BioFacts

Fueling a Stronger Economy

Ethanol from Biomass

What is Ethanol From Biomass?

- A domestically produced liquid fuel from renewable, virtually inexhaustible domestic resources
- A nonfossil transportation fuel that contributes little, if any, net carbon dioxide to the atmosphere during production and use
- A high-octane fuel that can contribute substantially to the U.S. automotive fuel supply
- A fuel that can be used as a blend, a component of ethyl tertiary butyl ether (ETBE), or as a pure fuel, with excellent efficiency and performance
- A potentially clean-burning fuel that reduces smog and emissions of carbon monoxide.

The Resource

Today, most U.S. ethanol production is based in the large grain-growing states of the Midwest, where about 13 million cubic meters (400 million bushels) of corn and other starch crops are used to produce approximately 3.8 billion liters (1 billion gallons) of ethanol annually. Because the anticipated demand for ethanol will eventually push up grain prices, the Department of Energy (DOE) is concentrating its efforts on developing an alternative, low-cost feedstock—cellulosic biomass. Ethanol can be produced from plentiful, domestic, cellulosic biomass feedstocks such as herbaceous and woody plants, agricultural and forestry residues, and a large portion of municipal solid waste and industrial waste streams.

Warren Gretz, NREL

Shown here, the simultaneous saccharification and fermentation process combines hydrolysis and fermentation steps in one vessel to produce high yields of ethanol from biomass.

Warren Gretz, NREL

Don Rice, a supervisor with James River Corporation, stands in a plantation of hybrid cottonwood trees, which make an excellent energy crop for biofuels production. This crop of trees, which will be used to make paper, is grown near Clatkansie, Oregon.

To ensure that a low-cost energy feedstock is available, researchers are examining dedicated energy crops—wood and grass species—that have been selected to produce high yields. With proper management, researchers estimate an average of 2.45 billion metric tons of cellulosic biomass could be available in the United States each year for fuel conversion—providing a potential ethanol yield of 1.02 trillion liters (270 billion gallons).

The Process

Cellulosic biomass is a complex mixture of carbohydrate polymers from plant cell walls known as cellulose and hemicellulose, plus lignin and a smaller amount of other compounds generally known as extractives. To produce ethanol from biomass feedstocks, a pretreatment process is used to reduce the feedstock size, break down the hemicellulose to sugars, and open up the structure of the cellulose component. The cellulose portion is broken down (hydrolyzed) by enzymes into glucose sugar that is fermented to ethanol. The sugars from the hemicellulose are also fermented to ethanol. The lignin is burned as fuel to power the process.

Scientists involved in DOE-sponsored studies at the National Renewable Energy Laboratory (NREL) are targeting a procedure known as simultaneous saccharification and fermentation (SSF) for converting cellulose to ethanol. The process combines the cellulose hydrolysis and fermentation steps in one vessel to produce high yields of ethanol. Advances in genetic engineering are making the fermentation of hemicellulose sugars more productive as well. Continued

improvements in such key technical areas will make biochemical conversion of biomass to ethanol an efficient and economical route to alternative fuels production.

The Program

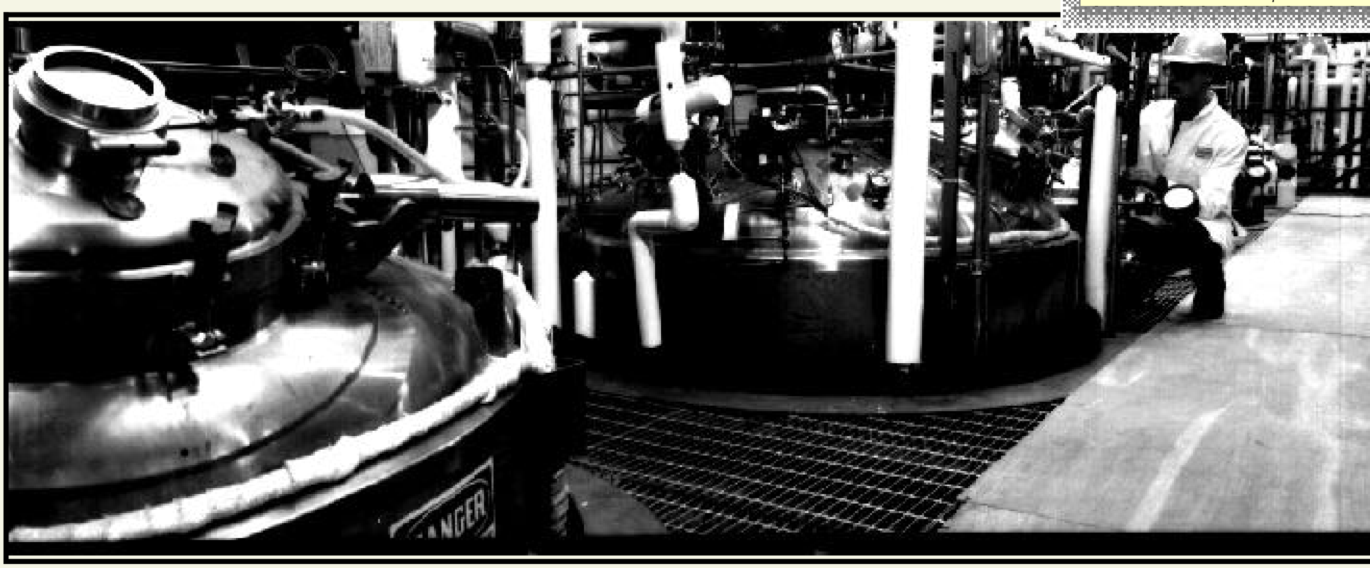
The DOE Biofuels Systems Division sponsors and supports the Ethanol from Biomass Program. The NREL Alternative Fuels Division is the field manager for the program. NREL solicits its participation in the program through subcontracts and cooperative research and development agreements (CRADAs) with industry partners, universities, and other national laboratories.

The objective of these industry, university, and government partnerships is to develop technologies for producing ethanol from biomass at a cost that will be competitive with the cost of gasoline by 2000 without tax incentives. Significant strides have already been made in bringing the conversion of biomass to ethanol into the realm of realistic and affordable alternative fuel technologies. Over the last decade, the program has succeeded in reducing the predicted cost of biomass-derived ethanol from $0.95/liter ($3.60/gal) to $0.34/liter ($1.27/gal).

Utilization

Service stations throughout the United States, especially in carbon monoxide nonattainment areas, are distributing ethanol blends. However, ethanol blends can be found in other areas of the country as well, and have been used for many years to boost gasoline's octane. (The addition of 10% ethanol to make "gasohol," can boost fuel octane by 3 points.) E85 and E95 (blends containing 85% and 95% ethanol) are being tested in North America in government fleet vehicles, flexible-fuel passenger vehicles, and urban transit buses. Although there are less than 100 such vehicles in operation, the role of ethanol is expected to grow as federal, state, municipal, and private fleet operators seek to comply with the alternative fuel requirements of the Energy Policy Act of 1992 and the Clean Air Act Amendments of 1990.

DOE recently completed the Process Development Unit, which can produce ethanol from a wide range of biomass. Partners from private industry can use the facility to test various processes and feedstocks and obtain the data they require to design, fund, and operate their own ethanol plants.


Warren Gretz, NREL

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Federal and nonfederal U.S. fleets were estimated to include more than 500 E85-fueled vehicles as of December 1994.

Environmental Effects

With proper crop management, production of ethanol from biomass feedstocks can reduce net greenhouse gases from automobile emissions. This is because plants require carbon dioxide (CO_2) for growth. Energy-crop production creates a “carbon cycle” when biomass-derived fuels are burned in vehicle engines—the CO_2 released in combustion is taken up by plants during the growth process. Ethanol can also help lower mobile-source carbon monoxide emissions. Ethers derived from ethanol, such as ETBE, are similarly beneficial. Neat ethanol is relatively low in toxicity, water soluble, and biodegradable, making the consequences of large fuel spills less environmentally threatening.

Use of ethanol does pose some difficulties that are currently being addressed by researchers. Ethanol contains only about two-thirds the energy per volume (or travel range per gallon) of an equal amount of gasoline, but efficiently designed engines could increase the travel range of pure ethanol to about 80% that of gasoline. Nonetheless, slightly larger fuel tanks would be needed if vehicles are to travel equal distances to gasoline on one fill-up of pure ethanol. (The range of vehicles fueled with ethanol blends such as gasohol is statistically indistinguishable from that of vehicles running on regular gasoline.) Pure ethanol’s low volatility is beneficial in reducing some emissions but can cause starting problems in cold weather. Researchers are working on ways to overcome this difficulty as well.

Overall, the environmental benefits, domestic producibility, and economic boost that ethanol from biomass could provide make it a very attractive transportation alternative.

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