What is Oil Equivalent Cost of Various Ethanol Sources ?

U.S. Corn ? Switch-grass ?

Brazil Sugarcane ? Sugar ?

What Form of Ethanol In Fuel Provides the Highest Market Value ?

E10 ? E85 ? ETBE ?

What Form of Ethanol Produces the Most Non-Petroleum Fuel ?

TEIR Associates, Inc

March 9, 2006

● In the U.S., renewable ethanol for fuel blending is normally produced by fermenting corn starch. There has been significant interest in producing ethanol from cellulose in the belief that it will cost less and will provide more a positive renewable energy balance. Because of today's higher crude oil prices, some policymakers would like to expand the use of ethanol in transportation fuels as a means to reduce the nation's dependency on imported oil which is now around $60 per barrel. Does this make economic sense for the U.S. economy? On a oil cost basis, what is the cost of ethanol compared to gasoline produced from crude oil?

● Policymakers have pointed to Brazil's use of ethanol as an example to reduce the dependency of crude oil. Brazil has a large scale fuel ethanol program derived from sugar and sugar cane. What is the oil equivalent cost of Brazilian ethanol from sugar?

● There are essentially three ways or forms to use ethanol in gasoline or gasoline vehicles: E10 (10% ethanol blend), E85 (85% ethanol blend) or ETBE (Ethyl tertiary butyl ether). Which form of ethanol provides the highest market value for the ethanol? Which form potentially maximizes the most non-crude oil energy in gasoline as a way to lessen the dependency on crude oil imports?

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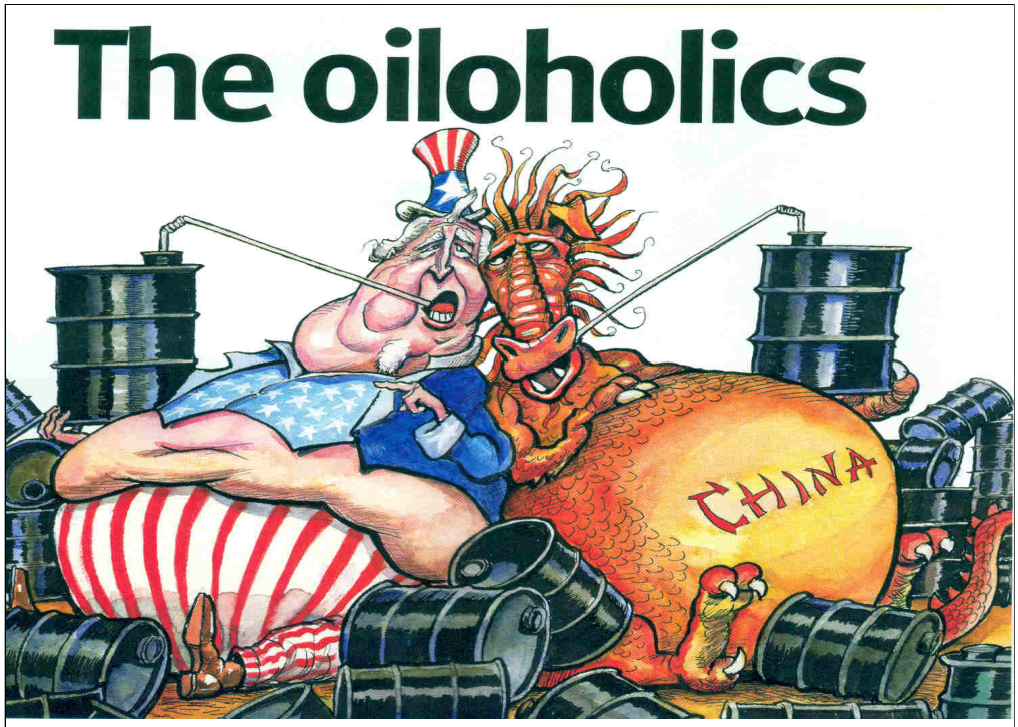
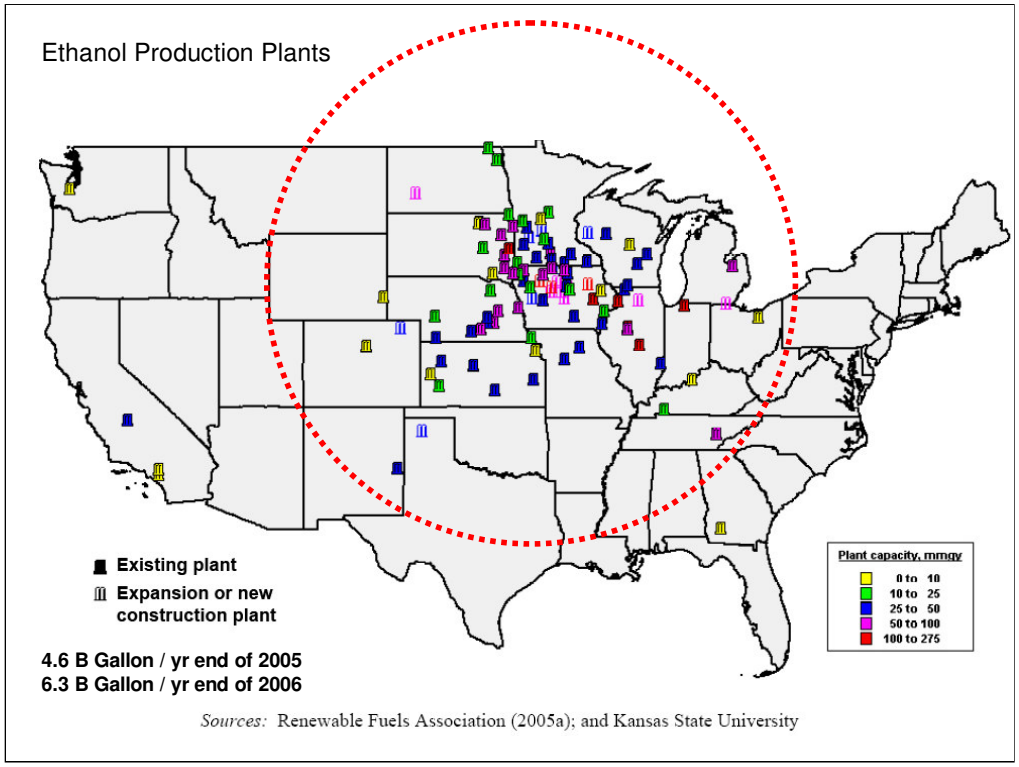


Fonte: The Economist, 27/08 – 02/09/05

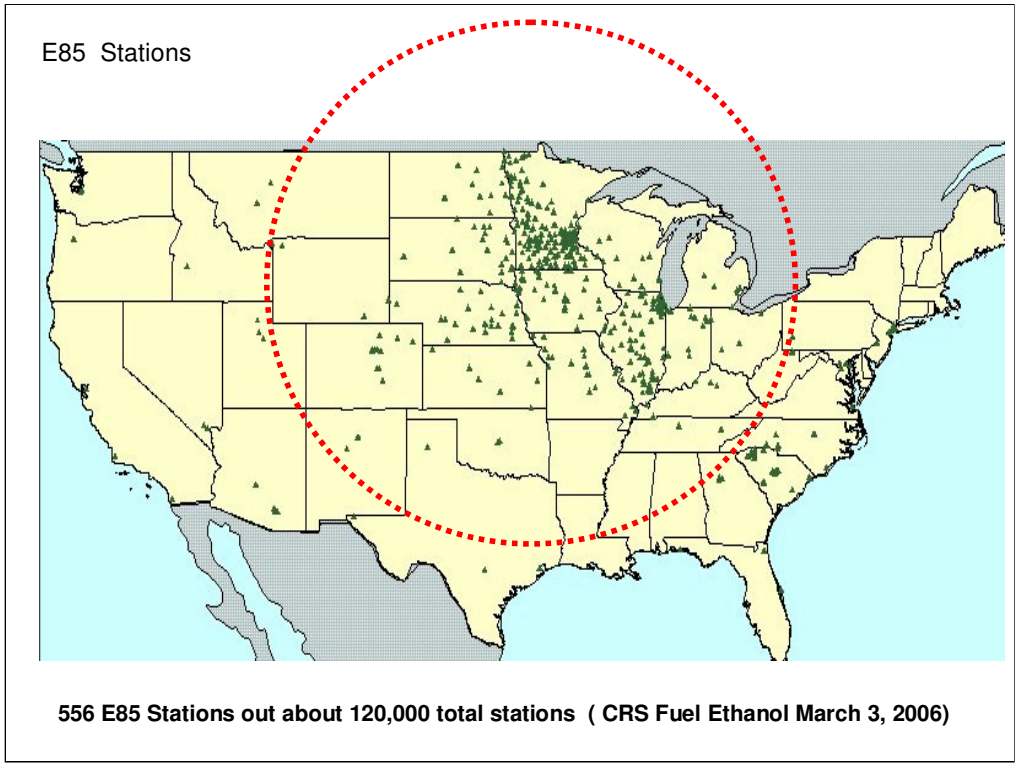
Will using more ethanol reduce the nation's "addiction to oil"?



● The map shows the location of all current and many forecasted ethanol plants in the US. The circle represents a radius of about 1000 miles that is near the center of most ethanol capacity. The US will produce over 4 billion gallons per year in 2006 which is blended in about 36% of the US gasoline, and much of the gasoline within the circle is already blended with ethanol. However, most gasoline (about 70%) is sold outside the circle and closer to coastal markets. The capacity to produce ethanol will exceed over 6 billion gallons per year in 2007. For ethanol use to further expand in the US, it will have to be shipped outside the circle toward the coastal gasoline markets by mostly railcar.

● Due to ozone exceedences, much of the gasoline along the coast is some version of low RVP such as RFG or 7 RVP gasoline during the summer time and represents over 50% of the gasoline during the summer. To avoid increased VOC's in these areas when using ethanol, about 5 to 8 % of the more volatile gasoline components (C5's and C6's) will have to be removed from the gasoline production in the summer time which will then negate much of the benefits of adding ethanol volume.

● Shipping the ethanol by railcar to the west and east coast gasoline markets will add about 8+ cents per gallon to the cost of ethanol.



● This map shows the location of the E85 stations located in the US at the beginning of 2006. Compared to the approximately 120,000 service stations in the US, there are only about 556 E85 stations located in the US, and of them, only about 60 are located outside the circle. This small number of E85 stations is compared to the approximately 5 million E85 flexible fuel vehicles that have been sold in the US according to the automakers.

● Therefore, it would appear that very few of the E85 flex fuel vehicles in the US fleet are actually using E85 fuel. This raises the issue of whether there is a actually a market demand or need for E85 fuel in the US.

Typical Market Prices Today

Crude Oil	**$ 60 / BBL**	
Gasoline	**$ 67 / BBL**	
	$ 1.60 / Gal	**Refinery Gate**
	$ 2.25 / Gal	**Street Price**
Natural Gas @ Plant	**$ 7.00 / MM BTU**	
Corn	**$ 2.25 / Bu**	**($ 90 / Dry ton)**
Switch-grass	**$ 40 / Dry ton delivered**	
Brazil:		
Sugarcane	**$ 10.00 / Dry ton**	
Sugar markets	**17 c / lb**	**($ 340 / Dry ton)**

● The above chart shows some of the typical market prices of raw materials and crude oil related economics used to evaluate and compare the costs of the various potential sources of ethanol. These prices are also used in this analysis to determine and compare the value of the various ethanol uses in gasoline.

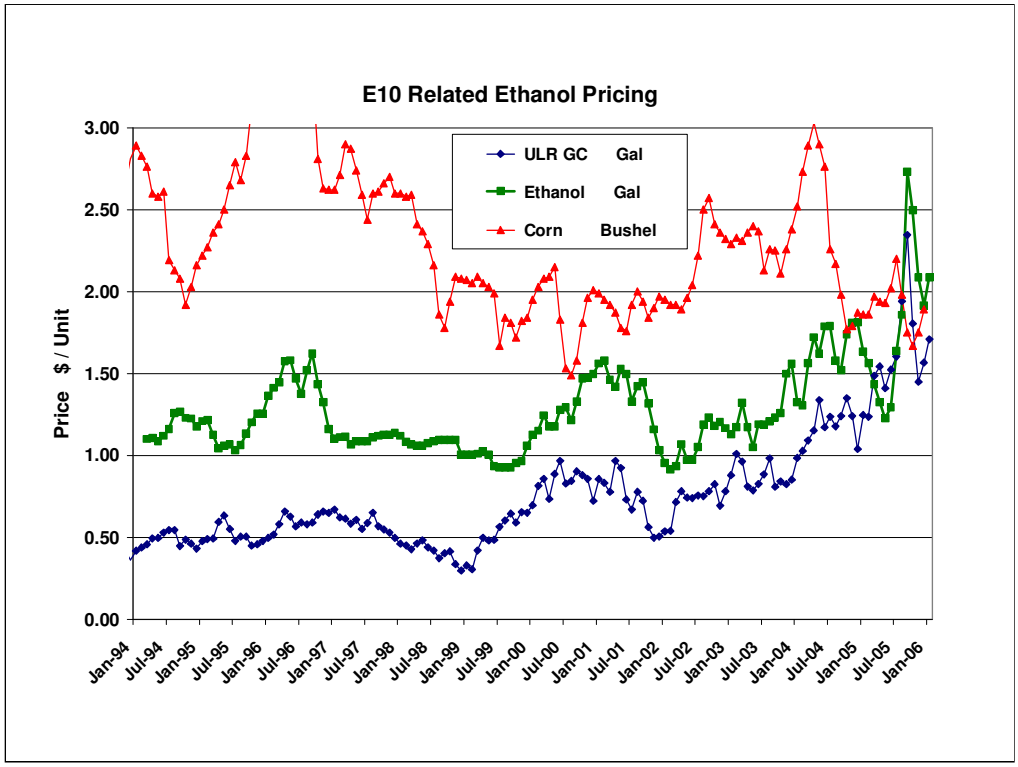
● Based on USDA cost analysis for crop farming, one caveat in these prices is that the true cost of producing corn is likely 50 to 75 cents per bushel higher than the corn market prices. These below-cost market prices for corn are apparently due to the government providing subsidies or payments to the farming operations which thereby covers some of the cost of farming or producing the corn.

OIL EQUIVALENT COST OF ETHANOL

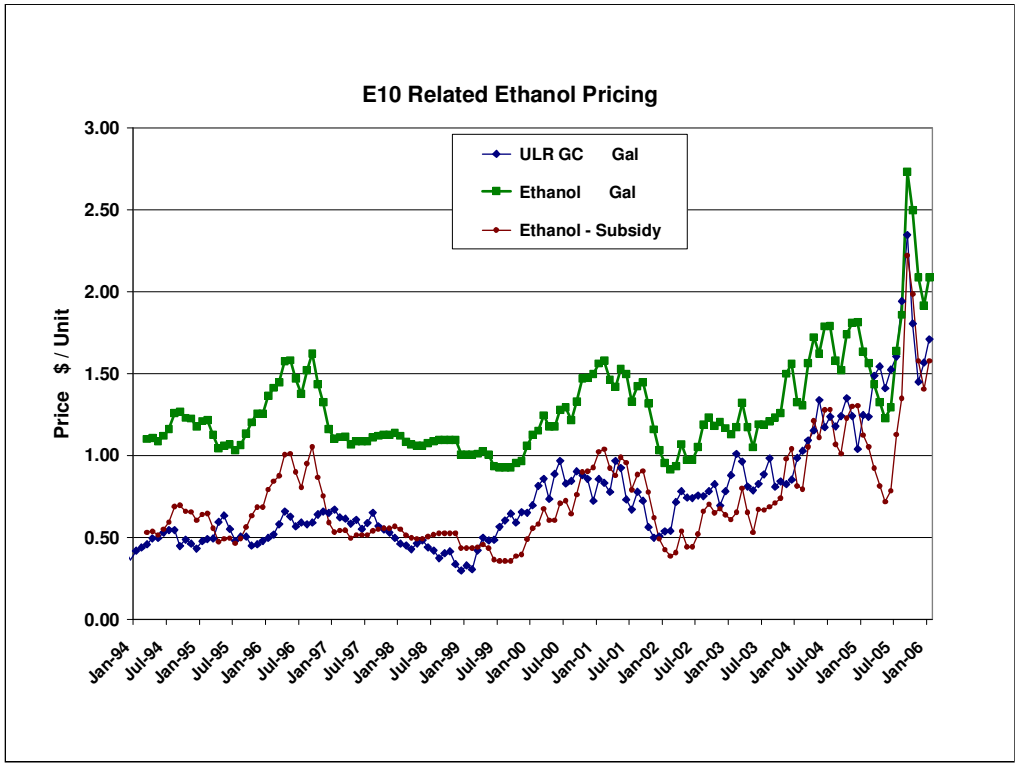
40 million gal per year plant
Ethanol Denatured with 5 % Gasoline

Raw Material Source		US Corn Starch	US Switch Grass	Brazil Sugarcane	Brazil Incremental Sugar
Investment					
$ / Gal of Capacity		1.40	4.80	1.33	
					$ / lb 0.17
Cost $ / gallon of ethanol :					
Raw Material		0.86	0.50	0.58	2.14
Co-Product Credits		(0.26)	(0.33)	(0.10)	(0.20)
Utilities		0.38	0.16	0.04	0.00
Chemicals & Other		0.07	0.24	0.04	0.00
Fixed Operating Cost		0.18	0.40	0.11	0.00
Cash Cost		**1.23**	**0.97**	**0.66**	**1.94**
Capital Recovery		0.21	0.74	0.20	0.00
Sales, Gen & Adm		0.03	0.03	0.01	0.03
Total Cost of Production		**1.47**	**1.74**	**0.88**	**1.97**
Transp. Cost to Terminals		0.08	0.08	0.04	0.04
Total Delivered Cost		**1.55**	**1.82**	**0.92**	**2.01**
Gasoline Equiv.	**$ / Gal**	**2.28**	**2.67**	**1.35**	**2.96**
	$ / BBL	**96**	**112**	**57**	**124**
Normalize out Oil	**$ / BBL**	**102**	**120**	**55**	**129**
WTI Oil Equiv.	**$ / BBL**	**95**	**113**	**48**	**122**

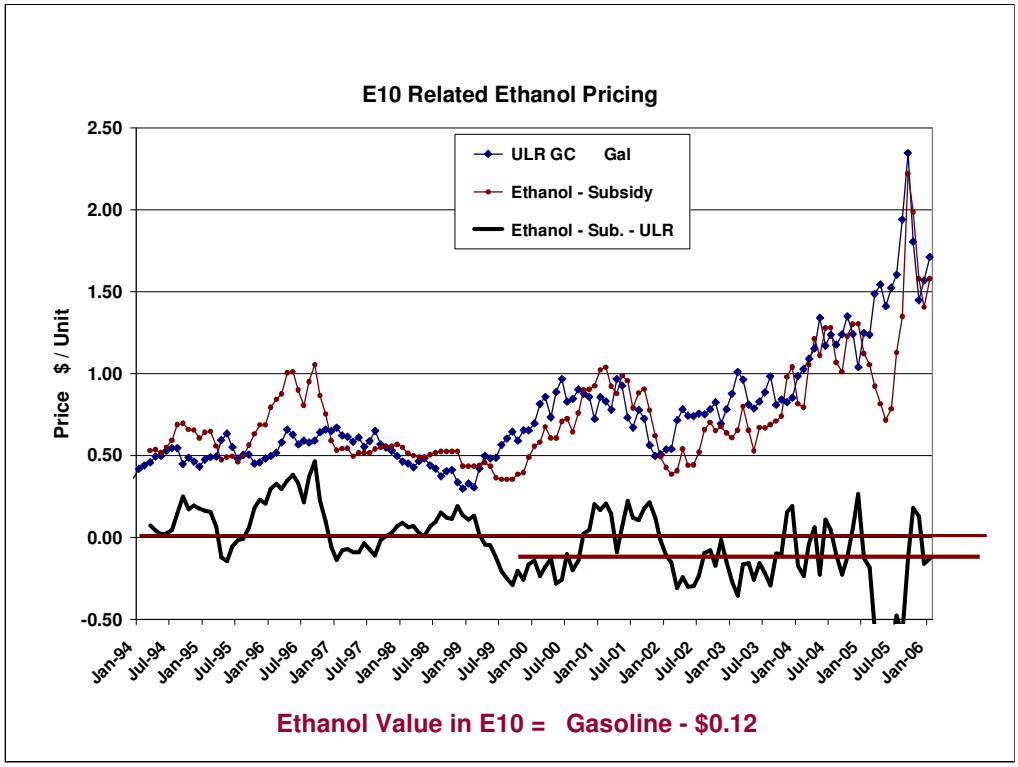
- The tabulations show the cost components of four potential sources of ethanol. The two in the US are (1) the well understood corn starch-based ethanol, and (2) the much discussed “cellulose to ethanol” process using switch-grass. The two options in Brazil are the competing sugar options which is using sugar at sugarcane cost versus using sugar valued at market value netbacks.
- In the US, the “cash cost” of the cellulosic route might potentially be lower than the ethanol from corn starch, but the higher cost of capital with the cellulosic route results in a much higher cost of ethanol. In the case of Brazil, the lower cost of producing sugarcane provides a low cost ethanol, but if the sugar is valued at the competing sugar market value, the cost of ethanol more than doubles.
- To properly compare the ethanol sources (with their lower energy density) as a substitute for gasoline fuel derived from crude oil, the ethanol costs needs to be corrected to an energy equivalent basis on a $/gal and a $/BBL of gasoline. Then, to correctly determine the breakeven oil-equivalent cost of producing the ethanol fuels, the cost of the crude oil products (which are much lower than the ethanol cost) used in the ethanol supply chain need to be “normalized out” of the cost of the ethanol fuel. Finally, correcting the ethanol fuel cost to a WTI crude oil-cost equivalent shows that US ethanol options are equivalent to about $ 95 per barrel or higher while Brazil’s ethanol produced from sugarcane is less than $50 per barrel of crude oil.



● This price chart shows the historical prices of corn ($/bu), and the spot prices of ethanol and gasoline (unleaded regular in the US Gulf Coast) ($/Gallon) which are related through E10 blending. During the last 12 years, corn prices have been generally decreasing while ethanol prices have been flat to increasing along with the market price of gasoline. This inverse relationship suggests that ethanol pricing is not related to cost (corn), but to ethanol's value in E10 blends (gasoline). Therefore, ethanol appears to priced at what gasoline marketers are willing to pay. However, ethanol prices are tracking higher than gasoline prices because of ethanol's federal subsidy and not necessarily because of any captured ethanol octane value.

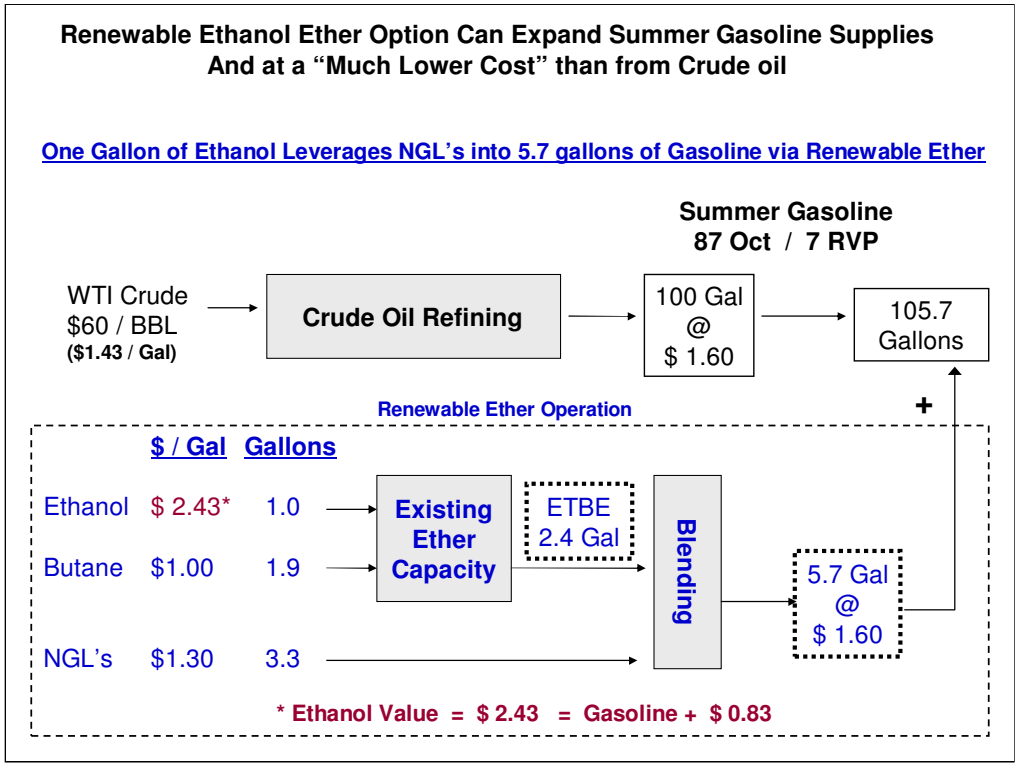


● When the federal subsidy received by gasoline blenders for ethanol is subtracted from the ethanol market price, the net market price of the ethanol to the gasoline blender falls to around the price of gasoline as shown on the above pricing chart. The chart history suggests that the "net price" of ethanol to the gasoline blender has closely tracked the price of gasoline. The relative value of ethanol to gasoline can be determined by subtracting the price of gasoline from the "net price" of ethanol over the history of prices as shown in the next chart.



● The dark 'difference' line (ethanol prices – subsidy – gasoline prices) on the chart shows that ethanol's net prices after subsidy were about equal to gasoline on the average prior to year 2000. This implies that ethanol in E10 takes on "extender" economics, and does not capture much octane value. However, around the year 2000, the net price of ethanol fell (on average) to a discount below gasoline. This price drop is likely due to the decrease in summer Phase II RFG RVP from about 8.7 to about 7 psi beginning in 2000. This RVP change in RFG is significant since RFG represents about 33 per of the gasoline in the nation. Because ethanol has such a high blending RVP, the refiner must reduce his blending of low cost C5 &C6 hydrocarbons when blending his 7 RVP summer gasoline.

● The average price relationship for ethanol since 2000 suggests that ethanol's value in E10 is about $0.12 per gallon below gasoline.



● ETBE is another option for incorporating ethanol into gasoline. It's use is widely growing in Europe to meet the EU Bio-fuels directive, and ETBE has been used in the US during the early 1990's. ETBE can be made in existing MTBE process units by replacing the methanol feed with ethanol. There is currently sufficient MTBE capacity in the US to convert about 1.7 billion gallons per year of ethanol into ETBE.

● By first converting ethanol into ETBE, the ethanol creates higher value by upgrading the lower cost butanes into a high octane and low RVP ether blendstock which premium blending properties then allow the refiner to blend more low cost NGL's (natural gasoline) into his gasoline. Therefore, for every gallon of ethanol converted into ETBE, it allows the refiner to expand his gasoline blending by approximately 5.7 gallons of summer grade gasoline (87 octane). This additional gasoline volume is derived mostly from non-petroleum energy resources, and does not require an expansion of crude oil refining capacity. In this example, the ethanol used in ETBE achieves a value that is equal to about gasoline + $0.83.

● Ethanol value in ETBE is superior compared to the E10 blending economics which explains why the EU gasoline market prefers to use ethanol as ETBE instead of direct blending of ethanol into gasoline.

E85 Exposes Ethanol's Lower Energy Density

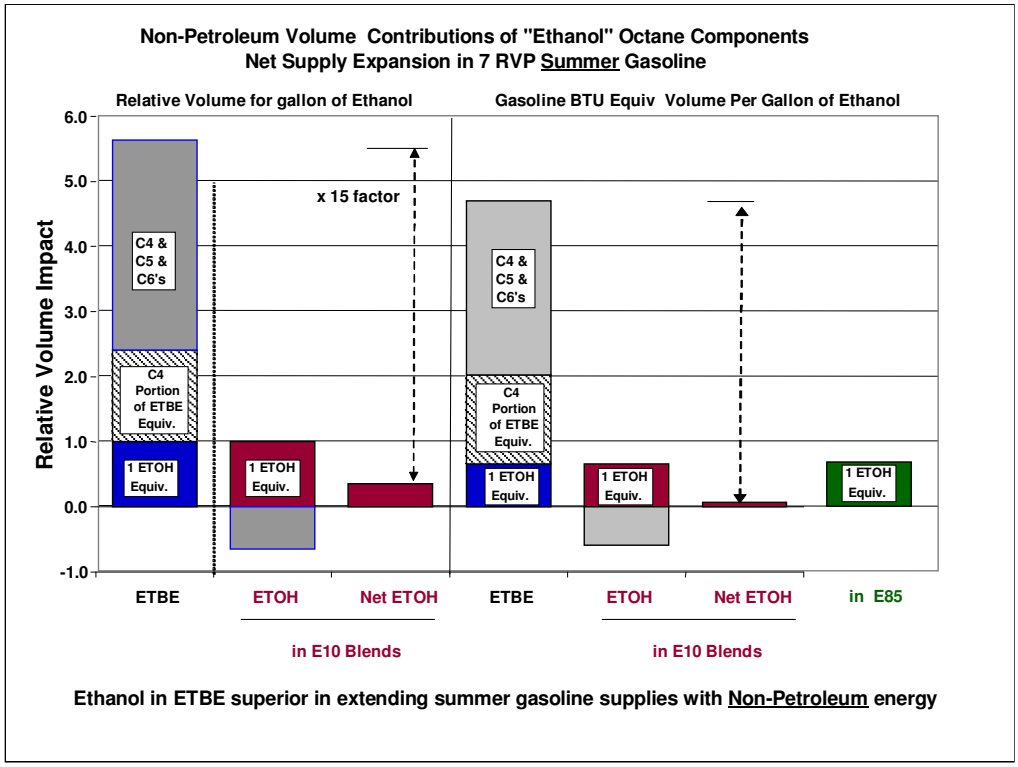
Crude Oil	**$ 60 / BBL**	
Gasoline	**$ 67 / BBL**	
	$ 1.60 / Gal	**Refinery Gate**
	$ 2.25 / Gal	**Street Price**
E85 Street Value	**$1.69 / Gal**	**75% of Gasoline Energy**
Ethanol Value in E85	**$0.94 / Gal**	**Value at Gasoline Terminal**

Ethanol Value = Gasoline - $0.66 **Value at Gasoline Terminal**

Ethanol Value is still not debited for new tankage at Gasoline Station

● E85 is a third option for using ethanol as an alternative to gasoline derived from crude oil. However, E85 has an energy density that is approximately 25% lower than that of regular gasoline according to the DOE. Therefore, a rational consumer would only be willing to pay an E85 price that is 25% lower than the price of regular gasoline. In this example of $2.25 of a street price (after taxes and retailer markup) for gasoline, the energy equivalent E85 street price is $0.56 per gallon lower. At the gasoline terminal where the ethanol is blended into E85, the value of the ethanol is $0.94 per gallon which is equal to gasoline minus $0.66. In addition, for a gasoline marketer to sell E85, he would also need to install a separate underground tank and fuel dispenser for a cost of about $30,000 to $40,000. Therefore, to pay for this added infrastructure, the value of the ethanol in E85 would have to be debited even further.

● The main reason for ethanol's lower value in E85 versus E10, is that E85 fully exposes the gasoline purchasers to ethanol's much lower energy density while most fuel purchasers do not notice the smaller 3% energy density loss of E10 blends. Therefore, gasoline purchasers unknowingly pay the same price for E10 fuel as regular gasoline even though they are getting less mileage per E10 gallon. Therefore the ethanol, when used in E10, does not incur an energy price debit by the gasoline consumer.



● This bar chart summarizes the potential gasoline volume impact for a gallon of ethanol in each of the three possible ways to displace gasoline from crude oil. The summer gasoline with 7 RVP is used to estimate the volume impacts since this is when gasoline capacity is lowest (loss of butane blending volumes) and demand is the highest.

● ETBE, by far, provides the highest gasoline volume contribution due to its ability to leverage in significant energy supplies of non-petroleum from the NGL market (natural gas liquids) such as butane and natural gasoline (low octane C5 & C6 hydrocarbon liquids from gas fields). One gallon of ethanol in the form of ETBE provides 5+ gallons of gasoline on a volume basis, and 4+ gallons of gasoline on an energy basis.

● One gallon of ethanol blended as E10 in a 7 RVP summer gasoline results in a much smaller net gasoline volume contribution since the high RVP of ethanol forces the displacement of a significant volume of other clean burning hydrocarbons (C5 & C6's) to maintain the 7 RVP. In a sense, ethanol as E10 has the opposite effect on the refiners' ability to blend C5 & C6's in gasoline than ethanol used as ETBE.

● Lastly, the gallon of ethanol blended in a E85 fuel blend will provide one gallon of gasoline-like fuel, but the ethanol only displaces about 0.67 gallons of gasoline demand because of the lower energy density of ethanol.

Values for Ethanol in Summer Gasoline

	$ Value		Gasoline Volume Per Ethanol Gallon	
Gasoline		$1.60		BTU Equiv.
E85	$0.94	- 0.66	+ 1.0	+ 0.67
E10	$1.48	- 0.12	+ 0.35	+ 0.23
ETBE	$2.43	+0.83	+ 5.7	+ 4.6

- E85's Ethanol market value is $0.54 less than E10 use
- Ethanol in E10 does not capture ethanol's energy density penalty
- ETBE is preferred over E5 in European Market
- Ethanol in ETBE provides
  - highest value in gasoline
  - produces greatest increase in non-petroleum gasoline volume

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● This chart summarizes the market values of the ethanol (ignoring the market distortion effects of government subsidies or mandates) as compared to the market price of gasoline. The ranking shows that ethanol in the form of ETBE has a premium value over gasoline for the reasons discussed in an earlier slide while E10 and E85 have ethanol values that produce a discount below gasoline market prices. E85 in particular produces a low market value that is about 50+ cents per gallon lower than in E10 because ethanol's lower energy density is not being captured and penalized in the consumer's purchasing decision when choosing to buy E10 versus regular gasoline. Without having differential subsidies to ethanol in E85, it is difficult to envision a free open market where the rational ethanol suppliers would be willing to drop the price of all their ethanol to make ethanol blending in E85 be economical. However, ethanol used in E85 can potentially displace more gasoline volume derived from crude oil than ethanol used as E10 in summer gasoline.

● ETBE provides the highest value for ethanol use in gasoline as well as the highest potential volume expansion of gasoline made from non-petroleum energy sources. This comparison helps explain why ETBE is the preferred means being used for blending ethanol into EU gasoline to meet their Bio-fuel directive.

OIL EQUIVALENT COST OF ETHANOL

Raw Material Source		US Corn Starch	US Switch Grass	Brazil Sugarcane	Brazil Incremental Sugar
Ethanol Cost Dlvd	$ / Gal	1.55	1.82	0.92	2.01
Gasoline Equiv.	$ / Gal	2.28	2.67	1.35	2.96
	$ / BBL	96	112	57	124
Normalize out Oil	$ / BBL	102	120	55	129
WTI Oil Equiv.	$ / BBL	95	113	48	122

- After 27 years of subsidized production, US Ethanol from biomass is still 50+ % more expensive energy than $60 crude oil
- Expanding Ethanol will drain more dollars from higher value use in the economy unless crude oil reaches $95
- Other potential domestic energy resources are cheaper in the future Coal to FT Liquids ~ $35, Shale Oil ~ $45

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● This chart summarizes the net cost of ethanol produced from the various sources on a $ per gallon basis of ethanol as well as the gasoline energy equivalent basis presented in earlier slides. This economic cost comparison suggests that ethanol from Brazil's sugarcane may be produced at about half the cost of ethanol derived from US corn, and is competitive in a $50 per BBL crude oil world while ethanol cost from US Corn is closer to $100 per BBL oil. Although US ethanol from cellulose has been touted as a potential low cost source of ethanol, this analysis suggests that it still has a long way to go before producing ethanol economically competitive with that sourced from corn. It has even farther to go to make ethanol fuel energy that is economically competitive with $60 per barrel crude oil, or with other liquid fuel that can be derived from the US's vast coal reserves and oil shale reserves for less than $60 per barrel.

● After 27 years of federal subsidies for US ethanol production from corn, it still appears to be 50+% more expensive than gasoline derived from $60 per barrel oil on an energy equivalent basis. Therefore, mandating or subsidizing additional expansions of ethanol use will likely divert substantial dollars away from higher value use in the US economy. Therefore, would a government requirement to further expand ethanol use convert a US "addiction to oil" to a bigger "addiction to corporate subsidies?"

● Unlike the cost-based pricing relationships of most other commodities, this review of ethanol economics suggests that ethanol pricing in the US is related to a gasoline market value (based on E10 extender blending in gasoline) and not to ethanol's cost of production. Although ethanol's true value "to refinery gasoline volume blending" appears to be a slight discount off of gasoline prices (on a volume basis) due to its high blending vapor pressure, the ethanol market price is artificially distorted to higher than its true volume-based value in gasoline through government subsidies and mandates in both the US and Brazil markets.