Ethanol (EtOH) & Other Renewables
IAEE – Houston Chapter
June 14, 2007

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Key Topics

US Ethanol Supply & Demand

- Forces Driving Ethanol / Biofuels
- Current Situation
- Possible Future Scenarios
- Increase in Renewable Fuels Standard Mandate?

Economics

- Ethanol Relative Production Costs --- Corn, Sugar Cane, Cellulosic
- Pro Forma Economics – Corn Dry Mill

Some Abbreviations and Terminology

- RFS = Renewable Fuels Standard
- EtOH = Ethanol
- BD = Biodiesel (B100 = 100%, B20 = 20% with refinery diesel)
- RFG = Reformulated Gasoline used in 9-12 areas of US
- MTBE = Oxygenate formerly used in RFG
- RBOB = Reformulated Gasoline Blending Component Before Oxygenate Blending (EtOH is the Oxygenate)

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Supply & Demand - Forces Driving US Renewable Fuels

Drivers

- "Renewable"
- Energy Prices / "Security"
- GHGs
- Loss of MTBE
- Blending Properties

Government Support

- Mandates
- Tax Incentives

- Bioethanol
- Biobutanol
- Biodiesel

- Good ROI
- Rural Jobs
- Fuel Diversification
- *"Lower Imports"*

RFS Expansion ?

- RFS mandate ***likely*** increases to 11-13 BGPY in 2012, 15 BGPY in 2015
- 2007 Farm Bill Re-authorization
- Democrats to push for more "energy independence" & force key Republicans to support RFS increase
- Sen. Bingaman's bill = ***35 BGPY***
- Some key energy committee members don't support EtOH
- NPRA trying to slow down RFS and reduce subsidies
- Other industries are objecting

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Corn Cost Backlash?

LOG CABIN

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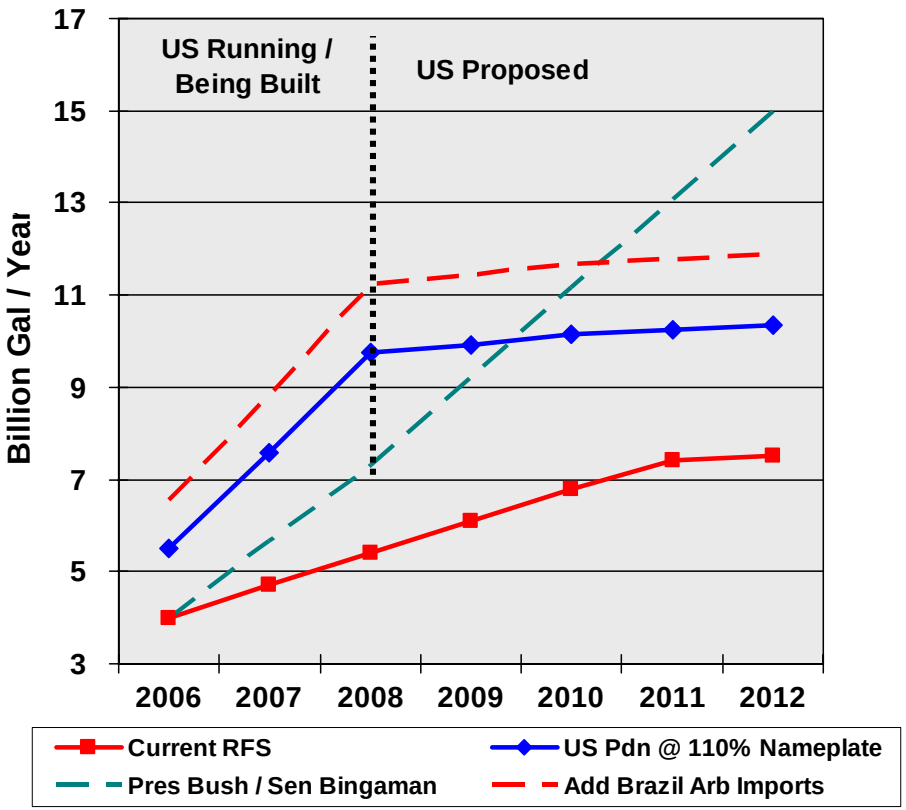
Supply & Demand – Possible Scenarios

Western Hemisphere Ethanol S & D 2006-2012 --- Possible RFS Changes



- US capacity exceeds *current* RFS demand thru 2012
- Subsidies / tariffs --- overbuilding?
- New plant proposals driven by EtOH producers betting on RFS increase
- Increased capital costs will cause some proposals to be cancelled
- Sen. Bingaman's bill = ***35 BGPY***
- Petrobras JV in Japan and possible increase of EtOH in mogas from 3% to 10% *might* reduce US avails
- India, China, Canada, Thailand, EtOH programs add complexity

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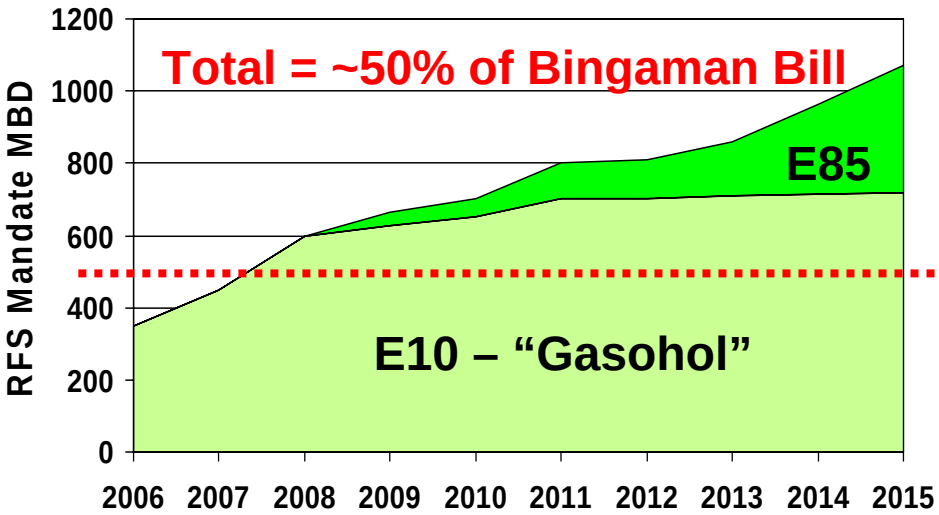
Supply & Demand - Can US Market Absorb More Ethanol?



% of US Mogas in 2015

RFS = 490 MBD = 5%

15 BGY = 980 MBD = 10%

35 BGY = 2.3 MMBD = 23%

E85 Issues

- 17 BGPY RFS requires ~350 MBD E85
- "Planting" State of Iowa = 600 MBD
- EIA says sufficient E85 vehicles will be built --- but by when?

E85 has huge potential, but - - -

- About 30% lower mpg – Consumers?
- Cannot be shipped in pipelines
- Only about 3% of U.S. cars can currently use it (5% by 2015)
- Domestic auto companies will support
- Significant investment required to make available to consumers
- EPAct 2005 incentive to gas stations

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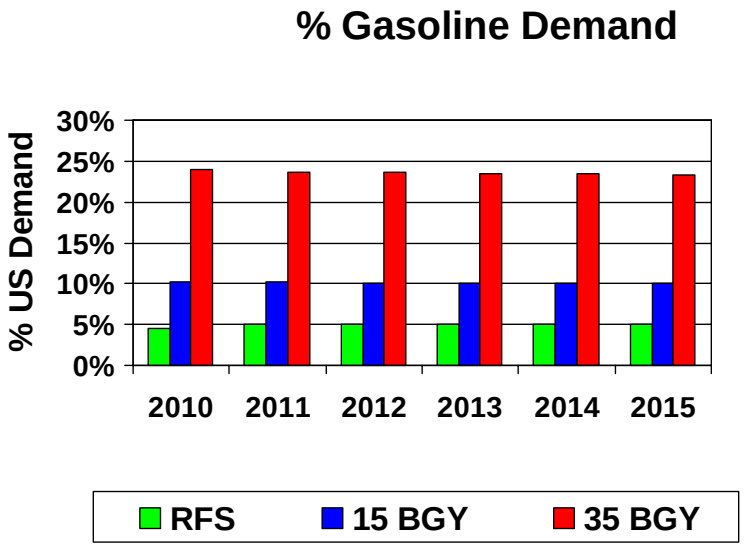
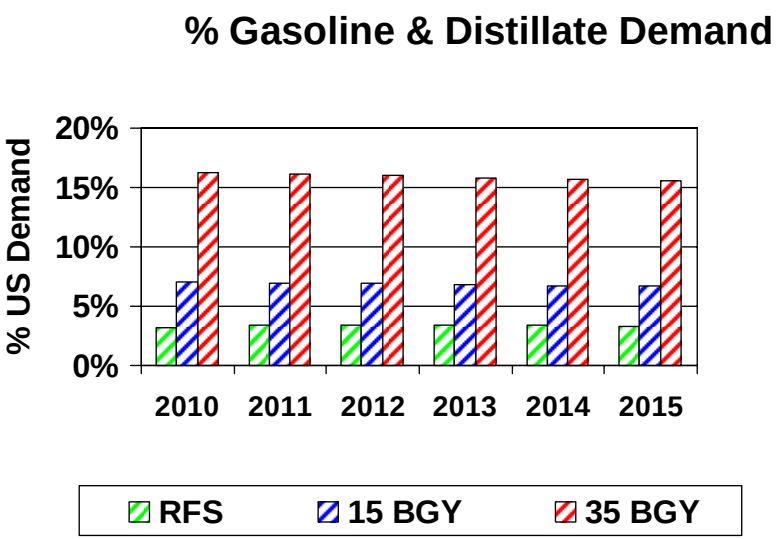
Supply & Demand - Can US Market Absorb Renewables?





- Can't quickly turn over auto fleet to E85 "Flex-Fuel"
- Logistics limit E85 availability
- Unlikely all 35 BGY renewable is EtOH into mogas
- Resistance to EtOH is Increasing
- Biodiesel helps and has advantages
- Emerging biobutanol is another possibility & "better" than EtOH
- ***Likely that significant incentives must continue***

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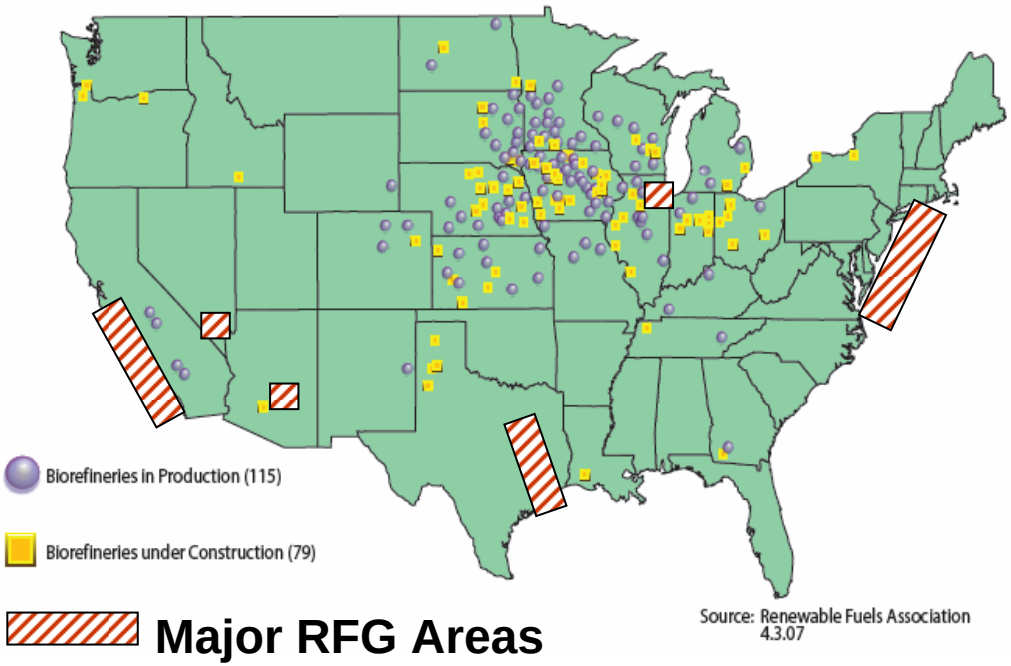
Supply & Demand – Domestic & Import Supply Sources

Domestic Supply



Imports

- CBI imports limited to 7% of US production; never at this level
- Some CBI imports from Brazil
- Largest imports from Brazil - - - If arb is open
- Arb open with high mogas prices
- Current tariff 54 cpg + 2.5% duty
- 2006 imports about 666 MM Gal or 15% of RFS demand

- Current US capacity 5.8 BGPY
- Forecasted in 2010 10-11 BGPY

Huge majority of demand on East, Gulf & West Coasts

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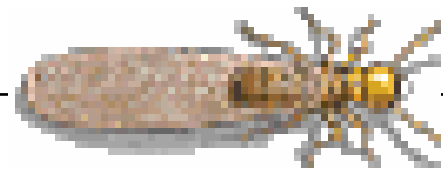
Cost Comparison – Various Ethanol Feedstocks

Feed	Yield – Gal / Acre	Technology Rating
Dry Mill Corn	400	Well Known
Sugar Cane	725	Well Known
Cellulosic – Corn Stover	800-1,200	? ? ?
Cellulosic – Switch Grass	~1,000	? ? ?



From a land use and food cost perspective . . .

- **EtOH BTU / gal = 2/3 gasoline BTU / gal**
- **1 MM acres of corn = 17 MBD gasoline and**
- **"One Iowa" = 600 MBD gasoline**
- **Current RFS = 490 MBD gasoline**

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Economics - Comparison of Ethanol Processes

Factor	Sugar Cane	Dry Mill Corn	Wet Mill Corn	Cellulosic
Feed Cost	Higher	Lower	Lower	Lowest
Energy	Can be Low	High Nat Gas	High Nat Gas	Highest
Other Opex	Low	Moderate	Moderate	1.5x Dry Mill
Capex	High	< Wet Mill	High	4x Dry Mill
Technology	Proven	Proven	Proven	Unproven
Difficulty	Easy	Difficult	Difficult	"Termites"
Co-products	None	High Value	High Value*	Maybe

- Despite uncertainty, Shell, Goldman Sachs, Abengoa pursuing cellulosic
- Economic analysis based on Dry Mill process that dominates in US

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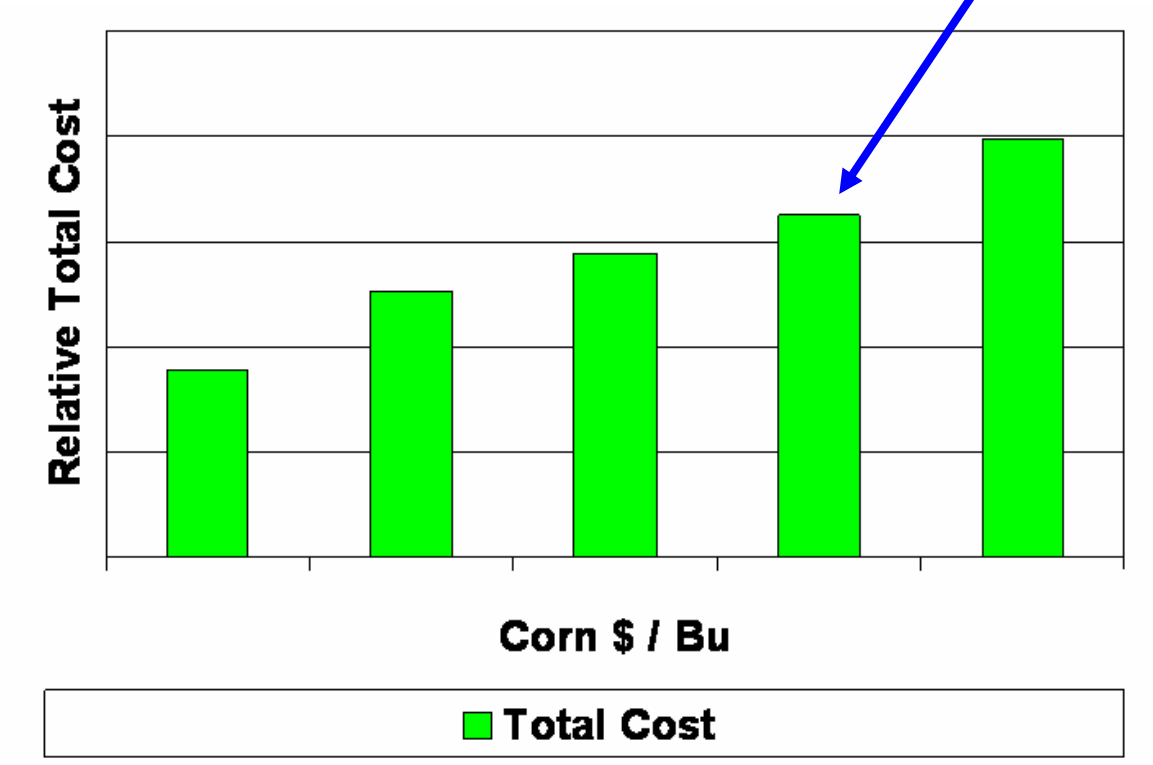
Cost Comparison – Dry Mill Ethanol Manufacturing Cost

"Avg" Corn Futures June 2007 ~$4.00



Platts Average 2007 YTD June 5 Prices @ USGC (CPG)

EtOH = 235 UL 87 = 194 RBOB = 198

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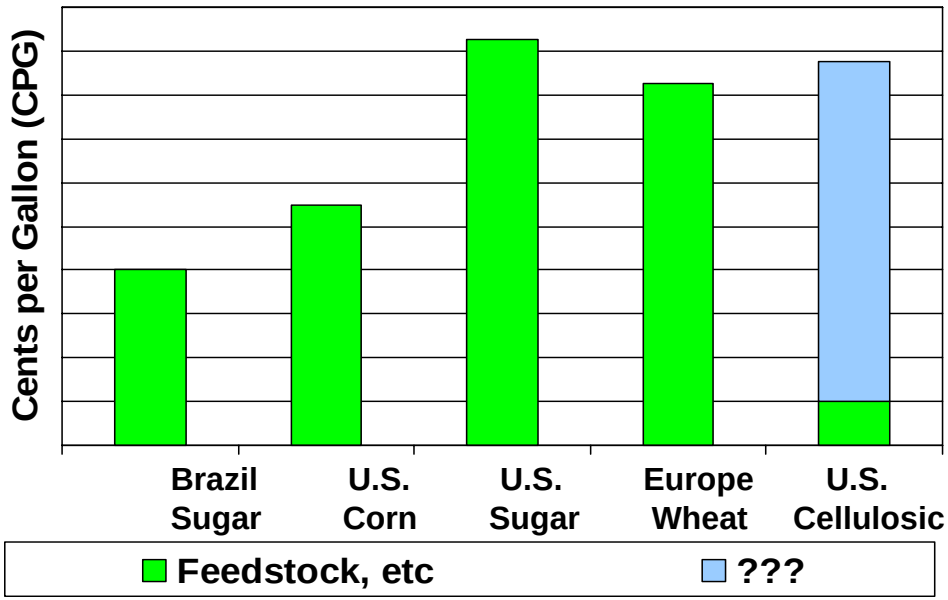
Economics – Ethanol Production Costs



All normalized to US Corn @ $2.50 / per Bushel

- **Highly dependent on feedstock cost**
- **US sugar already heavily subsidized Sugar to EtOH easier than starch to EtOH**
- **Cellulose to ethanol the most difficult, technology still evolving**
- **Corn is best in US**
- **Brazil burns bagasse in many plants**
- **Brazil labor costs < US**
- **Brazil still has best economics**

Sources: Various Consultants

Economics – Comments on Efficiency

- Industry is growing rapidly, but generally is operating inefficiently
- Some small plants have logistics disadvantages --- far from rail lines; small in scale --- ***BUT*** local economic impact drove the locations
- Current average plant capacity of 52 MMGPY limits use of unit trains;
- New technologies reducing energy consumption, improving efficiency, developing new co-products, using new feedstocks
    - Seed research to increase corn & ethanol yields
    - Corn fractionation
    - Cold starch hydrolysis
    - Corn oil extraction
    - Lower gas usage --- biomass, fluidized bed reactors, turbines
- Plant in West Texas to use methane from adjacent cattle feed lot and sell co-products as animal feed

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Economics - Barriers to Market Entry

- **Entry barriers are low - - - "NIMBY" non-existent due to local benefit --- Rural communities want the jobs generated**
- **Only 4 firms design / engineer ethanol plants --- same cost pressures as refining industry**
- **Financing readily available from banks, venture capitalists, hedge funds at favorable rates**
- **Easier to obtain financing for larger plants --- lenders at this level comfortable with commodity risks**
- **But Biodiesel is an "easier" process**

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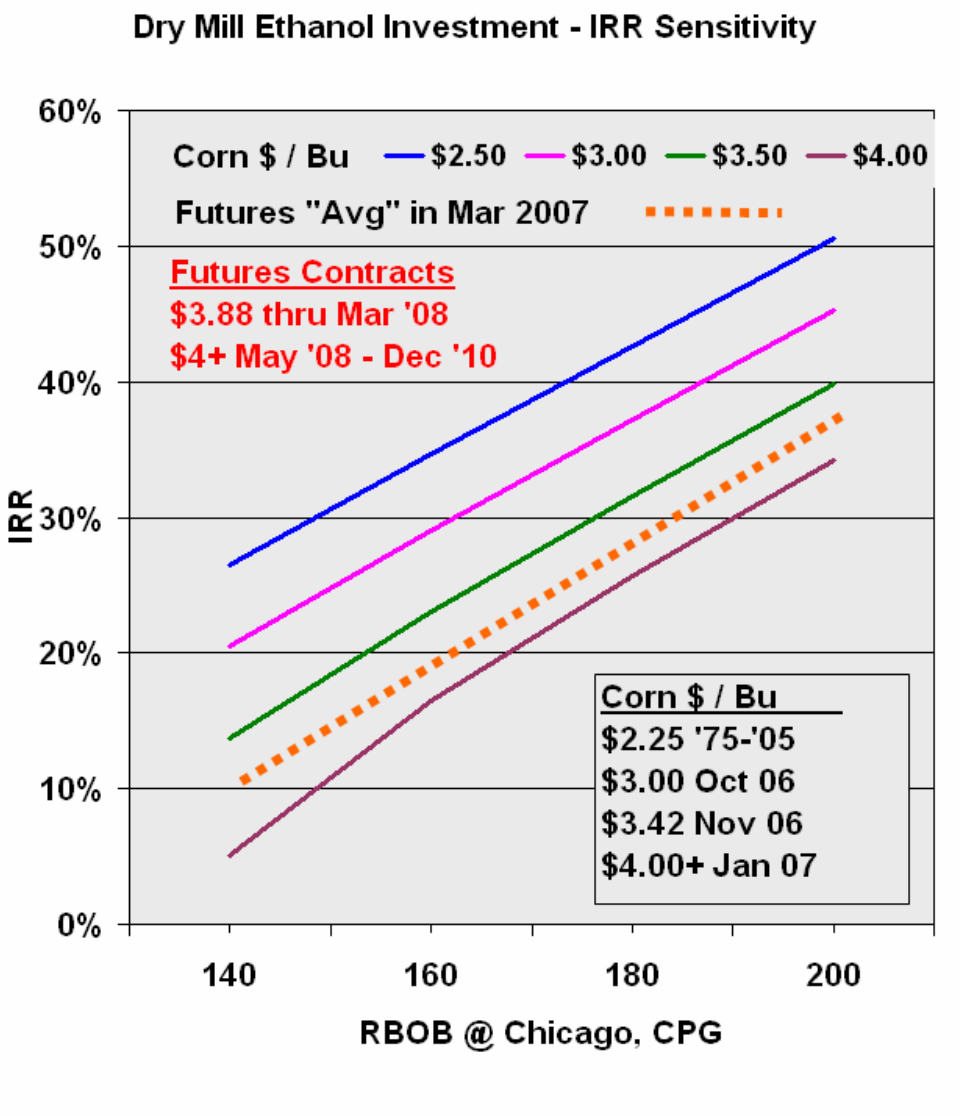
Pro Forma Economics



- **Invest then 1 year to build**
- **100% Equity Financing**

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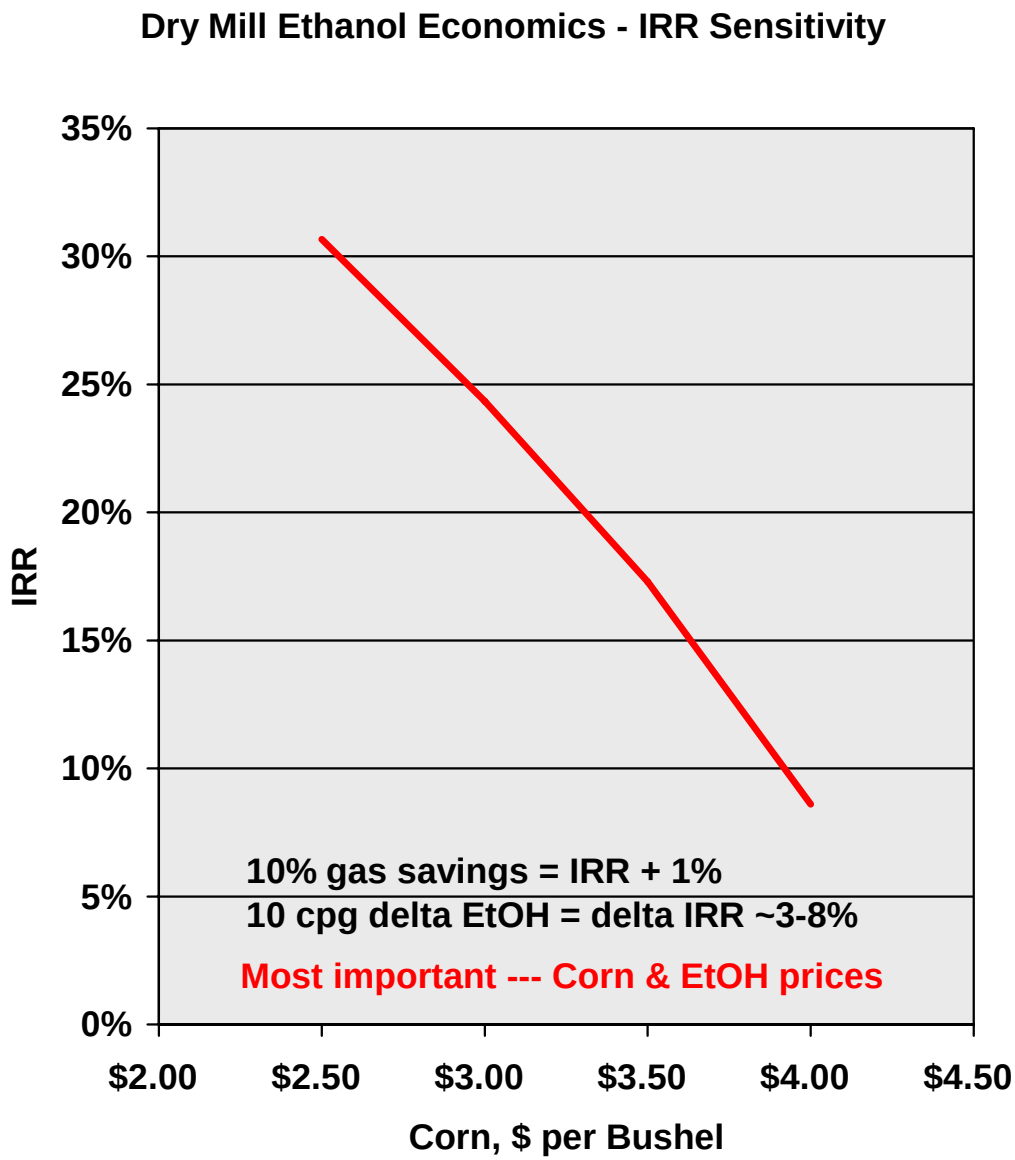
Pro Forma Economics



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Economics – IRR Sensitivity

Corn Price	$2.50	$3.50
Capex 200 MM (% IRR)	24	13
EtOH @ BTU Parity in 2009	<0	<0
Base Case - 165 MM Capex (% IRR)	29	16
EtOH @ BTU Parity in 2009	<0	<0
Capex 130 MM (% IRR)	37	21
EtOH @ BTU Parity in 2009	<0	<0

Financiers already are demanding greater equity stake by plant owners --- 60-65% debt leverage had been the norm

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The Future - How Do Biofuels Fit in US system?

- All have a place, but none totally replaces gasoline
  - EtOH and Biobutanol are good octane boosters
  - Biobutanol better than EtOH
- All *appear* to have GHG advantages over hydrocarbon based fuels
- Some have performance advantages
  - BD zero sulfur, adds lubricity
  - Biobutanol has BTU and shipping advantage over EtOH
  - BD can be made from waste fats and grease
  - Cellulosic EtOH *"Changes the rules"*
- But some key disadvantages
  - EtOH can't ship via pipelines
  - BD (Biodiesel) can, *BUT* how does it impact
  - Until cellulosic or waste grease proven, "food vs. fuel"
  - BD reputation damaged by "garage shop" manufacturers

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Back-Up Slides

Brazilian Ethanol (EtOH)

- Made from sugar cane since 1930s
- Low cost global producer - - - But cost varies with sugar prices
- Brazilian Gasoline
  - Hydrous 95% EtOH --- “Ethanol cars” and export
  - Anhydrous EtOH --- “Gasohol” for “flex-fuel” vehicles
  - Conventional refinery gasoline
- 2006 EtOH Production 4.2 BG (273 MBD); ~45 MBD Exported
- Plans to almost double production by 2009

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Competing Ethanol Technologies

Corn Processes

- Gas savings to 60% in corn based with Fluidized Bed Reactors or gas turbines
- Location near feed lots reduces methane and animal feed costs
- Seed research underway to improve ethanol yield per bushel of corn
- Proximity of feed and CO2 markets, nat gas price drive corn / EtOH logistics
- Wet mill by-products require additional processing and add costs

Cellulosic Processes

- Available for 25-30 years; never economic, technology unproven on large scale
- ***May have*** very long term potential to produce “diesel-like” molecules

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Economics - Corn vs Ethanol Logistics

Build Near Feedstock or Near Fuel Market?
Ship Ethanol or Ship Corn ?

Feedstock cost, 2/3 of total Opex, increases for "destination plants" such as Northeast Biofuels in upstate NY

Concept works when:

- **Livestock feed demand is nearby**
- **Local CO_2 markets exist**
- **Natural gas prices are reasonable**
- **Nearby mogas demand is high**

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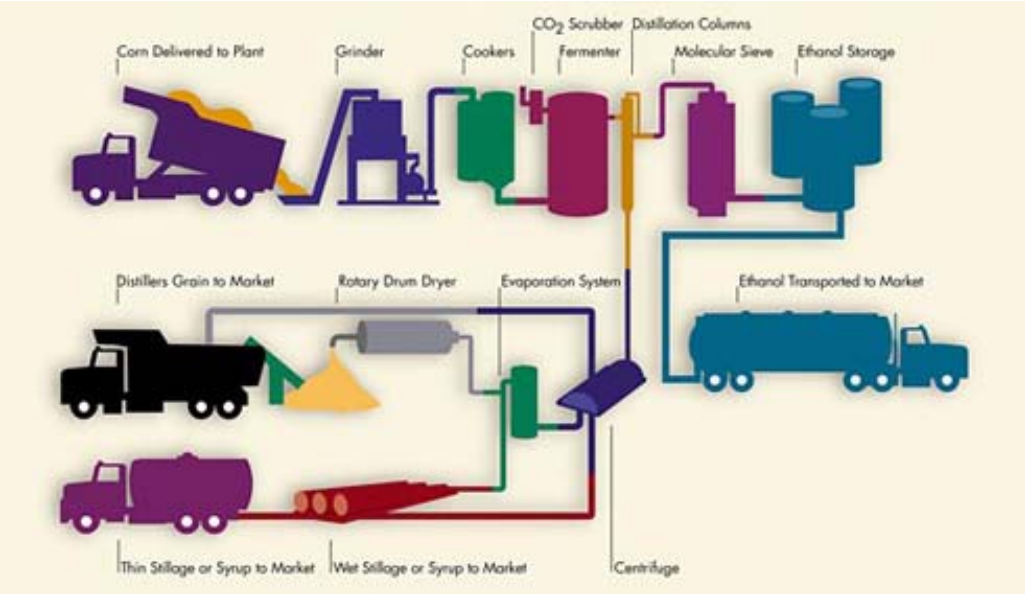
Competing Technologies – Dry Milling

Dry Milling



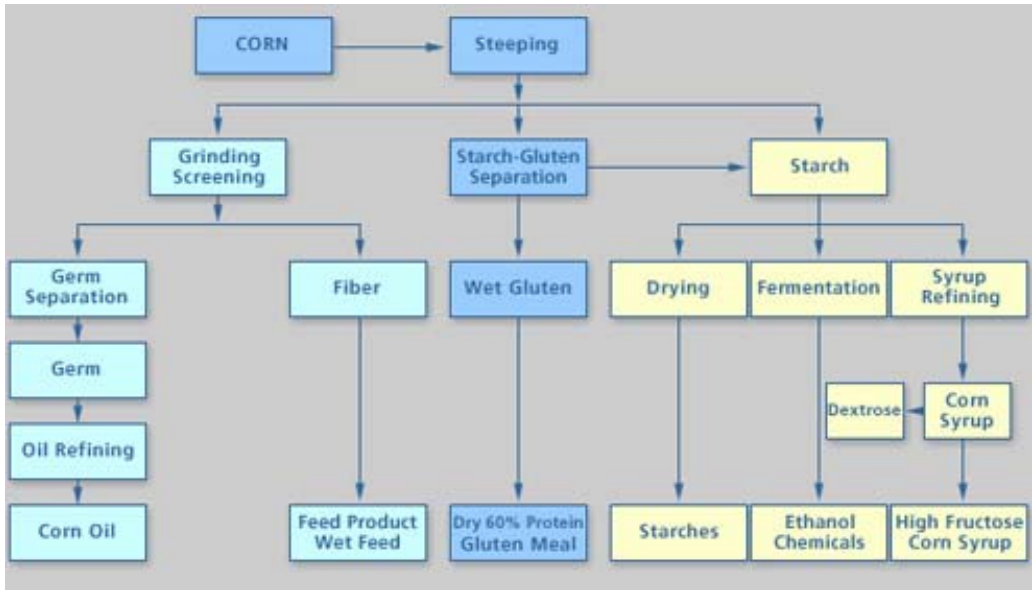
- Grind entire kernel into flour
- Slurry with water & add enzymes
- Convert starch to dextrose (NH3 for pH)
- Heat to reduce bacteria levels
- Cool, add yeast & ferment to EtOH & CO2 over 40 to 50 hours
- Transfer to distillation columns to separate EtOH "stillage"
- EtOH distilled 190 proof (95%)
- Dehydrated to ~200 proof in a molecular sieve system
- Denatured with about 5% natural gasoline

- Stillage centrifuged to separate coarse grain from solubles
- Solubles concentrated to ~30% solids by evaporation --- (Condensed Distillers Solubles (CDS) or "syrup"
- Coarse grain & syrup dried to produce dried distillers grains with solubles (DDGS)
- CO2 captured and sold for soft drink carbonation & dry ice

Source: Renewable Fuels Association

Competing Technologies – Wet Milling

Wet Milling



- Soak grain in dilute sulfurous acid 24 – 48 hrs
- Grind slurry to separate corn germ
- Extract corn oil from germ on-site or sell germ to crushers
- Separate remaining fiber, gluten, starch with centrifugal, screen, hydroclonic separators

- Concentrate steeping liquor & co-dry with fiber portion & sell as corn gluten feed to livestock industry
  - ➢ can sell heavy steep water as feed ingredient directly
  - ➢ also can use in “Ice Ban”

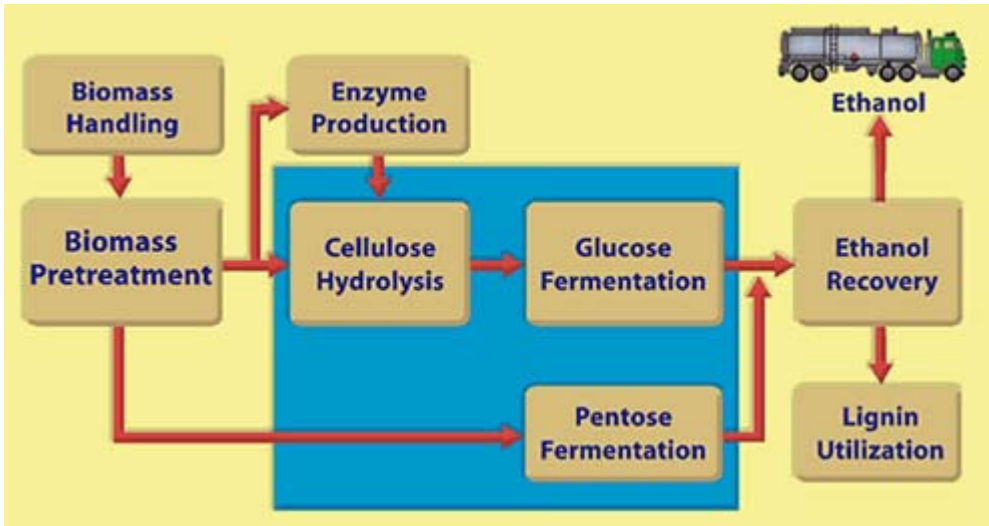
- Filter and dry gluten (protein) to gluten meal, a valuable poultry feed

- Process starch and any water from mash:
  a) ferment into EtOH (similar to dry milling)
  b) dry, sell as dried / modified corn starch
  c) process into corn syrup

Source: Renewable Fuels Association

Competing Technologies – Cellulosic Biomass

Cellulosic Ethanol



- Variety of options for pretreatment
- Variety of other steps in the process
- Several technologies combine two or all three of the hydrolysis and fermentation steps
- An evolving technology that has yet to be proven commercially

- Capex = 4 x Dry Milling
- OPEX = 1.5 times Dry Milling
- Highest energy cost of all processes
- ***But Potentially zero cost feedstock***

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