

## Using Biomass to Enhance Dry-Grind Ethanol Profits



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Fuel Ethanol Workshop  
Milwaukee, WI  
June 21, 2006



## Why Conduct this Project?

- While very profitable in the past year due to high ethanol prices and cheap corn prices---- control of energy costs may be essential to firm success.
- Dry-Grind plants are subject to volatile and increasingly expensive natural gas.
- Abundance supplies of biomass are available to enhance profits of ethanol plants.

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## My Talk Today

- Describe the basis for this research (using DDGS or corn stover to replace NG)
  - Petroleum prices, ethanol prices, NG prices
- Describe the research underway and how it may be useful to dry-grind plants

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## Our Project

- Develop technical data and economic tools to guide the decisions of dry-grind ethanol plants seeking to enhance profits by using biomass to produce process heat and electricity.

### Project Sponsors



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## Our Team

- Dr. Vance Morey,
- Biosystems & Ag. Engineering  
U of Minnesota
- Doug Tiffany,  
Dept. of Applied Economics,  
U of Minnesota
- Dennis Hatfield, RMT,  
Madison, WI
- Rod Sears, RMT,  
Madison, WI



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## Participating Plants



- Ace Ethanol----- Stanley, WI
- Badger State Ethanol-----Monroe, WI
- Corn Plus----- Winnebago, MN
- Chippewa Valley----- Benson, MN
- Agri-Energy-----Luverne, MN



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## Our Work Plan

- Collect samples of DDGS, DDG, concentrated solubles (syrup), and corn stover
- Conduct analysis of combustion and emissions characteristics of biomass sources under various protocols
- Determine capital and operating costs to compare systems
- Develop user-friendly spreadsheet for dry-grind ethanol plants seeking greater profits by replacing natural gas with biomass fuels.
- Post results on website and share conclusions by other means with the fuel ethanol industry

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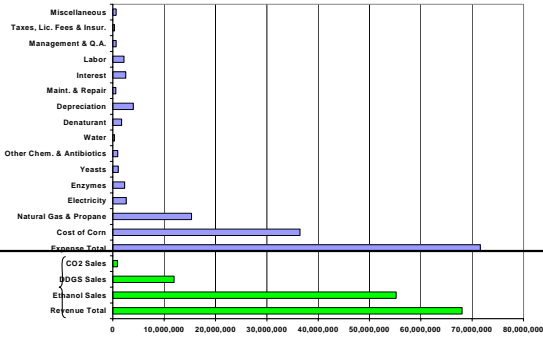
## What Everyone Knows

- Natural Gas is a great fuel— except for price levels and volatility.
- Natural Gas is the second major cost of ethanol production after corn in typical dry-grind plants.
- Natural Gas Prices have risen and threaten ethanol plant profits.



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### Ethanol Plant Revenue and Expenses (Spring 2005)



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### Minnesota Commercial Natural Gas Prices

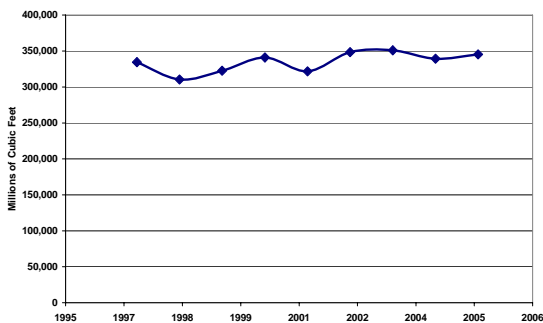
(Source: E.I.A.)



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### Natural Gas Delivered to Minnesota Consumers

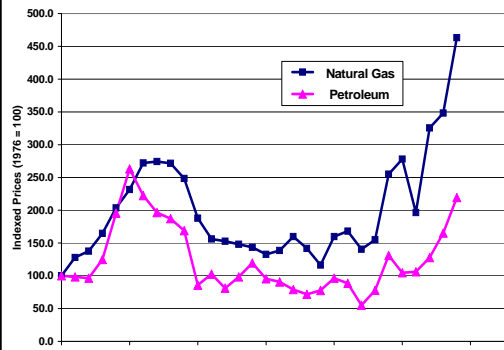
Source: EIA



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### Indexed U.S. Annual Natural Gas and Petroleum Prices 1976-2005

Source: EIA



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## Biomass Has Costs

- Opportunity Costs as Feed, Bedding, and Soil Enhancer



- Procurement Costs
- Transportation
- Storage
- Handling
- Emissions
- Ash Disposal

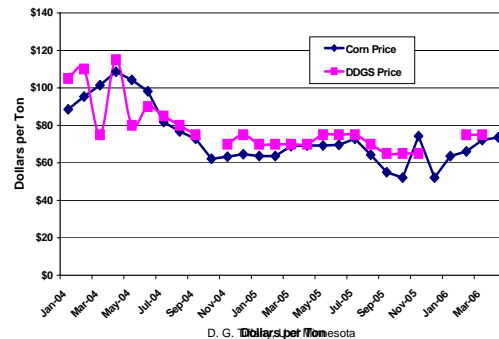


- However----, reliable, well-located supplies

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Minnesota Corn and DDGS Prices 2004-2006

(Sources: Commodity Specialists Company and USDA)



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## USDA Analysis of 2005 Energy Bill through 2012

- Additional ethanol will primarily be derived from corn at dry-grind facilities.
- Corn prices will increase 8% (\$.30 per bushel) increase in U.S. by 2012.
- Ample DDGS supplies will reduce prices of SBM 7%.
- Demand to make biodiesel will raise soy oil price 6%.
- Corn acres will rise 3.5%.
- Soybean acres will decline 3%.
- Broiler and turkey production will expand with cheap SBM.
- Production of all other livestock will decline due to higher corn prices.
- Expect biomass ethanol and biodiesel to be more important after 2012.

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## Considering Ethanol Prices



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## Ethanol Success Model Indicates:

- that without specific subsidies for the ethanol plant, the cost per gallon of denatured ethanol with corn at \$2.00 per bushel and natural gas at \$10.50 is \$1.526 per gallon of denatured ethanol,
- the co-products are 1 gallon of denatured ethanol, 6.4 pounds of DDGS, and 6.4 pounds of CO<sub>2</sub>, and
- selling the DDGS at \$.04 per pound gives a net cost of \$1.27 per gallon of ethanol.

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## Longer Run Relationship Between Petroleum, Wholesale Gasoline and Wholesale Ethanol Prices

- Ethanol prices are expected to move into their historic relationship to gasoline prices by mid 2007.
- Gasoline /Gallon = \$.036 + \$.029 (Price of Crude Oil/Brl)
- Ethanol's Historic Premium is \$.35 to \$.45 per Gallon.

Crude Oil/Brl.	Gasoline/Gallon	Ethanol
\$40	\$1.20	\$1.55 to 1.65
50	1.49	1.84 to 1.94
60	1.78	2.13 to 2.23
70	2.07	2.42 to 2.52

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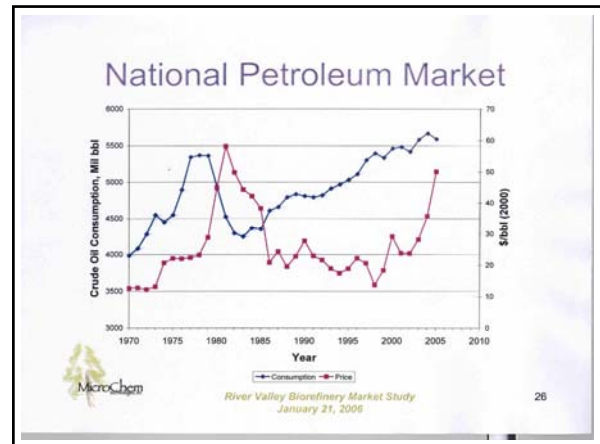
## Additional Factors To Watch Concerning the Profitability of Ethanol Plants

- Netback prices a plant receives are less than the rack prices one reads about.
- Availability of blender's credit of \$0.51/gal. (Intact through 2010)
- The price of natural gas or other boiler fuel.
- Price of corn

Corn Price	Net Cost /Gallon
\$2.00	\$1.27
2.25	1.36
2.50	1.45
2.75	1.54
3.00	1.63

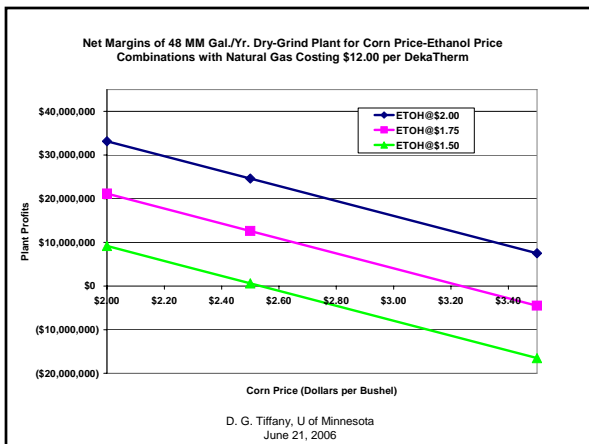
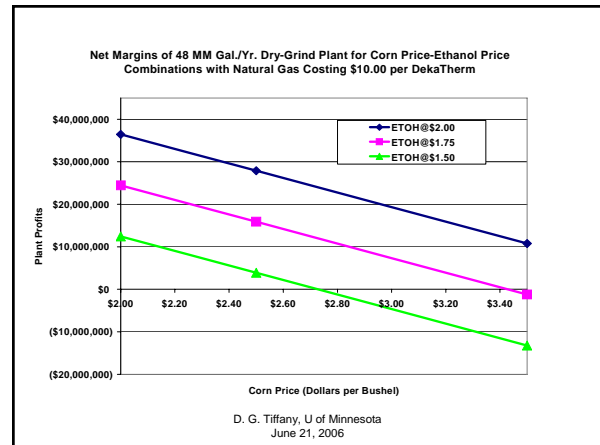
- Conversion of MTBE production capacity to isooctene and isooctane capacity.

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- The following graphs demonstrate the effect of natural gas prices on net margins of typical dry-grind ethanol plants. Each of the three graphs is established for natural gas prices at a particular price for the year (\$8.00, \$10.00, and \$12.00 per Dekatherm). On each graph the X axis identifies corn prices and the Y axis shows net margins for the ethanol plant. As corn prices rise and/or ethanol prices realized by the plants decline, dry-grind plants will more acutely feel the higher costs of natural gas prices.

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## Planned Responses to NG Prices

- Replacing NG with Coal
- Reducing NG requirements by producing WDGS
- Replacing NG with DDGS or Syrup
  - Corn Plus (Winnebago)
- Replacing NG with Waste Wood
  - Central Minnesota Ethanol (Little Falls)
- Gasifying DDGS to make Syngas
  - Chippewa Valley Ethanol, Benson MN
- DDGS are produced at dry-grind ethanol plants in amounts sufficient to provide process heat, electricity in co-generation, and electricity to sell on grid.

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## Technologies and Feedstocks Analyzed

- Syrup Combusted in Fluidized Bed
- DDGS Combusted in Fluidized Bed
- DDGS Gasified to Produce Syngas that is used in several places in the plant.
- Corn Stover Combusted in Fluidized Bed
- Corn Stover Gasified in Fluidized Bed

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## Cases: Using Biomass to Replace:

- Process Heat
- Process Heat and Electricity Needs
- Process Heat, Electricity Needs, and Sales to the Grid.

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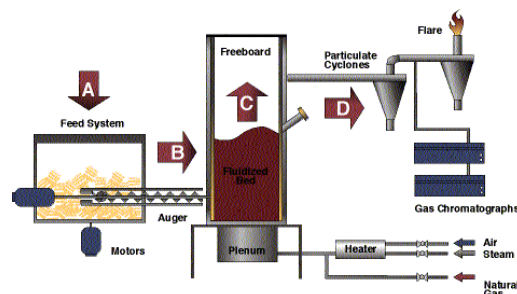
## Combustion and Emissions Modeling by RMT

- Need to Understand Steam Cycle of Plant
- Need to Characterize Emissions
  - Establish standards of equipment
  - Determine operating ranges for combustion to comply with permits
  - Emissions change during course of steam cycle (as steam demand changes)
  - Understand Ash Characteristics & Value

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## Bubbling Fluidized Bed Gasifier

Complements of BeCon Center, Iowa State University



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## Additional Capital Costs

- Emissions for Various Biomass Sources will work out---- but it is necessary to characterize the emissions and determine
  - Permitting Costs
  - Capital Costs for Biomass Handling, Storage
  - Capital Costs of Biomass Combustion Equipt.
  - Capital Costs of Electrical Generator
  - Capital Costs- Emissions Control of Biomass
  - Capital Costs for Ash Disposal

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## Cost Reductions or Revenue Gains

- Reduced Natural Gas Purchases
- Reduced Electricity Purchases
- Sale of Electricity to the Grid
- Becoming a QF by being able produce 65% Firm power during prime periods of 9:00 A.M.- 9:00 P.M. Monday-Friday, excluding holidays.
- Power payments and Capacity Payments--- (\$0.125 for 2006 for QF during prime hours summer months)

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## Additional Operating Costs with Biomass

- Procurement Activities for Biomass
- Storage of Biomass
- Preparation of Biomass Before Combustion
- Labor to Handle Combustion, Maintenance
- Use of Limestone for Sulfur Capture
- Replacement of Sand in Fluidized Bed
- Possible Ash Disposal or Sale of Nutrients

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## Early Indications of Operating Costs (Nicola, 2005)

- Biomass plants require an additional maintenance expense of \$180,000 per 50 MMGPY capacity.
- Biomass plants require 1 more employee per shift (4 total) per 50 MMGPY capacity.
- Management & Quality control are estimated as 1/3 of labor, so this expense is higher for biomass use.
- BTU/ gallon needed:
  - 34,000 BTU/gallon for Natural Gas plant
  - 37,000 BTU/gallon for Coal and Biomass plants
- Electricity consumption is 0.20 kWh/gallon lower in a natural gas plant.

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## Details of Expenses (Nicola, 2005)

- Ash disposal for Biomass and Coal plants
  - 5% ash content for coal
  - 7.1% ash content for corn stover
  - \$15/ton disposal ash disposal cost
  - \$80,000 per year for a 50MMGPY coal plant
- Lime Cost
  - \$12,000 per year for 20MMGPY biomass plant
  - \$83,000 per year for 50MMGPY coal plant
- Transportation Cost
  - For coal and biomass

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## Fixed Vs. Variable Costs

Capacity	Natural Gas		Coal		Biomass	
	50	100	50	100	50	100
Variable Costs	1.189	1.189	0.962	0.962	1.039	1.039
Fixed Costs	0.240	0.216	0.300	0.282	0.280	0.259
<b>Total Costs</b>	<b>1.428</b>	<b>1.405</b>	<b>1.262</b>	<b>1.243</b>	<b>1.318</b>	<b>1.298</b>

- (Diego Nicola, M.S. Thesis, University of Minnesota, December 2005.)

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## Modeling the Additional Revenues, Costs for Various Options

- Use EthanolSuccess Spreadsheet and Modified Version.

<http://www.agmrc.org/NR/rdonlyres/4C6BD4-DE-8DA0-44F6-A9AE-02320DBF99F6/0/ethanolsuccess.xls>



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2 Ethanol Dry Mill Spreadsheet		by Douglas G. Tiffany, University of Minnesota			
	Cost/Denat. Gal. Ethanol	Ranges for Column C			Plant Totals
3 7/23/03 20:30					
4 Nameplate Ethanol Prod. (Denat. Gal.)	40,000,000				
5 Investment per Nameplate Gallon	\$1,500	\$1.00-\$2.00			Plant Cost \$ 60,000,000
6 Factor of Nameplate Capacity	1,200%	(80%-150%)			
7 Debt-Equity Assumptions					
8 Factor of Equity	0.40				
9 Factor of Debt	0.60				Initial Debt \$ 36,000,000
10 Interest Rate Charged on Debt	0.07				
11 Rate of Return Req'd. by Investors on Equity	0.12				
12					
13 Conversion Efficiency Assumptions					Annual Production
14 Anhydrous Ethanol Extracted (Gal. per Bu.)	2,750	2.5-2.85 gal/bu		Bushels Ground	Denat. Gallons
15 DDGS per Bushel (lb. per Bu.)	18	15-22 lb./bu		16,581,843	48,000,000
16 CO2 extracted per Bushel (lb. per Bu.)	18	15-22 lb./bu			
17					
18 Establishment of Gross Margin		Price per Unit		Revenue/Bu. Ground	Revenue/Gal. Denatured Ethanol
19 Ethanol Price (denatured price) \$/gal.	\$1.15	\$ .80 to \$1.60		\$3,3289	1,1500 \$ 55,200,000
20 DDGS Price \$/T	\$80.00	\$60-\$120		\$0.7200	0.2487 \$ 11,938,927
21 CO2 Price (\$ per Ton liq. CO2)	\$6.00	\$2-\$12 / liq.Ton		\$0.0540	0.0187 \$ 895,420
22 MN Prod. Subsidy/gal.Denat. Ethanol	\$0.00			\$0.0000	\$ -
23 Federal Small Producer Subsidy					\$ -
24 CCC Bioenergy Credit					\$ -
25 Revenue per Unit				\$4,1029	\$1,4174 \$ 68,036,947
26 Corn Price Paid by Processor (\$ per bu.)	\$2.20	\$1.70-\$3.25		\$2,3000	\$0,7600 \$ 36,480,055
27 Gross Margin				\$1,9029	\$0,6274 \$ 31,554,282
28					

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	Price per Unit	Cost/Bushel Ground	Cost/Gal Denatured Sold	Plant Totals
29 Operating Expenses Per Bushel				
30 Natural Gas Price (\$ 1,000,000 Btu)	\$4.50 (\$1.50-\$0.00/Btu)			
31 LP (Propane) Price (\$ per gallon)	\$0.70 (\$5-\$0.72/gal.)			
32 Factor of Time Operating on Propane	0.02 0-12			
33 BTUs of Heat & Fuel Req./ Denat. Gal.	35,000 28,500-55,000			
34 Combined Heating Cost		\$0.4623	\$0.1597	7,665,569
35 Electricity Price (\$ per kWh)	\$0.05 \$0.025-\$0.090/kwh			
36 Kilowatt Hours Required per Denat. Gal.	1,000 (.85-1.2 kWh/denat. gal.)			
37 Electrical Cost		\$0.1578	\$0.0545	2,616,000
38 Total BTUs of Fuel and Electricity	45,000			
39 Total Energy Cost		\$0.6200	\$0.2142	10,281,569
40	Cost/Denat. Gal. Ethanol			
41 Enzymes	\$0.0480	\$0.1389	\$0.0480	2,304,000
42 Yeasts	\$0.0220	\$0.0637	\$0.0220	1,056,000
43 Other Proc. Chemicals & Antibiotics	\$0.0300	\$0.0579	\$0.0200	960,000
44 Boiler & Cooling Tower Chemicals	\$0.0050	\$0.0145	\$0.0050	240,000
45 Water	\$0.0060 \$0.005-010	\$0.0174	\$0.0060	288,000
46 Denaturant Price per Gal.	\$0.7000	\$0.1013	\$0.0350	1,679,952
47 Total Chemical Cost		\$0.3837	\$0.1368	6,527,952
48				
49 Depreciation based on C49 asset life	15 Years	\$0.2412	\$0.0833	4,000,000
50 Maintenance & Repairs	\$0.0125	\$0.0362	\$0.0125	600,000
51 Interest Expense		\$0.1520	\$0.0525	2,520,000
52 Labor	\$0.0450 \$0.04-\$0.06	\$0.1303	\$0.0450	2,160,000
53 Management & Quality Control	\$0.0136 \$0.010-\$0.022	\$0.0384	\$0.0136	652,800
54 Real Estate Taxes	\$0.0020	\$0.0058	\$0.0020	96,000
55 Licenses, Fees & Insurance	\$0.0040 0030-0050	\$0.0116	\$0.0040	192,000
56 Miscellaneous Expenses	\$0.0135 \$0.01-\$0.03	\$0.0391	\$0.0135	648,000
57 Total of Other Processing Costs		\$0.6555	\$0.2264	10,868,800
58 Total Processing Costs		\$1.6692	\$0.5768	27,678,321
59 Net Margin Achieved Per Unit		\$0.2337	\$0.8607	3,875,971
60 Farmer-Investor Req'd. Return on Equity	12.00%	\$0.1737	\$0.0600	2,880,000
61 Increment of Success/Failure to Meet Required Return		\$0.0601	\$0.0207	995,971
62				
63 Ethanol Plant Profits for Shareholders and Principal Reduction		\$3,875,971	\$3,875,971	3,875,971

## Preliminary Results

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### Annual Changes: Costs or Returns in \$Million before Capital and Operating Costs with Biomass

Natural Gas Price \$/DekaTherm	DDGS Price of \$73.00 per Ton					
	PH <sup>2</sup>	CHP-10% <sup>3</sup>	CHPG-20% <sup>4</sup>		CHPG-30% <sup>5</sup>	
			3¢/kWh	4.5¢/kWh	3¢/kWh	4.5¢/kWh
\$6.33	\$3.30	\$4.80	\$5.60	\$6.40	\$6.60	\$8.60
\$7.39	\$4.90	\$6.40	\$7.20	\$8.10	\$8.20	\$10.20
\$8.44	\$6.50	\$8.00	\$8.80	\$9.70	\$9.90	\$11.80
\$9.50	\$8.20	\$9.60	\$10.50	\$11.30	\$11.50	\$13.40
\$10.55	\$9.80	\$11.30	\$12.10	\$13.00	\$13.10	\$15.10

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### Biomass Needed, Net Energy Values, and Renewable Energy Ratios for Ethanol Technologies

Technology	Elect. Energy Prod., (kWh/gal)	100% DDGS			100% Stover		
		Amount <sup>1</sup> (lb/bu)	Net energy value (Btu/gal)	Energy ratio <sup>2</sup>	Amount <sup>2</sup> (lb/bu)	Net energy value (Btu/gal)	Energy ratio <sup>3</sup>
Current - Natural Gas	0	0	33,196	1.48	0	33,196	1.48
Biomass - Process heat only (PH)	0	12.2	49,408	2.42	15.5	65,902	2.79
Biomass - CHP-10% <sup>4</sup>	1.09	13.5	59,841	3.66	17.2	78,104	4.16
Biomass - CHPG-20% <sup>4,5</sup>	2.54	15.3	71,358	4.17	19.4	91,976	4.68
Biomass - CHPG-30% <sup>4</sup>	4.36	17.5	85,761	4.81	22.1	109,324	5.31

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## Thanks!!

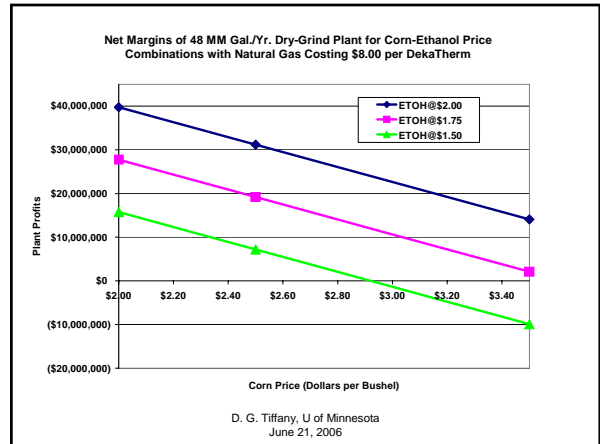
Please Check our Website for Further Information.

### BIOMASS FOR ELECTRICITY AND PROCESS HEAT AT ETHANOL PLANTS

- <http://www.biomassCHPethanol.umn.edu>

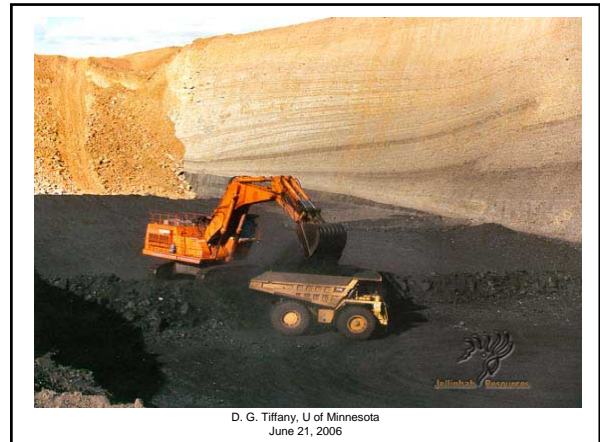
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## Data Sources

Input	Data	Source	Other Source
BTU per ton of Coal	17.6 million	UPRR	
BTU per pound of Corn Stover	6,500	Sebesta (15% moist.)	AURI 7,057 (9.14% moist)
BTU per pound of DDGS	8,396	Sebesta	AURI 8,459 (9.27% moist)
BTU per pound of Shelled Corn	6,924	AURI (13% moist.)	
Ash content of coal	5%	Average of PRB	
Ash content of Corn Stover	6.8	AURI	
Ash content of DDGS	4.20%	AURI	range 3.7 - 4.6 %
Ash content of Shelled Corn	1.13%	AURI	

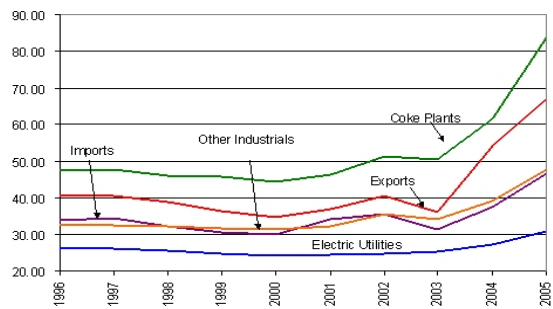
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## U.S. Delivered Coal Prices 1996-2005

Source: EIA



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