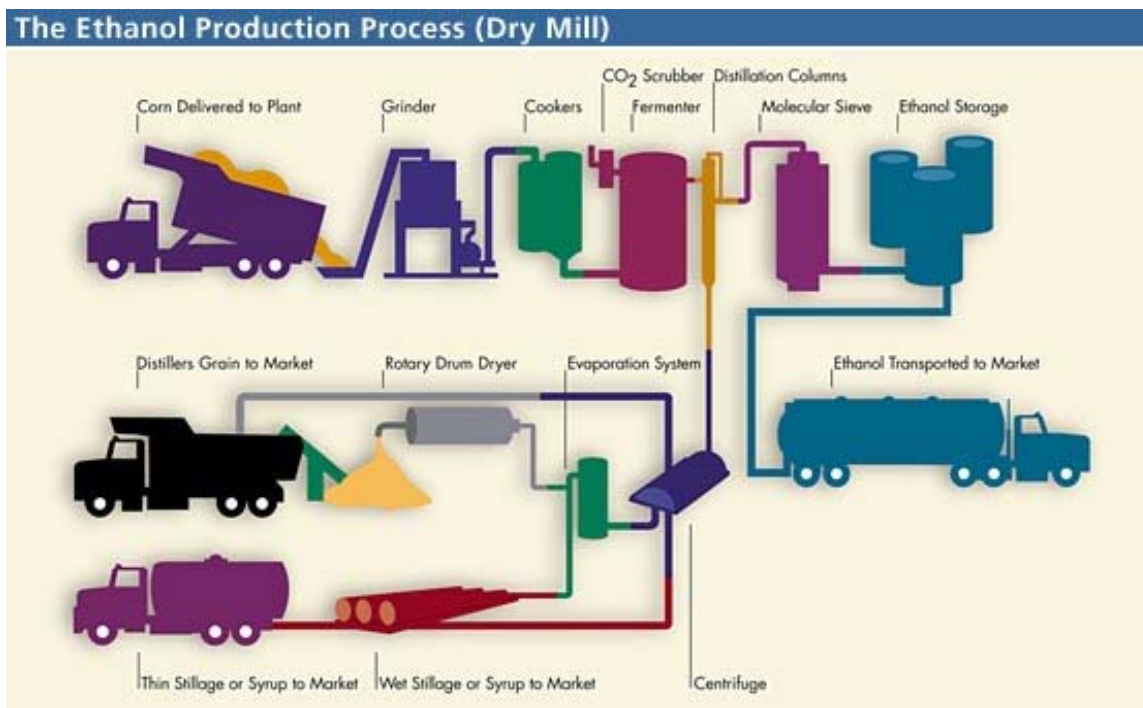
Air pollution from vehicles is the major contributor to smog and other air pollution problems. To combat air pollution, Minnesota has required the use of ethanol-blended gasoline in the Metro area since 1995 and throughout the state since 1997.

Almost 20 percent of the nation’s ethanol plants are located in Minnesota. The 14 Minnesota ethanol plants produce more than 400 million gallons of ethanol each year. (See table at the end of this fact sheet for production capacity of individual plants.) The largest plant produces 40 million gallons of ethanol each year; the smallest plant produces 2.6 million gallons per year. Twelve of the 14 plants are farmer coops, meaning they are co-owned by groups of local farmers.

## How Ethanol is Made

There are two different ethanol production processes: wet milling and dry milling. Twelve of the Minnesota plants are dry mills and two are wet mills. The primary difference between the two is the initial treatment of the starchy grain. Since 13 of Minnesota’s 14 ethanol plants use corn as the starchy grain, both processes are described on the next page using corn as an example.





graphic: Renewable Fuels Association, <http://www.ethanolrfa.org>

## Dry Milling Process

Corn is delivered to ethanol plants by truck or rail car. The corn is then ground up in a hammer mill and made into “meal.” The meal is mixed with water to form a “mash.” Enzymes are added to the mash, which changes the cornstarch to a fermentable sugar. This step takes place in a high-temperature cooker.

After the mash has cooled, it is transferred to fermenters. Yeast is added to ferment the sugars, creating ethanol and carbon dioxide. There are two types of fermentation, continuous and batch. In the continuous process, the fermenting mash flows through several fermenters until the mash is fully fermented.

In a batch process, the mash stays in one fermenter for about 48 hours before the distillation process is started.

The fermented mash, now called “beer,” is about 10 percent alcohol, and 90 percent water and leftover solids from corn and yeast. The beer is pumped to the distillation system, where alcohol is separated from the solids and water.

The alcohol leaves its final distillation at about 96 percent strength (190 proof). The residual mash, called “stillage,” is transferred to the distiller grain processing area.

The separated alcohol passes through a dehydration system where any remaining water is removed. Most ethanol plants use a molecular sieve to capture the last bit of water in the alcohol. The alcohol at this stage is called “anhydrous ethanol” and is 100 percent alcohol or 200 proof.

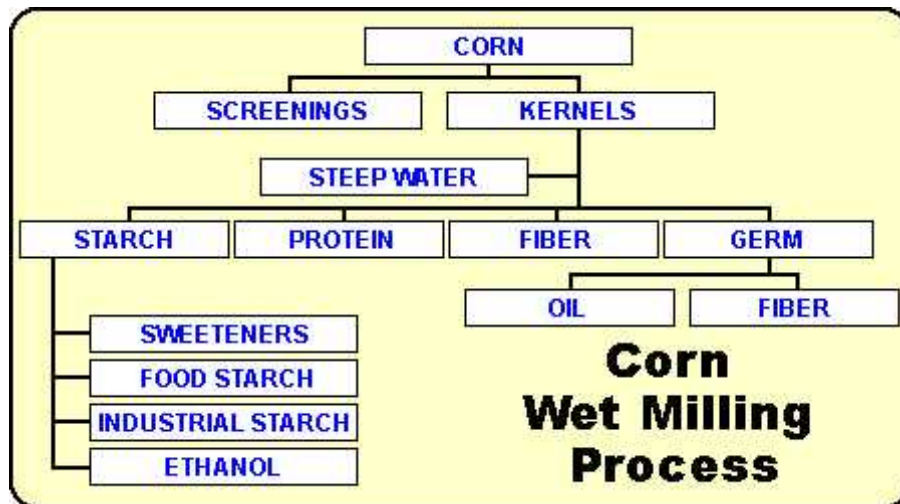
Anhydrous ethanol intended for fuel use is denatured with about five percent of a product like gasoline to make it undrinkable. Once the ethanol has been denatured, it is ready for shipment to gasoline terminals or retailers to be mixed with gasoline and sold as ethanol fuel. Ethanol-blended gasoline in Minnesota is required by law to be at least 2.7 percent ethanol.

The leftover stillage passes to a centrifuge that separates coarse grain from soluble material. Solubles are concentrated by evaporation to make “syrup.” Syrup can be sold on its own or mixed back with coarse grain to form “distillers grain.”



Distillers grain is sold as animal feed in either a wet state called “wet cake,” or after drying as dried distillers grain (DDGS). Distillers grain, wet and dried, is high in protein and other nutrients, and is a highly-valued livestock feed ingredient.

Another major byproduct created by ethanol production is carbon dioxide, given off during the fermentation process. Many ethanol plants collect the carbon dioxide, clean it and sell it for use in the carbonated beverage and dry-ice industries.



## Wet Milling Process

Corn is delivered to the plant by truck or rail car. After the corn is received, it is soaked or “steeped” in water and a dilute sulfurous acid for one to two days. Steeping makes it possible to separate the corn into its many component parts.

After the corn has finished steeping, the slurry is passed through a series of grinders, centrifuges, screens, and hydroclonic separators. These processes separate the corn into starch, protein, fiber, and germ.

Starch and remaining water are processed into ethanol through a fermentation process very similar to the dry mill process described above.

Ethanol is just one of many products that wet mills produce. Other products include Ice Ban, an alternative to salt for removing ice from roads; corn gluten, a feed for livestock; corn syrup, and corn oil.

## Air Emissions from Ethanol Plants

- As corn is delivered to the plant, then handled and milled, tiny particles are released into the air. Particles are also emitted during the drying process. These tiny, usually invisible particles are called particulates and can be unhealthy if inhaled.
- During fermentation, distillation and drying, volatile organic compounds (VOCs) are released. Some of these VOCs are known as “hazardous” or “toxic” at certain levels. These include some or all of the following: acetaldehyde, acrolein, ethanol, formaldehyde, 2-furaldehyde, methanol, acetic acid and lactic acid. Several of these emissions have an odor objectionable to some individuals.
- Carbon monoxide (CO) and nitrogen oxides (NOx) are generated from combustion in the boilers of the plant. CO may also be generated in the drying process.

For more information on emissions, see MPCA fact sheet *Air Emissions from Ethanol Plants* (AQ/General/#1.21).



## Minnesota Ethanol Plants, 2002

Plant name	City	Capacity Gallons/year	Start-up year	Wet or Dry mill
Minnesota Corn Processing	Marshall	40 million	1988	Wet
Diversified Energy Co LLC (DENCO)	Morris	20 million	1991	Dry
Corn Plus	Winnebago	44 million	1994	Dry
Heartland Corn Products	Winthrop	35 million	1995	Dry
Chippewa Valley Ethanol Company (CVEC)	Benson	49.5 million	1996	Dry
Al-Corn Clean Fuel	Claremont	30 million	1996	Dry
Ethanol 2000	Bingham Lake	39.5 million	1997	Dry
Minnesota Energy	Buffalo Lake	19 million	1997	Dry
Melrose Dairy Protein LLCs	Melrose	2.6 million	1986	Wet
Pro-Corn LLC	Preston	50 million	1998	Dry
Agri-Energy LLC	Luverne	22 million	1998	Dry
Central Minnesota Ethanol Cooperative	Little Falls	22 million	1999	Dry
Exol/Agra Resources Cooperative	Albert Lea	50 million	1999	Dry
Gopher State Ethanol	St. Paul	20 million	1999	Dry
<b>TOTAL</b>		443.6 million gallons		12 – Dry 2 – Wet

### For More Information:

#### About air permitting issues:

MPCA Customer Assistance Center  
(651) 297-2274 (Metro and outside Minnesota)  
1-800-646-6247 (Minnesota only)

#### About specific ethanol plants:

Rhonda Land, MPCA  
(651) 297-7707 (Metro)  
1-800-657-3864 (ask for Rhonda Land)

**MPCA Web site:** <http://www.pca.state.mn.us>