Volume 11 | Issue 9 Article 1

2015

Energy agriculture - ethanol energy balance

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Ag Decision Maker

A Business Newsletter for Agriculture

Vol. 11, No. 9 www.extension.iastate.edu/agdm *July 2007*

Energy agriculture - ethanol energy balance

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Fifth in a series

Does it take more energy to make ethanol than is contained in the ethanol? This question has been debated for decades as an indicator of the value (or lack of value) of ethanol.

The answer is an emphatic “yes”. As shown in Table 1, it takes about 1.75 British thermal units (Btu) to make one Btu of corn ethanol at the fuel pump. The answer has to be yes because you would have “created” energy and broken one of the basic laws of physics if you ended up with more energy than you started with.

A more relevant question is “What type of energy?” is used in the production of ethanol. For example, a large share of the energy for ethanol production (either corn or cellulosic) comes from sunlight, which is free to use and causes no environmental degradation.

If the analysis is restricted to just the fossil fuel energy used in producing ethanol (e.g. petroleum, natural gas, coal, etc.), it takes about .74 of a Btu to make one Btu of corn ethanol at the fuel pump. From a different perspective, one Btu of fossil fuels generates 1.36 Btu of ethanol (Table 2).

If we look just at the petroleum portion of the fossil fuels used in making ethanol, ethanol is a clear winner. Corn and cellulosic ethanol require about one-tenth of a Btu of petroleum to make a Btu of ethanol while gasoline requires more than one Btu of petroleum.

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Handbook updates

For those of you subscribing to the handbook, the following update is included.

Historic Corn Yields by County – A1-12 (10 pages)

Historic Soybean Yields by County – A1-13 (10 pages)

Historic Cropland Rental Rates – C2-11 (5 pages)

Flexible Farm Lease Agreements – C2-21 (4 pages)

Please add these files to your handbook and remove the out-of-date material.

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Inside . . .

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Table 1. Btu Used to Make One Btu at the Fuel Pump *

	Total Btu	Fossil Fuel Btu
Corn Ethanol **	1.75	.74
Cellulosic Ethanol	2.25	.10
Gasoline	1.23	1.23

* Argonne National Laboratory
** Dry Mill

There is considerable controversy over the energy balance question. Although most research shows the energy balance to be in the neighborhood of the numbers discussed above, some researchers claim that it takes more fossil fuel energy to create ethanol than is contained in the ethanol. Others report that 1.77 Btu of ethanol are produced per Btu of fossil fuel in dry mill plants.

An argument can be made that ethanol is being held to a higher standard than other energy sources. For example, it takes about 1.23 Btu of fossil fuels to create one Btu of gasoline. To produce gasoline, crude oil needs to be recovered, transported and refined. Most of this is done with fossil fuels.

Table 2. British Thermal Units Generated from One Btu of Fossil Fuels *

	Btu
Corn Ethanol	1.36
Gasoline	.81
Electricity	.45
Coal	.98
Cellulosic Ethanol	10.31

* Argonne National Laboratory

If ethanol is compared to other energy sources, it compares quite favorably. Conversely, electricity is one of the worst as shown in Table 2. Most electricity is generated in coal-fired plants, but there is little said about the poor energy balance because electricity is a more convenient energy source than coal. For example, it is easier to run your refrigerator on electricity than on coal. The electricity energy balance will improve and electricity will become a cleaner energy source as the portion of electricity produced from wind and solar power increases.

Trends in Energy Balance

To get a realistic view of the energy conversion picture, we must also examine where we have been in the past, and where we may go in the future. Approximately one-third of the fossil fuel energy required to produce a gallon of ethanol relates directly to corn production. The other two-thirds are due to converting the corn to ethanol.

As shown in Table 3, the conversion of corn to ethanol has improved substantially in recent years. This means that the fossil fuel used in corn production is spread over more gallons of ethanol. In addition, corn production has become more energy efficient. Corn output per pound of fertilizer has risen 70 percent in the last 35 years.

Table 3. Improvements in Conversion of Corn to Ethanol

	Early 1980s	Early 1990s	Current
Ethanol yield (gallons per bushel)	2.2	2.5	2.7-2.8

In the 1980s, ethanol plants used 2.5 to 4.0 kWh of electricity per gallon of ethanol. Today it is significantly below 1 kWh. If the electricity is generated using wind or solar power, the consumption of fossil fuels is reduced even more. Overall, ethanol production today requires about 50 percent less energy than in the early 1980s. Currently, non-fossil fuel energy sources are being investigated as a substitute for natural gas.

A 1995 study (Table 4) outlined the industry average production using average practices in existence in terms of Btus of ethanol produced from a Btu of fossil fuels. It shows that the energy balance is significantly better (2.09) if we just consider the most efficient corn and ethanol producers. The state-of-the-art balance (2.51) is achievable by farmers and ethanol producers using all of the best and most energy efficient technologies and practices.

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Table 4. Corn Ethanol Net Energy Balance -- Three Scenarios (Btu per gallon ethanol) *

	Industry Average (Btu)	Industry Best (Btu)	State-of-the-Art (Btu)
Ethanol Btu Produced per Btu Fossil Fuels Used	1.38	2.09	2.51

* Institute for Local-Self Reliance, David Lorenz and David Morris, August 1995

It seems reasonable that through improvements in management and technology the industry average will move toward the efficiencies of the "industry best" and even the "state-of-the-art", and the new "industry best" and "state-of-the-art" will be at even higher levels.

Greenhouse Gas Emissions

Recent scientific research has confirmed the threat of global warming due to greenhouse gas emissions. So, reducing greenhouse gas emissions is an important energy goal. As shown in Table 5, corn ethanol blends have lower greenhouse gas emissions than straight gasoline. And cellulosic ethanol is about three times better than corn ethanol.

Table 5. Greenhouse Gas Emissions Reduction from Straight Gasoline *

	Corn Ethanol	Cellulosic Ethanol
10 Percent Blend	-2%	-6%
85 Percent Blend	-23%	-64%

* Argonne National Laboratory

This reduction is true even though about one-third of the production (by weight) from a corn ethanol dry mill plant is carbon dioxide. And the carbon dioxide is usually vented into the air.

However, the carbon dioxide is part of the natural carbon cycle that does not create new carbon dioxide in the atmosphere. Plants, including corn, take in carbon dioxide for photosynthesis when they grow. When the plant dies and decomposes, the carbon dioxide is released back into the atmosphere. Instead of releasing the carbon dioxide when the corn kernels decompose, it is released when the corn kernels are processed.

By contrast, emissions from the use of fossil fuels pump new carbon dioxide into the atmosphere. These emissions are from carbon that was sequestered deep in the ground in the form of crude oil, coal, natural gas, etc.

Ethanol's Lower Energy Content

Ethanol has been criticized because there are fewer Btu in a gallon of ethanol than a gallon of gasoline. As shown in Table 6, ethanol has only two-thirds percent the Btu of gasoline.

Table 6. Energy Content of Various Fuels *

	Btu per Gallon	Relative Percent Btu (gas 100%)
Gasoline	124,000	100%
Ethanol	83,333	67%
Diesel Fuel	139,000	112%

* Energy Information Administration

However, ethanol's combustion efficiency makes up for some of its lower energy content. Due to ethanol's octane rating of 113 – 115 as compared to 87 for unleaded gasoline, high-compression engines can perform just as well on fewer Btu.

There is probably significant variation in the ethanol mileage reduction among different brands and models of cars and light trucks. For example, the 2005 Flexible Fuel Ford Taurus has a 15 percent reduction in mileage (Popular Mechanics) when operated on E85 as compared to straight gasoline. From a personal level, checking your fuel mileage with both straight gasoline and E85 is the best way to determine how much of a price discount you need for E85 to make it economically feasible.

Conclusion

All the talk about ethanol being an inefficient energy converter is wrong. Moreover, the energy

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balance question is largely bogus. Whether you are concerned about weaning the U.S. from foreign oil, stopping global warming, or both, ethanol is better than gasoline and getting better every day.

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Issues in agriculture - summer programs for 2007

by Ann M. Holste, Extension Program Specialist, 515-294-4197, aholste@iastate.edu

The recent changes in agriculture indicate we are in another "Golden Age." There is no clear answer to how long high prices will last, or how much corn will ultimately be needed to meet ethanol demands. To help with decisions related to these issues, there are meetings to be held across Iowa this summer that will answer questions related to farmland leasing and what to do with all that extra grain.

Farmland Leasing Workshops

A hot issue that began last fall with the rise in grain prices and will continue to be an issue for a few years is rental rates. Currently, over 70 meetings are planned in Iowa with the majority of them occurring in July and August. The deadline for terminating a lease is September 1, so leasing decisions are being made right now for 2008.

Meetings are approximately 3 hours in length and are facilitated by ISU Extension farm management specialists. These workshops are designed to assist landowners, tenants and other agri-business professionals with issues related to farmland ownership, management, and leasing agreements. Each workshop attendee will receive a set of useful materials about farm leasing arrangements.

Topics covered include:

- Cash Rental Rate Survey and Land Values Survey
- Comparison of different types of leases
- Lease termination
- Impacts of yields and prices
- Calculating a fair cash rent
- Use of spreadsheets to compare leases
- Available Internet Resources

All available dates, times, and registration information will be listed in the Iowa State University Extension Calendar (http://www.extension.iastate.edu/calendar/) as they become available. Search under the Category "Financial Management & Strategic Planning" to find meeting information, or contact your county office to find the meeting being held closest to you.

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