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Special issue:
Renewable Fuels and the Bioeconomy

"Renewable Fuels and More: Creating a Sustainable Bioeconomy for the Nation" was the title of the January 31, 2007 Agronomy Seminar at K-State. It was presented by Steven Fales, Associate Director, Office of Biorenewable Programs and Professor, Department of Agronomy at Iowa State University. The following is a summary of Fales' seminar.

You can watch the entire seminar on the web at:
http://wms.oznet.ksu.edu/medialab/Agronomy/Renewable_Fuels.wmv

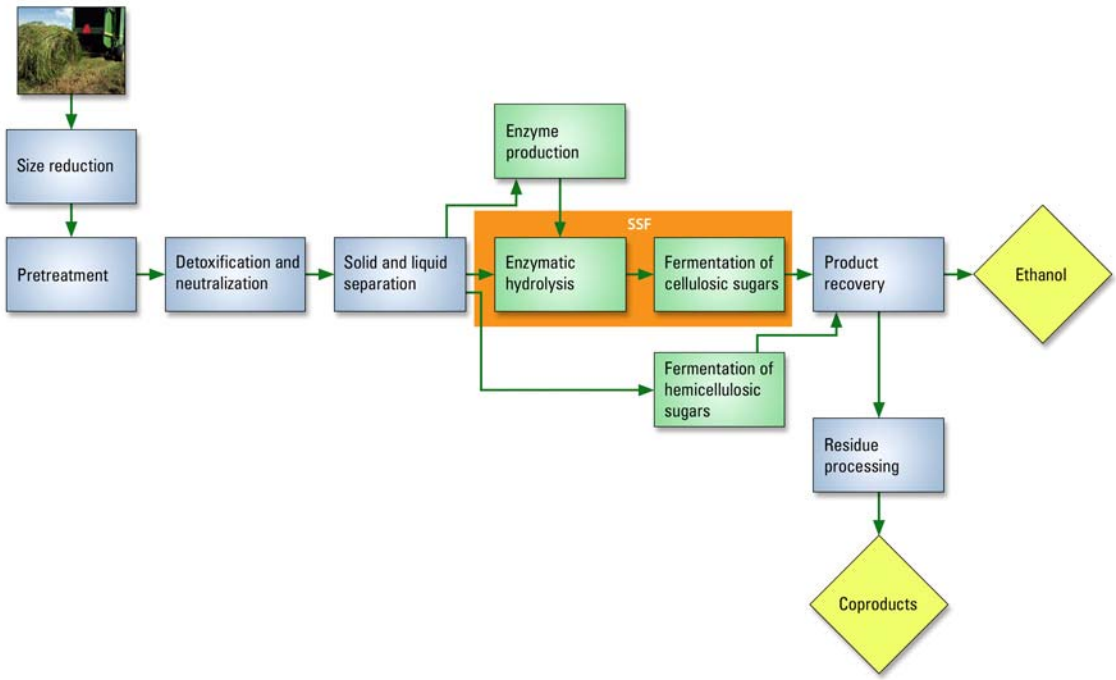
– Steve Watson, Agronomy e-Update Editor

Introduction

The new "bioeconomy" involves a union of agriculture and manufacturing to produce bioenergy – primarily ethanol and biodiesel. Two of the main driving forces behind this rapidly emerging industry are national security and climate change issues. If the bioeconomy is planned and executed properly, it will be a golden opportunity for long-term revitalization of rural communities throughout the Midwest.

There are two main platforms used in the biofuels industry:

1. Biochemical: Starch or cellulose. Starch-based plants convert corn grain (primarily) directly into ethanol. Cellulose-based plants start by pretreating biomass with dilute sulfuric acid to cleave the lignin from the cellulose and hemicellulose. The cellulose and hemicellulose are then converted to ethanol, while the lignin can be combusted through co-generation facilities to generate electricity and the steam required for ethanol production. The traditional process of converting biomass into ethanol is depicted in the following graphic from DOE:



2. Thermochemical: Gasification or fast pyrolysis. In these plants, biomass is burned at 400-500 degrees C under controlled air conditions, producing "syngas." Co-products of this process are ash and ammonia, which can be made into ammonium carbonate and possibly used as a fertilizer product.

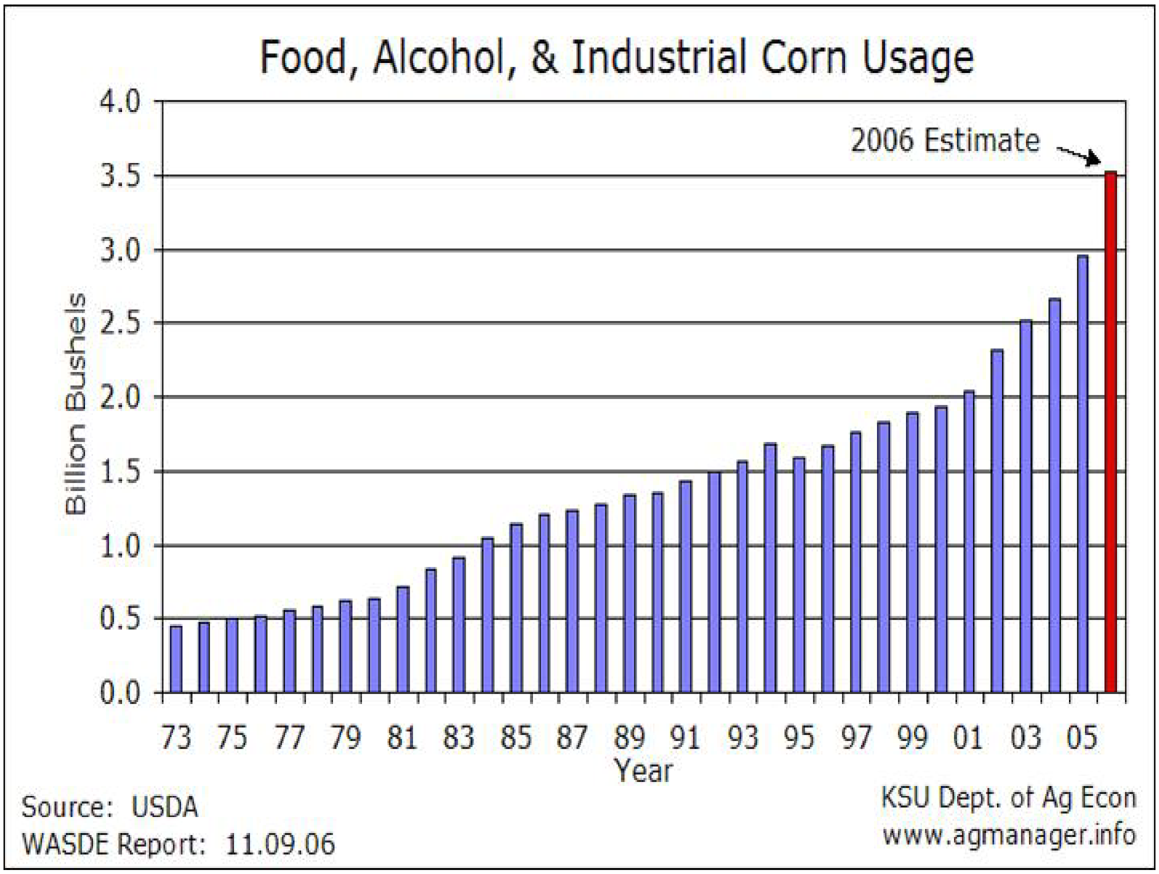
There are also hybrid plants, which are a combination of those two platforms. One such hybrid plant is now under construction in Emmetsburg, Iowa by Broin Industries. This plant will utilize both the grain and stover of corn. Starch is converted to ethanol in the normal manner. The germ is processed into oil. The bran is used as a source of cellulosic biomass and combined with the stover to produce more ethanol. Waste from the conversion of starch to ethanol is put through an anaerobic digester and combined with other byproducts to generate bio-gas, which is used as a source of energy for the plant's operation.

Starch-based Ethanol

At the moment, starch is king in the biofuels industry. Almost all ethanol plants operating in the U.S. are converting starch (mostly from corn grain) to ethanol. There are 110 working ethanol plants currently in the U.S. Most of them are in Illinois, Iowa, Nebraska, Kansas, and other states in the eastern or western Corn Belt. Iowa alone produces 25 percent of the nation's ethanol.

The supply of corn for ethanol, and the price of corn, is becoming a concern to both the livestock industry and ethanol plants. The demand for corn in Iowa in 2008 is expected to by 129 percent of the amount of corn produced in 2006. This means that Iowa is predicted to be a corn-deficit state by 2008, and Iowa grows more corn than any state in the U.S. As of late January, corn in Iowa for March delivery was about $4 per bushel or more. The breakeven corn price for profitability of ethanol plants is somewhere between $4-5 per bushel, depending on several factors, including the price of ethanol.

The bottom line is that, based on the available supply and prices of corn, the corn ethanol industry has reached its saturation point now in terms of the number of plants being built to convert starch to ethanol. This could change if corn yields keep increasing. The plant breeding industry contends that it will be possible for corn yields to reach 300 bushels per acre within 10 years. If so, that will help increase supply without a great increase in acreage, but it will require a lot of nitrogen fertilizer.



Cellulosic Ethanol

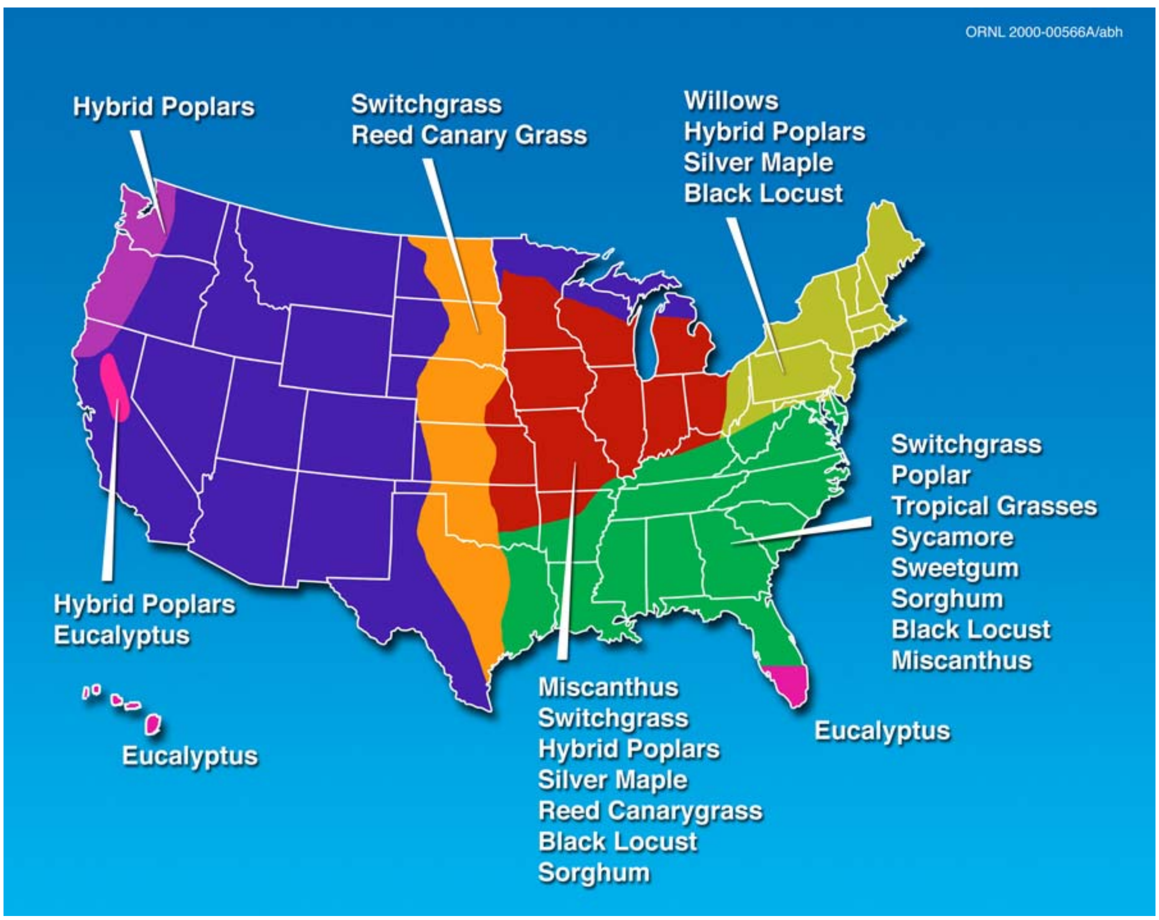
The U.S. Department of Energy (DOE) recognizes that even with an increase in corn yields, corn grain alone cannot meet the needs of ethanol production. The DOE projects that by 2020, 15 billion gallons of ethanol will be needed annually in this county. The amount of ethanol that can be produced from corn grain alone can't come close to meeting this need by 2020. As a result, DOE projects that by 2020, the majority of ethanol will have to be biomass-based, cellulosic ethanol.

Will there be enough biomass available to meet the projected need? DOE did a nationwide, county-by-county study in 2004. It looked at the potential for crops, crop residues, and dedicated energy crops that could be used for bioenergy production. DOE concluded that 1.3 billion tons of biomass per year was available to be produced in this country. That is almost exactly the amount of biomass needed to replace the amount of oil currently being imported from the Middle East.

Most of the biomass production will come from the Midwest. According to the DOE study, the top 4 states in terms of potential biomass availability are: Illinois, Iowa, Nebraska, and Kansas. Kansas is projected to produce 20 million dry tons of biomass per year.

The sources of biomass for biofuel production in the future will include some combination of:
* Corn stover
* Other crop residues
* Perennial energy crops, such as miscanthus and switchgrass
* Sweet sorghum

The DOE projects the following possibilities for biomass production:

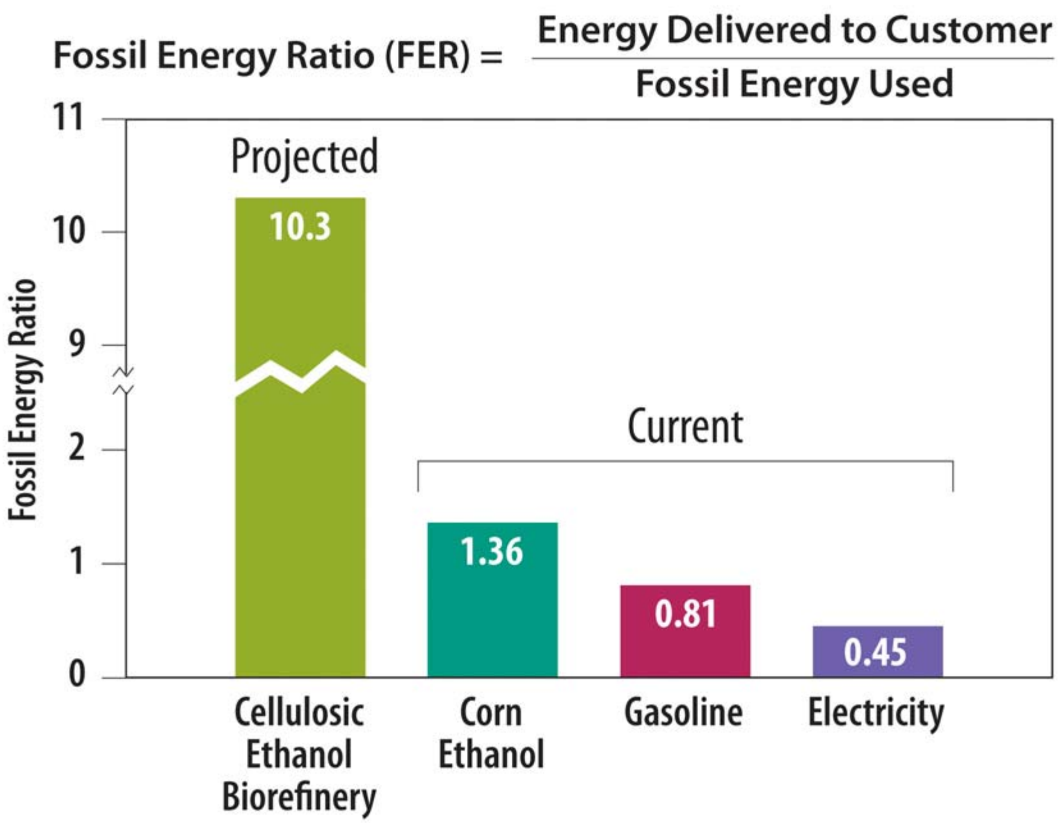


About 20 percent of the projected biomass production can come from corn stover (assuming an average of 3 tons per acre of stover per year) without compromising soil quality (assuming all corn is in no-till production). Perennial energy crops make up the majority of projected biomass production by 2020.

Producers in Kansas may be familiar with switchgrass, but possibly not miscanthus. Miscanthus is a perennial grass native of southeast Asia. It is widely grown in Europe, and has produced 14 tons per acre of dry matter in Illinois.

Miscanthus: A single season’s growth in Illinois. Source: DOE

Switchgrass: Bales from a 5-year-old field in southeastern South Dakota. Source: DOE



The DOE chart above provides a comparison of energy yields and energy expenditures of various sources of fuel. The fossil energy–replacement ratio (FER) compares energy yield from four energy sources with the amount of fossil fuel used to produce each source. Note that the cellulosic ethanol biorefinery's projected yield assumes future technological improvements in conversion efficiencies and advances that make extensive use of a biomass crop's noncellulosic portions for cogeneration of electricity. Similar assumptions would raise corn ethanol's FER if, for example, corn stover were to replace current natural gas usage. The corn ethanol industry, already producing ethanol as an important additive and fuel extender, is providing a foundation for expansion to cellulosic ethanol.

Issues Involved in Cellulosic Ethanol

Crop residues will be the first cellulosic ethanol feedstock in commercial use. This is the most readily available source of biomass. Despite the DOE's projection about the use of biomass to produce cellulosic ethanol by 2020, there are several practical issues to consider.

1. Collection and storage. A typical cellulosic ethanol plant is projected to consume about 2,000 tons of dry biomass per day. At that rate, a year's supply of corn stover would require a storage area equivalent to 100 acres of bales stacked 25 feet high.
* Is this much storage area available?
* How can this material be kept from spoiling or burning?
* How can a reliable supply be ensured when corn stover is directly related to crop production conditions?
* How much will plants have to pay to get corn stover? In its projections of future ethanol production, the DOE assumes plants will pay producers $30 per ton for corn stover. When surveyed, however, producers in Iowa stated they would not sell their corn stover for that price.
* Can the stover be clean enough for use by the plants? The processing system of an ethanol plant cannot tolerate any soil contamination on the feedstock being used.
* Will it be possible to get stover to 15 percent moisture, and maintain that moisture level in order to preserve the biomass?

2. Transportation. Bales of biomass are quite large, and will max out the load capacity of semi trailers quickly. This will be the main constraining factor on the size of cellulosic ethanol refineries. Economics show that it doesn't pay to transport biomass more than 50 miles to an ethanol plant. So the question becomes, how much biomass can be grown within a 50-mile radius of a proposed cellulosic ethanol plant? In practical terms, this means that the biomass-based ethanol industry will have to consist of many small, local plants.

3. Environmental impacts. Can the biomass ethanol industry expand as DOE projects without negatively impacting soil and water quality? If corn and grain sorghum stover is required for ethanol production, it will be important to determine the effects on soil organic matter in different tillage systems. Crop production systems may have to change, especially in the Eastern Corn Belt, to include less tillage and more use of cover crops or small grains produced after corn harvest. Crops will have to be produced over a greater proportion of the year in these areas.

Goals for Bioenergy Crop Production, Policy, and Research

There are four primary goals for energy crop systems:

1. Yield, yield, yield. This is by far the most important factor in maximizing the value of any crop to be used as a feedstock in the ethanol industry.
2. Minimize or eliminate any potential negative impact of energy crop production on soil and water quality.
3. Develop cropping systems that utilize multiple crops per year instead of continuous monocropping with a crop such as corn.
4. Ensure that energy crop production gives a good economic return to producers.

Policy issues also need to be addressed. Governmental policy will need to provide incentives for producers to produce energy crops, if this is to be a national priority. There will also need to be incentives to improve the transportation infrastructure. Short-line railroads will likely become an important player in the new bioeconomy.

Most importantly, a comprehensive national energy policy is needed. At most, biomass can replace about 30 percent of current energy needs in this county. Energy conservation must become a priority.

In terms of research and education, there are several goals and needs:

1. Develop an educated workforce. This is desperately needed now within the industry. Education and training are required in the fields of agriculture, engineering, and chemistry.
2. Identify existing and promising new cultivars for bioenergy production.
3. Develop new plant germplasm specifically for biomass production.
4. Develop better, more user-friendly soil carbon models to predict how biomass ethanol production may impact soil and water quality.
5. Develop better technology for harvesting and collecting biomass.
6. Develop better storage and transportation systems.
7. Educate producers on how to transition to the production of bioenergy crops.

For more information, the DOE Biofuels web page can be found at:
http://genomicsgtl.energy.gov/biofuels

These e-Updates are a regular weekly item from K-State Extension Agronomy. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Jim Shroyer, Research and Extension Crop Production Specialist and State Extension Agronomy Leader
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