BioEnergy

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Fueling America Through Renewable Resources

Economics of Ethanol

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EXPERT REVIEWED

Farming for fuel is a relatively new concept for U.S. agriculture. Biofuels include both ethanol (corn) and biodiesel (soybean oil), but ethanol is far in the lead. Production capacity across the country is expected to exceed 8.0 billion gallons by early 2008 and substitute for approximately 5% of U.S. gasoline consumption. Some hope that biofuel production can eventually substitute for as much as 25% of the country's gasoline over the next 20 to 30 years. The ultimate importance of biofuels will be determined by events that are still to unfold. The drivers are expected to be found in energy prices, state and federal energy policy (Doering, 2006), and in technology, particularly the improvement of the process to produce ethanol from cellulose (plant material) (Mosier, 2006).

Why is there such startling interest in fuels from farms? The nearly "gold rush" status is driven by powerful profitability, especially for ethanol. The federal subsidy of $0.51 per gallon of ethanol was established when crude oil was less than $30 per barrel. At that price of crude oil, the subsidy was necessary to make ethanol profitable. However, with crude oil much higher, ethanol has shifted from being just profitable to being highly profitable, and thus major investment in the sector has been stimulated. The value of ethanol can be thought of as coming from three components:

1. The energy value as a replacement for gasoline

2. The value of subsidies and policy incentives provided to ethanol,

3. The value of ethanol as an additive that is primarily an oxygenate (to produce cleaner burning fuel) and octane enhancer for gasoline.

Energy Value

The energy value in a gallon of ethanol is less than in a gallon of gasoline. While exact difference in gas mileage will probably vary somewhat, it is expected that a gallon of ethanol will only do about 70% of the work of a gallon of gasoline. Therefore, we would expect the energy value of ethanol to be about 70% of the wholesale price of gasoline.

Subsidy-Policy Incentive Value

Federal government policy is to stimulate ethanol production and thus provides a $0.51 per gallon subsidy to blenders of ethanol. This $0.51 per gallon is about $1.35 per bushel of corn used. There are other federal ethanol
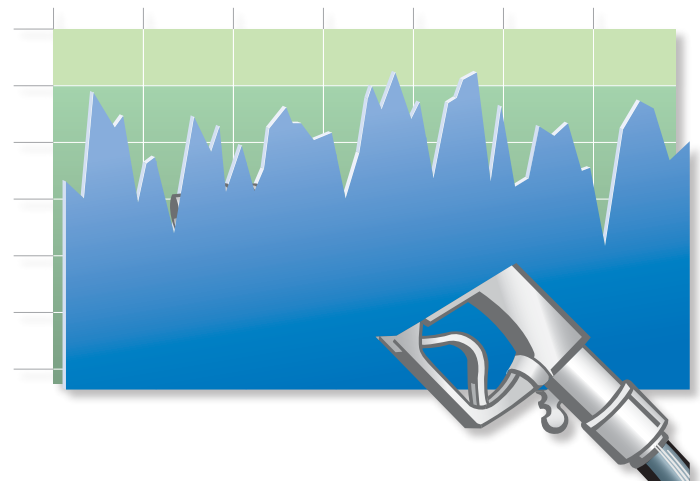
subsidies primarily targeted at initial production years and smaller plants. The national Energy Bill passed in the summer of 2005 mandated the use of at least 7.5 billion gallons of biofuels by 2012, a level that will be exceeded in 2007.

Some states also have a state subsidy for ethanol production, and still other states provide financial incentives to ethanol producers such as support for infrastructure development and job training assistance. Finally, more states are passing their own state renewable fuels standards. Minnesota, for example, mandates all gasoline sold in the state must be at least 20% renewable.

Additive Value

Ethanol tends to trade at a premium price even above its value of energy and the subsidies. Twenty-five states have either restricted or outlawed the use of MTBE (methyl tertiary butyl ether) as a gasoline oxygenate because it is highly toxic and has been found in ground water. The 2005 federal energy legislation ended the federal requirement for specific oxygen levels in gasoline. Oil companies are now free to meet the clean air requirements in any way they choose. Thus, in May 2006, when the oxygen requirements ended, oil companies were no longer required by the government to add a certain level of oxygen, and most companies feared legal liability if they continued to use MTBE.

For most blenders, the best way to meet the emissions standards in the Clean Air Act is now to use ethanol to blend with their gasoline. The largest part of this premium is related to the value of ethanol to replace MTBE as an oxygenate. Also, ethanol has an octane of 106 compared to 87 for gasoline, so it has value to enhance octane. Beyond these technical values, some drivers will pay premiums to use ethanol blends over straight gasoline. There is also a strong national interest in reducing the dependence on foreign oil, which helps enhance ethanol demand as well.

Economic Bottom Line

Figure 1 illustrates the economics of ethanol, depicting the relationship of crude oil prices and the estimated break-even price per bushel that an ethanol plant could pay for corn. Breakeven corn prices still allow the plant to be paid off in 15 years and for equity investors to receive 12% per year return on their investment dollars. Construction and operating costs similar to November 2006 are assumed. The three lines relate to the three component values for ethanol. (The Appendix explains the complete set of assumptions behind the relationships in Figure 1.)

The bottom line in Figure 1 represents the value of the energy in ethanol based upon 70% of the value of gasoline. As an example, with $60 per barrel crude oil an ethanol

Figure 1. *Corn Breakeven Price for Ethanol: November 2006 Estimated Costs*
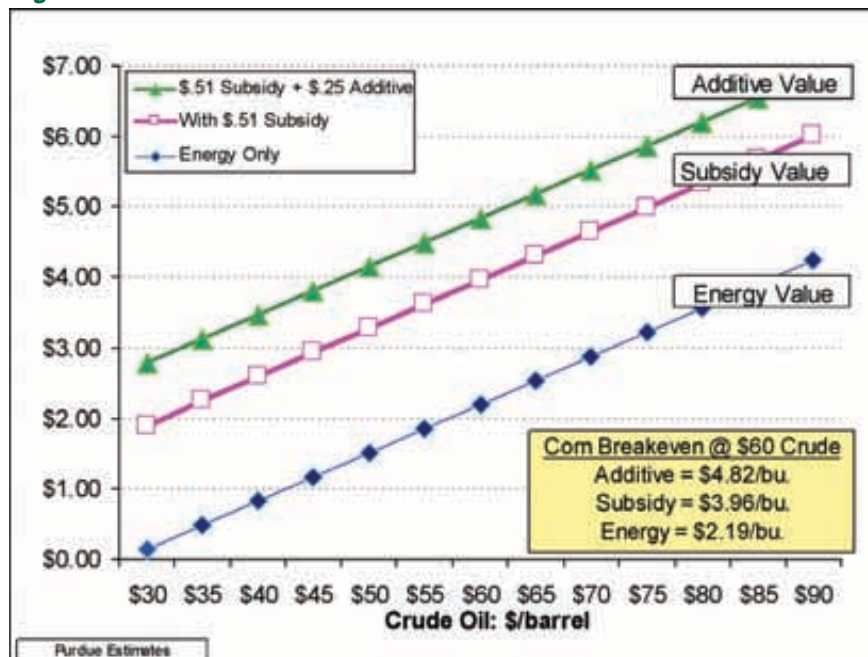
plant could pay $2.19 per bushel for corn. The middle line represents the corn breakeven price when the value of the $0.51 per gallon federal subsidy is added, and at $60 oil this is $3.96 per bushel. Finally, when an oxygenate premium of $0.25 per gallon is added, this raises the estimated break-even price an ethanol plant could pay to $4.82 per bushel. During some periods, the oxygenate premium has been considerably higher than the 25 cents per gallon assumed here.

Given these assumptions, this means that if a plant can buy corn at less than $4.82 per bushel, the owners will get a higher return than 12% and/or a quicker payback than 15 years. We should note also that the capital cost component of ethanol production cost is about 30 cents per gallon, or 80 cents per bushel. This means that existing plants with capital costs already recovered could potentially pay 80 cents more per bushel or about $5.60.

This summarizes some of the great opportunities in ethanol, but also highlights some of the extreme vulnerabilities. One vulnerability is the oxygenate premium. As the supply of ethanol increases to meet the amount needed to replace MTBE, the oxygenate premium could drop sharply. We have not experienced the situation in which ethanol production exceeds oxygenate demand, so there is considerable uncertainty regarding ethanol market value once we reach that threshold. Without the oxygenate premium, the ethanol industry will be operating on the middle line in Figure 1. You can see that lower crude oil prices could make ethanol profits vulnerable as well. The corn breakeven on the middle line with $50 oil as an example is a bit over $3.00 per bushel.

The high demand to build ethanol plants is bidding up construction and processing costs, which also make ethanol profits vulnerable. Another major vulnerability is that as more ethanol capacity comes on line, the increasing demand for corn results in higher corn prices, thus narrowing ethanol producers' margins. Finally, the federal subsidy is very large and could be subject to change, as higher corn prices have adverse impacts on livestock producers and ultimately on livestock product consumers (Tyner and Quear, 2006).

Conclusion

The future direction of ethanol will be highly dependent on state and federal governmental policy and on energy and corn markets. If all factors were to stay as they are today, the exponential expansion of ethanol plants would continue until corn prices were bid up to near their breakeven level. It is much more likely, however, that policy and energy prices will also be dynamic, that corn prices will rise, and that other constraints will dramatically slow the growth of the industry after 2007.

It is clear that the ethanol industry cannot continue to grow at the current rate based on the use of the corn seed as a feedstock source without hitting major constraints including extreme competition for corn to be used for feed, exports, and food. After 2007 the industry will have to grow at a much slower rate, probably keeping pace with corn production increases. The hope is that cellulose-based ethanol can then emerge by 2010 to 2012. However, as long as corn based ethanol is profitable, investors will probably prefer the more certain technology to the still uncertain cellulose technology.

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Appendix

The link between crude oil price and breakeven corn price requires numerous assumptions. Following are the most important assumptions updated to November 2006:

1) Relationship between crude oil price and gasoline price—This relationship is given by the equation below:

   Wholesale gasoline price ($/gal.) = 0.3064 + 0.03038 * crude oil price ($/bbl.)

   The data for this equation was monthly data 2000-2006 from EIA/DOE. However, longer and shorter time periods were tested, and the results are remarkably stable. The adjusted R2 for the equation is 0.93, meaning that 93% of the variability in gasoline price over time is explained by changes in the crude oil price.

2) Relationship between gasoline price and ethanol price—The energy equivalent price of ethanol is assumed to be 70% of the gasoline price. That is slightly higher than the pure energy equivalence.

3) Relationship between corn price and DDGS price—DDGS price is a function of the prices of corn and soybean meal as follows:

   DDGS price ($/ton) = 1.52 + 0.205 * soybean meal price ($/ton) + 21.98 * corn price ($/bu.)

   Substituting a price for soybean meal of $200/ton into this equation yields the equation used in the model:

   DDGS price ($/ton) = 42.52 + 21.98 * corn price ($/bu.)

   All data is from USDA, monthly 2003-06. Illinois prices were used for corn and soybean meal, and Lawrenceburg, IN, for DDGS.

   It is assumed that 18 pounds of DDGS is produced per bushel of corn used.

4) Ethanol yield per bushel of corn is assumed to be 2.65 gallons. Newer plants may have higher yield, but this figure is close to the industry average.

5) Capital cost for the plant is assumed to be $1.80 per gallon of capacity. Older plants had considerably lower capital cost, and much of the capital probably has already been paid off. The plant is assumed to operate at full capacity.

6) Financial assumptions:

   The plant is 40% equity and 60% debt finance.

   The debt interest rate is 8%, and the equity return is 12%.

7) No value was assigned to the CO2 produced.

8) Energy costs:

Natural gas	$9.00/mil. BTU
LP	$1.20/gal.
Electricity	$0.06/KWH
Total energy	$0.383/gal. of ethanol

9) Other costs:

Chemical and enzyme costs	$0.182/gal. of ethanol
Other processing costs	$0.297/gal. of ethanol

   Given these assumed relationships and values, the Tiffany/Eidman (University of Minnesota) spreadsheet model of a dry-mill ethanol plant was used to calculate profitability and thus derive the breakeven prices. Breakeven was assumed to be the point of zero economic profit; that is, it includes the payment of debt and stipulated return on equity. Clearly, any of these assumptions and values could be modified in the future as conditions change.

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