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Cellulose to Ethanol: An Update on the POET Bio-Refinery in Emmetsburg

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Background

Grain-based ethanol production has greatly expanded in Iowa in the past 5 years. Future growth of ethanol production will depend on cellulosic feed stocks. Some of these feed stocks may include grass/forage, municipal wastes and crop residues. Much of the technology to convert cellulosic feed stocks to ethanol is still being developed.

The Midwest is likely to be a major source of feed stocks to future biorefineries. Figure 1 illustrates the density of biomass (agricultural, and forest) available per square mile.

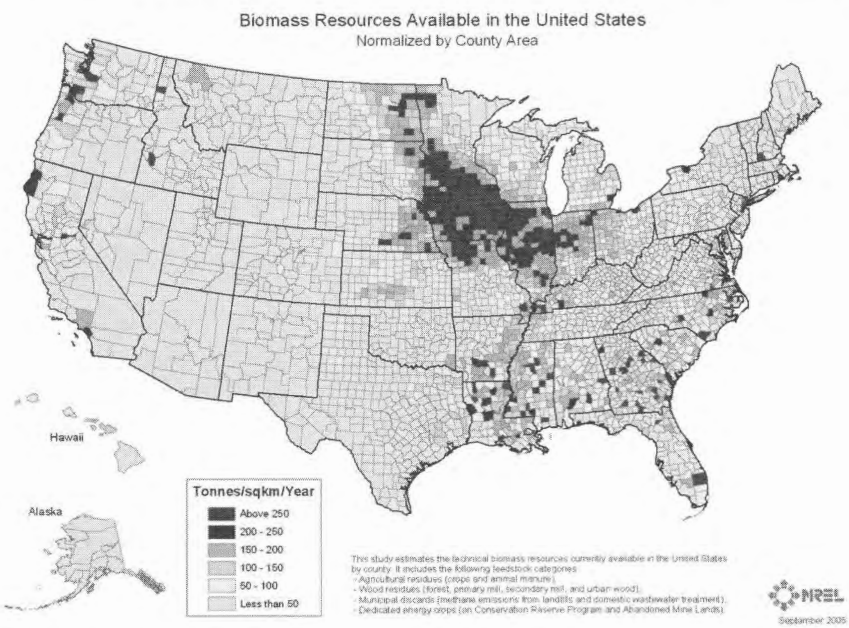

Figure 1. Biomass Resources Available in the United States

The U.S. Department of Energy (DOE) awarded funds to five demonstration cellulose projects. The projects are geographically dispersed across the nation. They will test numerous cellulose feed stocks, and will demonstrate both thermochemical and biological conversion methods to ethanol.

POET and the U.S. Department of Energy signed a Cooperative Agreement on September 30, 2007, the first of two Project Liberty agreements. This first agreement is mainly for preliminary engineering, and will lead to a decision about proceeding with the second agreement for construction. The first agreement will last about 20 months, with construction lasting from 2009 to 2011.

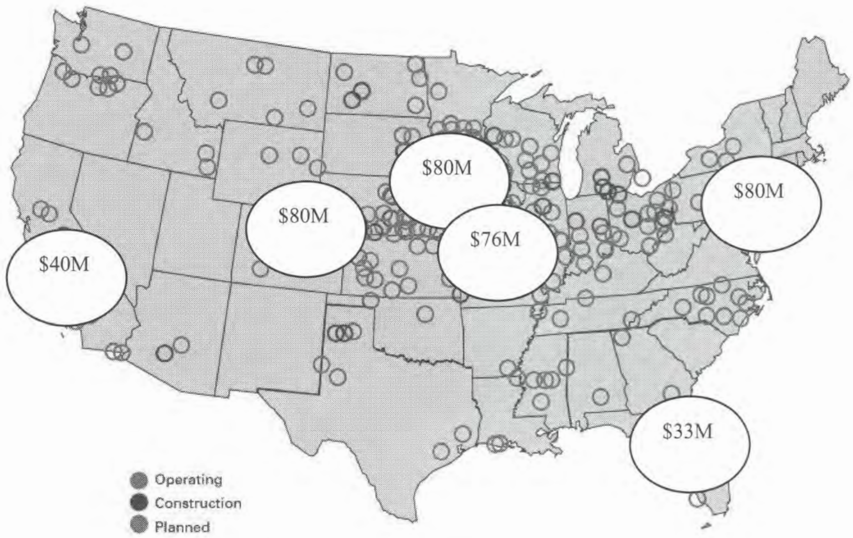

Figure 2. 2007 DOE Biorefinery Awards = $385 million

Ethanol production

A typical grain ethanol biorefinery receives corn grain, mills it, adds enzymes and cooks the mash. The mash is then fermented and distilled. Most biorefineries produce both ethanol and dried distillers grains (DDGs).

Grain is a very popular source of ethanol production. However, another plant component is lignocellulose, the primary structural component of plants. Many organizations around the world are conducting research on the conversion of lignocellulose to fuel.

Table 1. Conversion Efficiencies (Wallace et. Al., 2005 USDA/USDOE)

Corn Grain to Ethanol	120 gal/dry ton or 2.84 gal/bu
Lignocellulose Biomass to Ethanol	79 gal/dry ton

There are three types of conversion processes for carbohydrates and cellulose:

1. Biochemical plants use biological processes like fermentation and anaerobic digestion to convert starch and cellulose to products like ethanol and bio-based plastics.
2. Thermochemical processes that use heat, pressure, and chemicals to convert biomass to biofuels and bio-products.
3. "Hybrid" systems that use both biological and thermochemical processes.

Converting cellulose to ethanol is a developing industry. This conversion is less efficient than converting grain to ethanol. However, conversion processes are expected to improve as resources are dedicated to discovery, research, and commercial applications of cellulose to ethanol conversion.

The process depicted in this flow chart is one potential biorefinery model. This is an example of thermochemical processing. Thermochemical processes use heat, pressure, and chemicals to convert plant material to bio-based products.

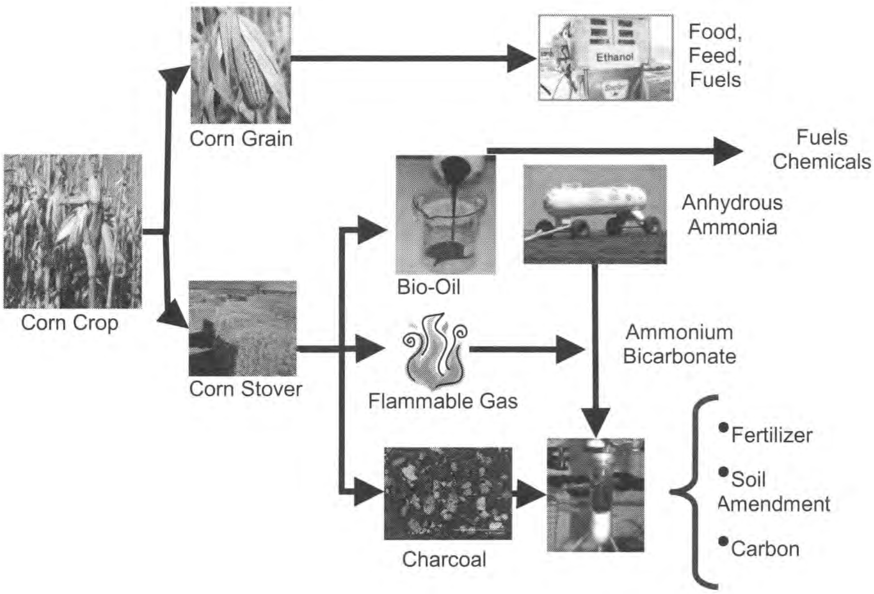

Figure 3. Thermochemical Biorefinery Model

Project Liberty

The POET project in Emmetsburg involving the DOE grant has been named Project LIBERTY. Following is a description of some of the things that will happen there:

- The plant will integrate cellulose-to-ethanol and grain-to-ethanol technologies.
- The total cost of the biorefinery will be over $300 million.
- Total ethanol production will be 125 million gallons - which includes 25 million from cellulosic feedstock.
- The plant will serve as a model for the cellulosic process with cobs and corn fiber as the feed stocks.
- The plant will also be used as model for replication at other biorefineries.

POET biorefineries are located throughout the Corn Belt. The LIBERTY process can be added to other POET biorefineries, after it has been proven at the Emmetsburg biorefinery.

POET selected cobs as the primary feedstock by POET over corn stalks or corn stover. Some of the reasons are as follows:

- Cobs are fairly uniform in terms of moisture content, density and ethanol yield.
- Cobs have a high ethanol yield when compared to stover.

- Cob harvest, storage, and retrieval are somewhat similar to corn grain.
- Cob collection is less weather dependent than stover collection.
- Farmers may find it easier to adapt cob harvest systems when compared to stover harvest.

Project LIBERTY at Emmetsburg will fractionate corn grain into corn germ, corn bran and starch. The corn bran and cellulose from the cobs will be converted to ethanol. This additional process will operate in tandem with the biological conversion of starch to ethanol.

Project Liberty will deliver more efficient production of ethanol from the corn crop. This process will provide for:

- 11% more ethanol from a bushel of corn
- 27% more ethanol from an acre of corn
- 83% less fossil fuel consumption
- 24% less water consumption

Cob Harvest

Many factors will influence a farmer's decision to participate in this cob harvest for cellulose production. Farmers will need to consider economics of cob harvest which include the selling price of the cobs and cost of harvesting the cobs. Other things farmers will consider will include equipment costs, the need for more farm help, and timeliness of harvest operations.

POET is conducting research on many of the logistical concerns of cob harvest. POET is working with a farm operation in South Dakota where they are harvesting approximately 4,000 acres of grain and cobs.

One process used to collect cobs is the Cob Caddy® method. The Cob Caddy is pulled behind the combine and collects the cobs and material from the back of the combine. An engine on the Cob Caddy powers a separator that cleans the cobs. The Cob Caddy is then emptied into a dump cart and taken to the cob storage site.

Another process used to collect cobs is a modified combine to harvest a Corn Cob Mix (CCM). Nearly any combine can be adjusted to harvest CCM. The CCM has about 50% more volume and about 80% less weight than corn grain. The CCM is handled like grain in the field. The Corn Cob Mix is then delivered to the grain/cob storage site where a grain screener is used to separate cobs from grain.

Research is also being done on cob storage. Questions on the size of cob pile, aeration, and the need for inside storage are all being addressed. Other questions that will be addressed include moisture content of the cobs and retrieval and delivery of corn cobs.