

## Economics of Bio-ethanol versus crude oil

23<sup>rd</sup> June 2010

### Executive Brief

Bio-ethanol is not used for road going vehicles as a fuel without a certain amount of petrol mixed with it. The fuel containing the highest bio-ethanol content is E85 (85% bio - ethanol) and to use bio-ethanol a modified engine is required. It is usually accepted that an unmodified engine can use up to 10% bio-ethanol without engine damage.

Nominally 56 lbs, (1 US bushel of maize at 15.5% moisture content) will produce 2.65 US Gallons of bio-ethanol.

At today's crude oil price - \$71/BBL (8<sup>th</sup> June 2010) the 'break even'\* price would be about \$5.6 per 56 lbs of maize, (see Note 1 below). As of 10<sup>th</sup> June 2010 maize peaked for the day at \$3.59 per 56 lbs showing that its use for bio-fuel production is currently profitable. These figures include a subsidy equivalent of \$1.35 per 56 lbs of maize used and as can be seen the process would still be commercially acceptable without it:  $5.6 - 3.59 = 2.01 > 1.35$ .

As part of the dry mill process of making bio-ethanol from maize, about 18 pounds of livestock nutrient (DDGS)\*\*\* is returned to the food chain for every 56 pounds (at 15.5% moisture content) used. This equates to a 32% return of product to the food chain. Alternatively the DDGS can be burnt as an addition to coal in power stations as a prime mover or to reduce harmful emissions.

### Preamble

Bio-fuels include both bio-ethanol (from maize) and biodiesel (from soybean oil), but bio-ethanol is far in the lead in the USA. When considering the economics of using bio-ethanol as a fuel it should be remembered that it is usually mixed with a percentage of petrol: E85 being 15% petrol and 85% ethanol – so the cost of petrol is important to the 'bottom line'.

In the USA there is a subsidy per US gallon of ethanol of \$0.51. It was established when crude oil was less than \$30 per barrel. On the 8<sup>th</sup> of June 2010 it was \$71 per barrel and has shifted from being just profitable to being highly profitable.

In the USA the value of bio-ethanol can be thought of as coming from three components:

- 1 The energy value as a replacement for petrol.
- 2 The value of subsidies and policy incentives provided to ethanol.

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

### Energy Value

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

### Subsidy-Policy Incentive Value

US government policy is to stimulate bio-ethanol production and thus provides a \$0.51 per gallon subsidy to blenders of bio-ethanol. This \$0.51 per gallon equates to about \$1.35 per 56 lbs of maize used. There are other state related subsidies, which to avoid complication will not be discussed here.

### Additive Value

Bio-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 petrol 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 petrol. Oil companies are now free to meet the clean air requirements in any way they choose (bio-ethanol addition). 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 company's feared legal liability if they continued to use MTBE.

### An economic benefit of bio-ethanol

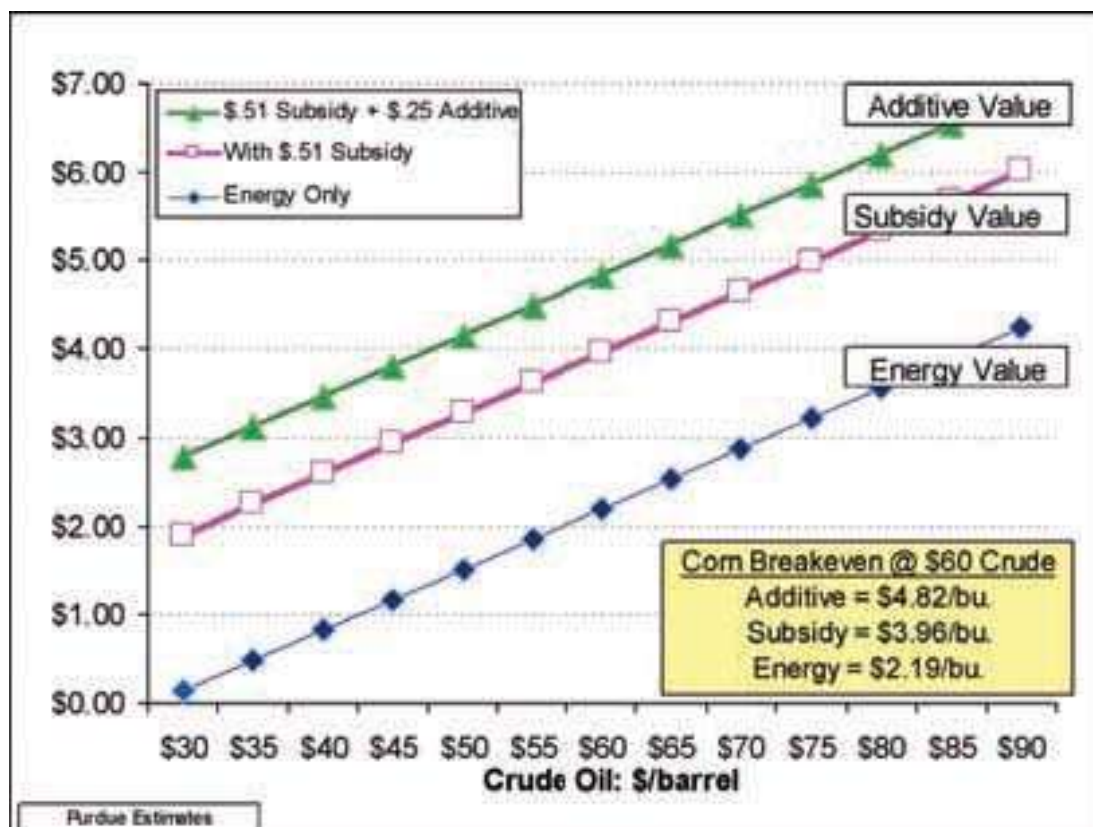
For most blenders, the best way to meet the emissions standards in the US Clean Air Act is now to use bio-ethanol to blend with their petrol. The largest part of this premium is related to the value of ethanol to replace MTBE as an oxygenate. Also, bio-ethanol has an octane of 94 to 96 (depending on measurement method\*\*) compared to 87 for petrol, so it has value to enhance octane.

### Economic Bottom Line

The graph below illustrates the economics of bio-ethanol, depicting the relationship of crude oil prices and the estimated 'break even' price per 56 lbs (1-US bushel at 15.5% moisture content) that a bio-ethanol plant could pay for maize. 'Break even' maize 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 bio-ethanol.

(Since 2006 when these figures were compiled the price of crude oil has varied greatly, but the [CPI](#) data indicates that in food and transport prices have fluctuated to about +12% relative to 2006 figures.)

Maize 'break even' price for bio-ethanol: November 2006 estimated costs.



### Economics of bio-ethanol

The bottom line in the graph represents the value of the energy in bio-ethanol based upon 70% of the value of petrol. As an example, with \$60 per barrel crude oil a bio-ethanol plant could pay \$2.19 per 56 lbs of maize. The middle line represents the maize 'break even' price when the value of the \$0.51 per gallon federal subsidy is added, and at \$60 oil this is \$3.96 per 56 lbs. Finally, when an oxygenate premium of \$0.25 per gallon is added, this raises the estimated 'break even' price a bio-ethanol plant could pay for maize to \$4.82 per bushel (56 lbs).

Given these assumptions, if a plant can buy maize at less than \$4.82 per 56 lbs, 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 bio-ethanol production cost is about 30 cents per gallon, or 80 cents per 56 lbs. This means that existing plants

with capital costs already recovered could potentially pay 80 cents more per 56 lbs of maize or about \$5.60.

One vulnerability of these economics is the oxygenate premium. As the supply of bio-ethanol increases to meet the amount needed to replace MTBE (Methyl Tertiary Butyl Ether), the oxygenate premium could drop sharply. The situation in which bio-ethanol production exceeds oxygenate demand, has not yet been experienced, so there is considerable uncertainty regarding bio-ethanol market value once that threshold is reached. Without the oxygenate premium, the bio-ethanol industry will be operating on the middle line in Figure 1. You can see that lower crude oil prices could make bio-ethanol profits vulnerable as well. The maize 'break even' price on the middle line with \$50 oil as an example is a little over \$3.00 per 56 lbs.

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

### **Fuel Safety**

There are a few major differences between Flex Fuel Vehicles (those modified to use high bio-ethanol content fuel) and non-FFVs. One is the elimination of bare magnesium, aluminium, and rubber parts in the fuel system. Another is that fuel pumps must be capable of operating with electrically conductive ethanol instead of non-conducting dielectric gasoline fuel. Fuel injection control systems have a wider range of pulse widths to inject approximately 40% more fuel. Due to bio-ethanol being corrosive to several materials, stainless steel fuel lines, sometimes lined with plastic, and stainless steel fuel tanks in place of terne (an alloy coating of lead and tin used to cover steel, in the ratio of 20% tin and 80% lead) fuel tanks are used. In some cases, FFVs use acid-neutralizing motor oil. For vehicles with fuel-tank mounted fuel pumps, additional differences to prevent arcing, as well as flame arrestors positioned in the tank's fill pipe, are also sometimes used.

Bio-ethanol when burning is difficult to see in daylight and the flame you can see is only a small part of the fire. Bio-ethanol is less volatile than petrol alone but becomes more so at low temperatures.

### **Consumer Price Index**

Difference between December 2006 and December 2009

Adding the percentage increases for transportation from December 2006 to December 2009 (CPI-U-RS) shows a change of +11% versus +12.4% for food and beverages against an overall increase of +9.5% for 'All items'. These figures should be noted when factoring for 2006 to 2010.

## Conclusion

The production and use of bio-ethanol from maize is currently viable in the USA and with the disproportionate rise in oil prices is set to become even more profitable. Even without the subsidy of \$0.51 per US gallon the process would still be profitable at today's maize and crude oil prices (June 2010).

By 2011 to 2012 technology, particularly the improvement of the process to produce ethanol from cellulose (plant material) could overtake the bio-fuel from maize process but vested interest in newly commissioned maize using plants may well delay the full implementation of this.

*Source of base production/cost data Purdue University (USA)*

## Notes

Note 1:-

When considering the use of cost and price data from this report the following should be considered:-

*1 US bushel = 2150.42 cubic inches (a UK bushel = 2219.36 cubic inches)*

***However the bushel has commonly become used to denote the weight of product and in the case of maize it relates to 56 lbs at 15.5% moisture content.***

*1 US barrel of crude oil = 42 US gallons (34.9723 UK gallons or 158.9873 litres)*

Prices used in the graph below were current in 2006 and the correction data from the [CPI](#) at the end of this report should be taken into account.

Note 2:-

A dry-mill bio-ethanol plant was used to calculate profitability and thus derive the 'break even' prices. 'Break even' 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.

Relationship between petrol price and bio-ethanol price — the energy equivalent price of bio-ethanol is assumed to be 70% of the petrol price. That is slightly higher than the pure energy equivalence.

Relationship between maize price and DDGS\*\*\* (Distiller's Dried Grains with Solubles) price. DDGS price is a function of the prices of maize and soybean meal and it is assumed that 18 pounds of DDGS is produced for every 56 lbs of maize

used. This has a variable value as a livestock feedstuff and is a significant part of the economics of bio-ethanol production from maize.

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.

Financial assumptions: the plant is 40% equity and 60% debt finance. The debt interest rate is 8%, and the equity return 12%.

No value was assigned to the CO<sub>2</sub> produced, although in a cooperative venture it could be piped/tanked to greenhouses to stimulate growth and to avoid its atmospheric discharge.

Total energy used in the production process: \$0.383/gal. of bio-ethanol.

Chemical and enzyme costs: \$0.182/gal.\*\*\*\* of bio-ethanol and other processing costs \$0.297/gal. of bio-ethanol produced.

\*The 'break even' price for maize is based on an economic model that includes allowance for commercial plant capital amortisation over 15 years together with a return that accommodates this and stipulated return on equity but with a zero economic profit beyond that.

\*\* The often cited 105 octane for E85 is incorrect. This number was derived by using bio-ethanol's blending octane value in petrol. This is not the proper way to calculate the octane of E85. Bio-ethanol's true octane value should be used to calculate E85's octane value. This results in an octane range of 94-96. The **octane rating** is a measure of the resistance of petrol and other fuels to auto-ignition in spark-ignition internal combustion engines. Octane rating does **not relate to the energy content** of the fuel (see heating value). It is only a measure of the fuel's tendency to burn in a controlled manner, rather than exploding in an uncontrolled manner. Where octane is raised by blending in bio-ethanol, **energy content per volume is reduced**.

\*\*\* When bio-ethanol plants make ethanol, they use only starch from maize and grain sorghum. The remaining nutrients - protein, fibre and oil - are the by-products used to create livestock feed called 'Dried Distillers Grains with Solubles' (DDGS). Almost a third of the maize that goes into bio-ethanol production comes out as DDGS. Each **56 lbs of maize** used in the bio-ethanol making process produces **2.65 US gallons of bio-ethanol; 18 pounds of DDGS and 18 pounds of carbon dioxide**. Newer plants may have higher yield, but this figure is currently close to the industry average.

The dry mill process of producing bio-ethanol from maize has several stages; including milling, mashing (where enzymes are added), fermenting (where yeast is added), distillation dehydration, centrifuging, evaporation, **Drying, which produces DDGS**, molecular sieving and on to bio-ethanol storage.

\*\*\*\*Recent developments indicate that the enzyme cost could be reduced to about \$0.50 per gallon of bioethanol produced.