



Ethanol from Biomass

FACT SHEET 5.6

INTRODUCTION

Ethanol, also known as ethyl alcohol or grain alcohol, is a flammable, tasteless, colorless, mildly toxic alcohol having a fairly distinguishable odor. It is the same alcohol found in alcoholic beverages and is used alternatively for industrial purposes as well as a transportation fuel. Industrial produced ethanol is used in solvent-based paints, pharmaceuticals, perfumes, inks, and cleaning products. As a biofuel, ethanol is produced most commonly from corn and sugarcane feedstocks. It has the potential to be produced from woody biomass feedstocks. Yet this has rarely been the case except in laboratory situations.

HISTORY OF ETHANOL Ethanol is by no means a new alcohol. The use of ethanol by humans dates back to prehistoric times when the substance was largely consumed as a beverage. It was not until the early to middle 1800s, however, that ethanol was first dissected as a compound and prepared synthetically. Ethanol, as a fuel, was used in lamps during the pre-Civil War era, but a liquor tax placed

on ethanol to help fund the war made the fuel costly compared to kerosene and other fuels. Ethanol rose again briefly in popularity when Henry Ford designed the model T automobile to run on the fuel. However, this was short lived with the onset of Prohibition-related bans.

In the 1960s and 1970s, interest in fuel ethanol was stimulated due to large imports of foreign crude oil. In the U.S., the primary approach was the production of gasohol, a blend of about 90 percent gasoline and 10 percent ethanol. Corn was the major feedstock for ethanol. As octane enhancers, ethanol and its derivative ethyl tert-butyl ether actually increase the efficiency of gasoline burned in internal combustion engines. Gasoline remained the primary fuel because of its lower cost in production compared to ethanol.

Today in the U.S., ethanol occupies a niche in the transportation fuel market. Ethanol or methyl ter-butyl ether (MTBE) is used as an oxygenate in urban areas that do not meet U.S. Environmental Protection Agency (EPA) air quality standards to increase the

combustion efficiency of gasoline, thus decreasing carbon monoxide emissions in cold weather. This is especially the case now that five states using MTBE are phasing the additive out as an oxygenate due to its toxicity (Figure 1).

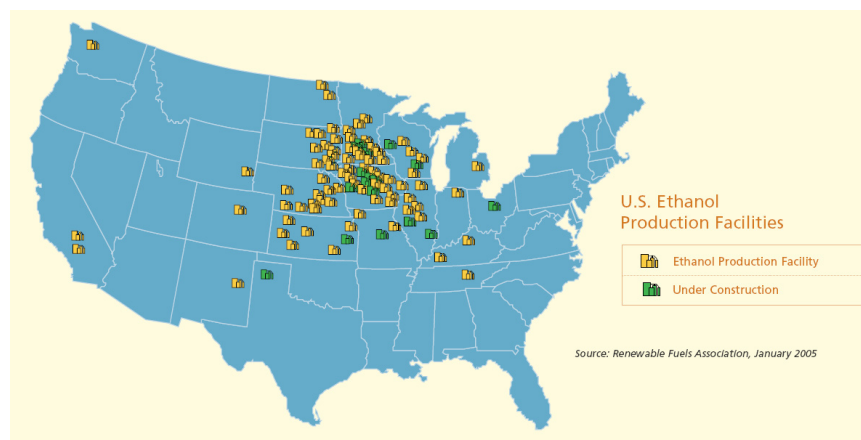


Figure 1. U.S. Ethanol Production Facilities

Ashton, S.; P. Cassidy. 2007. Ethanol from Biomass. Pages 183–186.

In: Hubbard, W.; L. Biles; C. Mayfield; S. Ashton (Eds.). 2007. Sustainable Forestry for Bioenergy and Bio-based Products: Trainers Curriculum Notebook. Athens, GA: Southern Forest Research Partnership, Inc.



Today many automobiles manufactured in and for the U.S. are equipped to run on either gasoline or E85, a blend of 85 percent ethanol and 15 percent gasoline¹. Flexible fuel vehicles (FFVs), at no extra cost to the consumer, have a few minor engine modifications and a fuel line made out of a slightly different material than that found in conventional automobiles. E85, although manufactured in large quantities elsewhere, is still relatively hard to find in the U.S.

often made chemically, whereas ethanol for fuel is often made biologically or with a two-step process of hydration and fermentation. In general, to make fuel ethanol from biological feedstocks, certain yeasts break down sugar in the absence of oxygen producing ethanol and carbon dioxide. With woody biomass, the process is a bit more complex. Hydrolysis of cellulose, the decomposition of cellulose by reaction with water, must occur first in the

DID YOU KNOW? ETHANOL FACTS IN 2005⁵

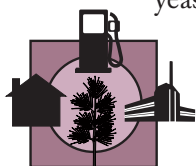
- Ethanol displaced 170 million barrels of oil.
- Ethanol lowered consumer gas prices by 8 cents a gallon.
- The ethanol industry produced 4 billion gallons of ethanol.
- Ethanol reduced green house gases by 8 million tons which is the equivalent of removing 1 million vehicles off the road.
- By 2012, ethanol may potentially displace more than 2 billion barrels of oil.

In the U.S., demand for starch-based ethanol is influenced by the commodity market price for corn. During the 1995 to 1996 marketing year, high demand for corn grain drove up corn prices to record levels, leading to high input costs and a downturn in ethanol fuel production. Many ethanol producers opted to suspend ethanol production and do maintenance on their manufacturing facilities. Other producers diverted ethanol fuel production to the alcoholic beverage market.

HOW IS ETHANOL MADE? Ethanol is produced chemically through the hydration of ethylene and biologically by fermenting sugars with yeast. Ethanol for industrial purposes is most

woody biomass to produce reducing sugars. Once this occurs, the sugars can then be broken down to produce ethanol and carbon dioxide. For more information on the fermentation process, please refer to the Fact Sheet 5.3 Technological Processes: Bio-chemical.

While the science behind making ethanol from woody biomass has been in place since before these fuels were used to power vehicles, large-scale production of fuel ethanol from lignocellulosic materials has been unfavorable economically². Cellulase enzymes, the enzymes that break down cellulose in the hydrolysis phase, have been cost prohibitive to use³ (*Image 1*).





WHY IS CELLULOSIC ETHANOL IMPORTANT?
Cellulosic ethanol, which is ethanol created from feedstocks containing cellulose, is not only created from a sustainable, renewable resource but it also burns cleaner than both gasoline and diesel. Environmentally speaking, ethanol has both low carbon and sulfur emissions as well as very little particulates. The large-scale production of ethanol from woody biomass or lignocellulosic biomass, in particular, is important because it would mean less waste when producing biofuels from feedstocks such as corn and cane. All of the feedstock could be used rather than just a few parts. In addition, complete replacement of petroleum-based fuel with food-based fuels alone would most certainly affect food supplies⁴. Additionally, a renewable resource like ethanol is more likely to be socially acceptable than a non-renewable resource such as fossil fuel. Because the woody biomass to produce can be grown and processed locally, there is less dependence on foreign sources of fuel.

SUMMARY AND CONCLUSIONS

While the majority of fuel ethanol continues to be produced from food-based feedstocks such as corn and sugarcane, there remains great opportunity in the use of woody biomass feedstocks for ethanol. Technological advances and research into how to reduce the costs are promising.

For more information, please refer to the Encyclopedia of Southern Bioenergy at <http://www.forestencyclopedia.com/Encyclopedia/bioenergy>.



Image 1. Ethanol Plant

source: Reuters New Media Inc.

ENDNOTES

- 1 Lugar, R. G.; Woolsey, J.R. 1999. The new petroleum. *Foreign Affairs*. 78(1): 15.
- 2 Zerbe, J. I. 1992. Liquid fuels from wood-ethanol, methanol, diesel. *World Resource Review*. 3(4): 9.
- 3 Sun, Y.; Cheng, J. 2002. Hydrolysis of lignocellulosic materials for ethanol production: a review. *Bioresource Technology*. 83(1): 1–11.
- 4 Hill, J.; Nelson, E.; Tilman, D.; Polasky, S.; Tiffany, D. 2006. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. *Proceedings of the National Academy of Sciences of the United States of America*. 103(3): 11206–11210.
- 5 Bob Dinneen, Renewable Fuels Association President. Speech given at the National Ethanol Conference “State of the Industry Address” Held in 2006, Las Vegas NV.

