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U.S. Ethanol Policy—
Possibilities for the Future

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EXPERT REVIEWED

This publication is motivated, in part, by the huge increase in ethanol production capacity in the U.S. in the past two years and the impact that increase is having on corn and other commodity prices. The current fixed ethanol subsidy was established in an era of cheap oil, but with oil around $60, the subsidy provides very large profits to ethanol producers and thereby a substantial incentive for the industry to grow. With this industry growth, demand for corn grows in parallel and thus its price. This publication reviews the history of U.S. ethanol policy, explains the economics

of ethanol production in today's market environment, and outlines some policy alternatives that could be considered for the future.

U.S. Ethanol Policy History

Ethanol has been produced for fuel in the United States for at least 26 years. The industry launch was initiated by a subsidy of 40 cents per gallon provided in the Energy Policy Act of 1978. Between 1978 and today, the ethanol subsidy has ranged between 40 and 60 cents per gallon. The history of subsidy changes is provided in Table 1. The federal subsidy today is

Table 1. *History of Ethanol Subsidy Legislation*

Year	Legislation	Description
1978	Energy Tax Act of 1978	$0.40 per gallon of ethanol tax exemption on the $0.04 gasoline excise tax
1980	Crude Oil Windfall Profit Tax Act and the Energy Security Act	Promoted energy conservation and domestic fuel development
1982	Surface Transportation Assistance Act	Increased tax exemption to $0.50 per gallon of ethanol and increased the gasoline excise tax to $0.09 per gallon
1984	Tax Reform Act	Increased tax exemption to $0.06 per gallon
1988	Alternative Motor Fuels Act	Created research and development programs and provided fuel economy credits to automakers
1990	Omnibus Budget Reconciliation Act	Ethanol tax incentive extended to 2000 but decreased to $0.54 per gallon of ethanol
1990	Clean Air Act amendments	Acknowledged contribution of motor fuels to air pollution
1992	Energy Policy Act	Tax deductions allowed on vehicles that could run on E85
1998	Transportation Efficiency Act of the 21st Century	Ethanol subsidies extended through 2007 but reduced to $0.51 per gallon of ethanol by 2005
2004	Jobs Creation Act	Changed the mechanism of the ethanol subsidy to a blender tax credit instead of the previous excise tax exemption. Also extended the ethanol tax exemption to 2010.
2005	Energy Policy Act	Established the Renewable Fuel Standard starting at 4 billion gallons in 2006 and rising to 7.5 billion in 2012.

Source: (Commerce, 2006) North Dakota Chamber of Commerce.

51 cents per gallon. Throughout all the history, the subsidy has always been a fixed amount that does not change with crude oil price or corn prices (Tyner and Quear, 2006).

In addition to the federal blending credit subsidy, there are also some other federal and state subsidies. In fact, Koplow (2006) calculates the total subsidy available for ethanol in 2006 to range between $1.05 and $1.38 per gallon of ethanol or between $1.42 and $1.87 per gallon of gasoline equivalent. Many would regard these figures as being high, but they do demonstrate that the ethanol industry has been one with substantial subsidies.

Ethanol Economics

Ethanol gets its value from the energy it contains and its additive value. Ethanol has value as a gasoline additive because it contains more oxygen than gasoline (and therefore causes the blend to burn cleaner) and because it has a much higher octane than gasoline (112 compared with 87 for regular gasoline). Historically, ethanol prices have been higher than gasoline prices because of the additive value and because of the federal and state subsidies.

Figure 1 provides the monthly ethanol and gasoline prices for Omaha, Nebraska, between 1982 and 2006. In Figure 1, one can see that the relationship between gasoline and ethanol prices began to change in 2002. Figure 1 also contains the regression fits for the entire period and for the separate periods 1982-2001 and
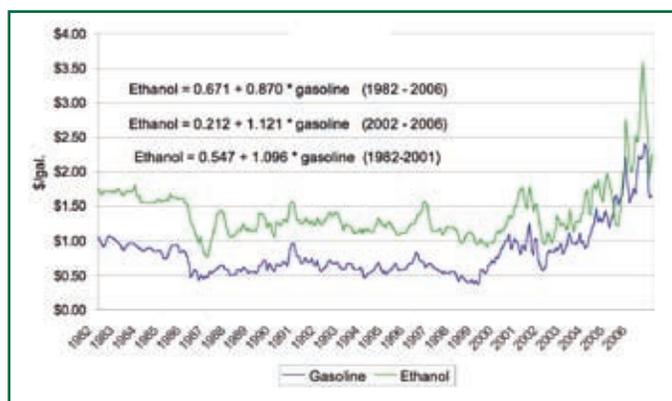

Figure 1. *Historic Ethanol and Gasoline Prices (Omaha, NE)*

2002-2006. The coefficients are all significant, and the regressions explain between two-thirds and three-fourths of the variance in ethanol prices.

Except for the summer of 2006, the spread between ethanol and gasoline was greater in earlier years than in the period 2002 and after. Ethanol even fell below gasoline for a few months in 2005, leading some to believe that the "natural" price for ethanol would be on an energy-equivalent basis with gasoline. The spread increased substantially in summer 2006 because of a change in federal rules that took effect May 8, 2006.

As of that date, the federal requirement for blending a certain percentage of oxygen ended. One of the major sources of oxygen had been a compound named "MTBE." However, this compound is highly toxic and was found in the water supplies in several areas and banned by many states. With there no longer being a requirement to blend a certain amount of oxygen, many companies feared legal prosecution if they continued to use MTBE and switched to ethanol, which increased substantially the demand and price of ethanol.

Components of Ethanol Value

As indicated above, there are three components to the market value of ethanol: energy, additive, and subsidy. It is interesting to portray these values in terms of the relationship between crude oil price and the maximum a corn dry mill could afford to pay for corn at each crude price. To estimate such a relationship, many assumptions were needed, and these assumption are detailed in Appendix A.

Figure 2 displays the relationships between crude oil price and breakeven corn price on the basis of energy equivalence, energy equivalence plus additive value (assumed to be 25 cents per gallon for this illustration), and energy equivalence plus additive value plus the current federal blending subsidy of 51 cents per gallon. The energy equivalence line was done assuming a figure of 70%, slightly more than the direct energy equivalent.

Using Figure 2, one can trace out the breakeven corn price for any given crude oil price. For example, with crude oil at $60/bbl., the breakeven corn price is $4.82/bu., including both the additive premium and the fixed federal subsidy. This figure is for a new
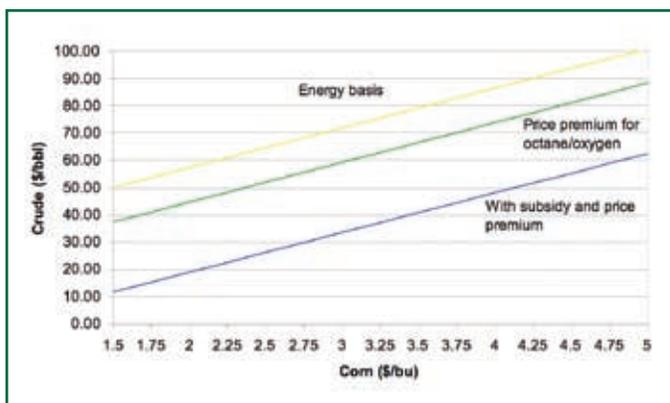

Figure 2. *Breakeven Corn and Crude Prices with Ethanol Priced on Energy and Premium Bases plus Ethanol Subsidy*

plant and includes 12% return on equity and 8% debt interest. If we consider an existing plant with capital already recovered, we add $0.78 per bushel to yield a breakeven corn price of $5.60.

Sensitivity Analysis

Any number of sensitivity analyses could be performed on the calculations contained in this publication. Table 2 provides results on some important sensitivity analyses. All the reported results are the corn breakeven for $60 crude oil. First, suppose that

Table 2. *Sensitivity Analysis for Corn Breakeven Prices*

Sensitivity Case	Corn Breakeven with $60 Crude Oil
Subsidy pass-through equal to $0.40 instead of $0.51	$4.50
Additive value equal to $0.30 instead of $0.25	$5.02
Additive value equal to $0.40 instead of $0.25	$5.37
Ethanol priced equal to gasoline on a volumetric basis instead of energy basis with no supplemental additive value	$6.20
Ethanol priced equal to gasoline on a volumetric basis instead of energy basis with $0.20 supplemental additive value	$6.89

not all the subsidy gets passed through to dry millers and to the corn price. The first sensitivity assumes the subsidy is effectively 40 cents instead of 51 cents. The breakeven corn price with the fixed subsidy becomes $4.50 instead of $4.82.

Next, suppose that the additive value is 30 cents per gallon instead of 25. The corn breakeven price becomes $5.02. With the additive value of 40 cents, the corn breakeven becomes $5.37. There is no doubt that ethanol has an additive value as an oxygenate and for octane, but it is impossible to predict what it will be as ethanol production increases beyond the needs for octane and added oxygen.

Another type of sensitivity would be to assume that ethanol might be priced equivalent to gasoline on a volumetric basis instead of an energy basis. Some argue that in the long term refiners will choose to modify their refining process to produce a lower octane gasoline, say 84 octane, which could be blended at 10% ethanol to produce the standard 87 octane regular gasoline.

We conducted two sensitivity analyses—one with the supplemental additive value then at zero and one with the additive value at 20 cents. With volumetric equivalent pricing and no additional additive value, the corn breakeven becomes $6.20. With volumetric pricing and 20 cents additional additive value, the corn breakeven becomes $6.89. In all these cases except the lower subsidy pass through, dry millers could afford to pay more for corn than in the base case. Combinations of these cases could be done as well, but the approximate outcomes can be inferred from these results.

During most of the history of the federal ethanol subsidy, crude oil prices ranged between $20 and $30 per barrel. With crude oil price in that range, the fixed federal subsidy did not put significant pressure on corn prices. However, with crude oil today around $60, there is significant pressure on corn prices. Ethanol investments in the United States have been highly profitable during the past two years, with payback periods as short as one year.

This high profitability has attracted significant new investment in the industry, as shown in Figure 3. Ethanol production grew 1 billion gallons in 2006 and is expected to grow 3 billion gallons in 2007, a doubling in two years. Because of this current and expected future growth in ethanol production, corn prices skyrocketed in fall 2006. In just a few months, prices were up from about $2.25 to $3.70 per bushel, an increase of about 65%. This leap in corn prices is leading to an emerging opposition to ethanol subsidies on the part of animal agriculture, export markets, and other corn users. Some are also concerned about the $4 billion cost of the subsidy in 2007.
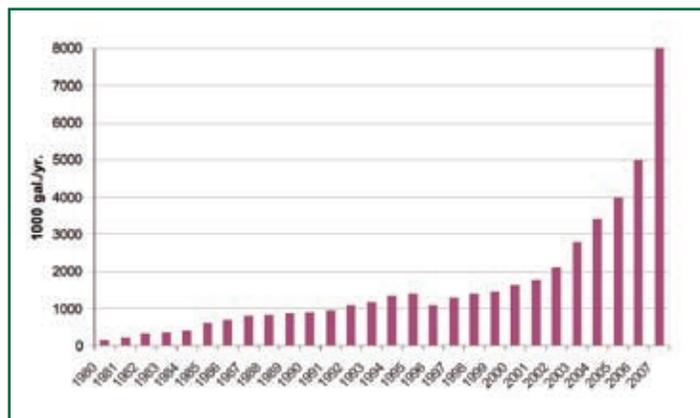

Figure 3. *Ethanol Production*

Future Policy Alternatives

In essence, the situation is that we are living an un-intended consequence of the fixed ethanol subsidy. When it was created, no one could envision $60 oil, but today $60 oil is reality, and many believe oil prices are likely to remain high. So given this reality, what future federal policy options could be considered that would support the ethanol industry but provide less incentive for rapid growth in the industry leading to abnormally high corn prices? There are several possible policy alternatives that could be considered:

- Make no changes, and let the other corn using sectors (particularly livestock) adjust as needed.
- Keep the subsidy fixed, but reduce it to a level more appropriate for crude oil prices around $60.

- Find a way to limit the quantity of ethanol that would receive the subsidy, thereby permitting better control of the growth of corn-based ethanol.
- Provide higher subsidies for cellulose-based ethanol in hopes of accelerating development and implementation of that technology.
- Convert the subsidy from a fixed subsidy to one that varies with the price of crude oil.

No Changes

Certainly, one option is to do nothing—to let the other corn-using sectors adjust to higher corn prices. But as can be seen from the results in the ethanol economics and sensitivity analyses sections above, that option could lead to substantially higher corn prices than we have seen historically. It certainly would lead to higher costs for the livestock industry (happening already) and ultimately for consumers of livestock products. It also would lead to reduced corn exports. The breakeven corn prices provided above are maximums the ethanol industry could pay to retain profitability.

Whether these prices would be reached would depend on the rate of growth of the ethanol industry compared with the rate of growth of corn supply. According to the Renewable Fuels Association, the operating ethanol capacity as of 29 December 2006 was 5.386 billion gallons, and 6.004 billion gallons were under construction (Association, 2007). Part of the 6 billion gallons under construction will come on stream in 2007, leading to a substantial increase in corn demand. We can certainly expect to see continued pressure on corn prices if no change is made in federal subsidy policy.

Lower Fixed Subsidy

Because the current pressure on corn prices comes from the combination of $60 oil and 51 cent per gallon subsidy, one option would be to maintain a fixed subsidy but lower it to a level more in line with the higher oil price. Figure 4 depicts the corn breakeven prices with a 20 cent per gallon subsidy instead of the current 51 cent per gallon subsidy. The corn breakeven price for $60 oil becomes $3.77 instead of $4.82
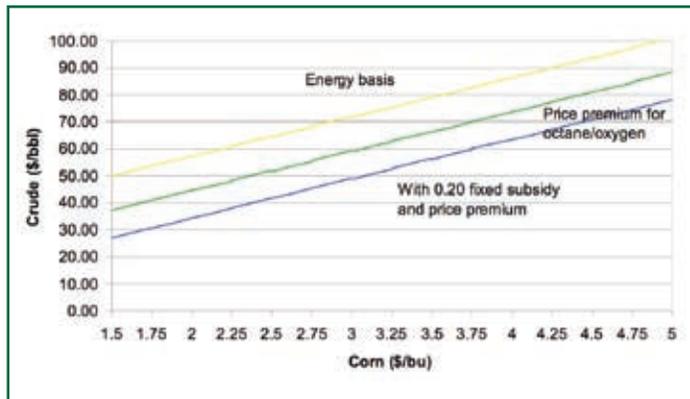
Figure 4. *Breakeven Corn and Crude Prices with Ethanol Priced on Energy and Premium Bases plus Lower Ethanol Subsidy*
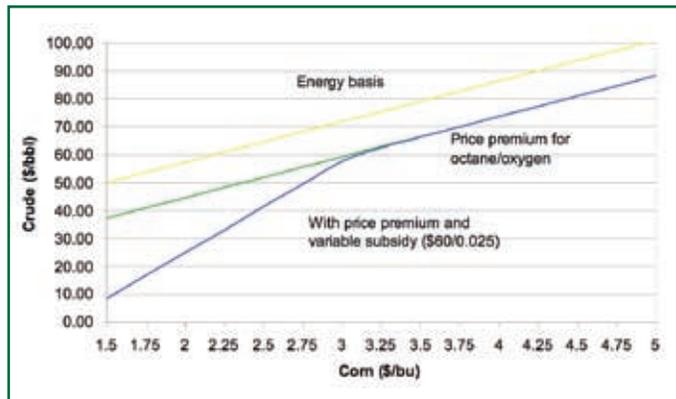

Figure 5. *Breakeven Corn and Crude Prices with Ethanol Priced on Energy and Premium Bases plus Variable Ethanol Subsidy*

under current policy. However, the fixed subsidy still has the disadvantage of not responding to possible future changes in oil prices. If oil fell to $40, the corn breakeven would be $2.40, and it would be $4.46 for $70 oil.

Variable Subsidy

In designing a variable subsidy, there are two key parameters: the price of crude oil at which the subsidy begins and the rate of change of the subsidy as crude oil price falls. We illustrate the variable subsidy using $60 crude as the point at which the subsidy begins. That is, when crude is higher than $60, there is no subsidy, but some level of subsidy exists for any crude oil price lower than $60. In this illustration, we use a subsidy change value of 2.5 cents per gallon of ethanol for each dollar crude oil falls below $60. Thus, if crude oil were $50, the subsidy per gallon of ethanol would be 25 cents. If crude oil were $40, the ethanol subsidy would be 50 cents per gallon. Therefore, for any crude oil price above $40, the ethanol subsidy would be lower than the current fixed subsidy. For any crude price less than $40, the subsidy would be greater than the current fixed subsidy of 51 cents per gallon.

Figure 5 illustrates the corn breakeven price for different crude oil prices if this variable subsidy were in effect. In this case, the corn breakeven price at $60 oil for a new ethanol plant would be $3.08 per bushel,

compared to $4.82 with the fixed subsidy shown in Figure 3. With oil at $50, the corn breakeven would be $2.77 for a new plant with the variable subsidy. $40 oil would support a corn price of $2.27 for a new plant and $3.05 for an existing plant with capital recovered. $70 oil would yield a breakeven corn price of $3.77 with no ethanol subsidy. So the variable subsidy provides a safety net for ethanol producers without putting inordinate pressure on corn prices.

The difference between the two subsidy approaches can be seen in Figure 6, which displays both the fixed and variable subsidies. Examining this figure, it is clear why the variable subsidy provides so much less pressure on corn prices. For any crude oil price above $60, there is no ethanol subsidy with the variable sub-
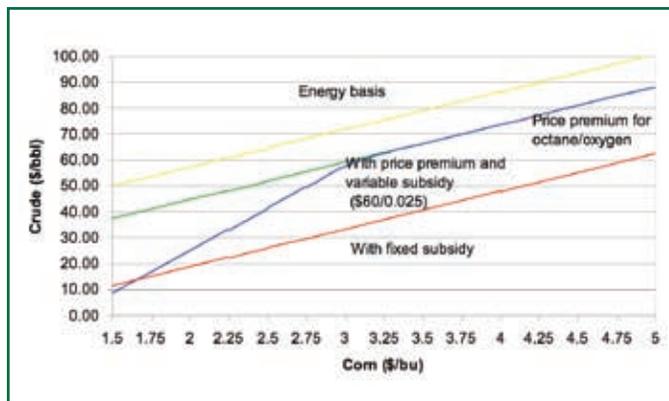

Figure 6. *Breakeven Corn and Crude Prices with Ethanol Priced on Energy and Premium Bases plus Variable and Fixed Ethanol Subsidy*

sidy, so ethanol plant investment decisions are made based on market forces alone instead of being driven by the federal subsidy.

For any crude price between $40 and $60, the variable subsidy is less than the fixed subsidy, thereby providing less incentive to invest and less pressure on corn prices, but maintaining a safety net. However, with the fixed subsidy, ethanol plant investment decisions continue to be heavily influenced by the government subsidy, even at crude oil prices that render ethanol very profitable in the absence of a subsidy. Thus, the variable subsidy alternative is one option that merits further consideration in the policy decision process.

Other Alternatives

Two other options mentioned above were a) to find a way to limit the quantity of ethanol that would receive the subsidy, thereby permitting better control of the growth of corn-based ethanol and b) to provide higher subsidies for cellulose-based ethanol in hopes of accelerating development and implementation of that technology. Either of these options could be implemented with either the fixed or the variable subsidy. So long as corn-based ethanol is highly profitable, it will be difficult to stimulate investment in cellulose technology because it is much more uncertain and at present more costly than corn-based ethanol production.

Conclusions

Ethanol has been subsidized in the U.S. since 1978, and the subsidy has ranged from 40 to 60 cents per gallon over that period. Currently, the subsidy is 51 cents per gallon, and combined with $60 oil, ethanol production has become highly profitable. This profitability has stimulated a huge increase in ethanol production capacity, with 6 billion gallons of new capacity under construction as of January 2007. This increase in ethanol production is increasing corn demand and prices. Under the current policy, ethanol producers could still invest profitably in new production with corn price as high as $4.82/bu. Other assumptions could yield substantially higher corn prices.

If government is interested in reducing upward pressure on corn prices, alternatives to the current fixed 51 cent per gallon subsidy could be considered. One option would be to lower the fixed subsidy. This alternative would reduce the pressure on corn prices but would still provide ethanol subsidies under higher oil prices when they are not needed. It also does not change based on underlying market conditions.

A second option would be a variable subsidy that provided an ethanol subsidy that changes with the crude oil price. The option evaluated in this publication provided no subsidy for crude oil price above $60, and a subsidy that increased 2.5 cents per gallon for each $1 crude price is below $60. This option yields a breakeven corn price for $60 oil of $3.08/bu., compared with $4.82/bu under the current policy.

Another option, clearly, is to make no change in current policy. With this alternative, the other corn-using sectors such as livestock production and corn exports would be forced to make the needed adjustments. Less corn would be used in these sectors, and prices for all livestock products likely would increase.

Appendix A

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 R^2 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, which translates to about 29 cents per gallon produced**—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 CO_2 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	$0.23/gal. of ethanol
Other processing costs	$0.09/gal. of ethanol

   Given these assumed relationships and values, the Tiffany/Eidman (University of Minnesota) spreadsheet model (2003) 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.

   Source: (Hurt and Tyner, 2006)

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