Economics of Expanding Biofuel Production in the Upper Midwest

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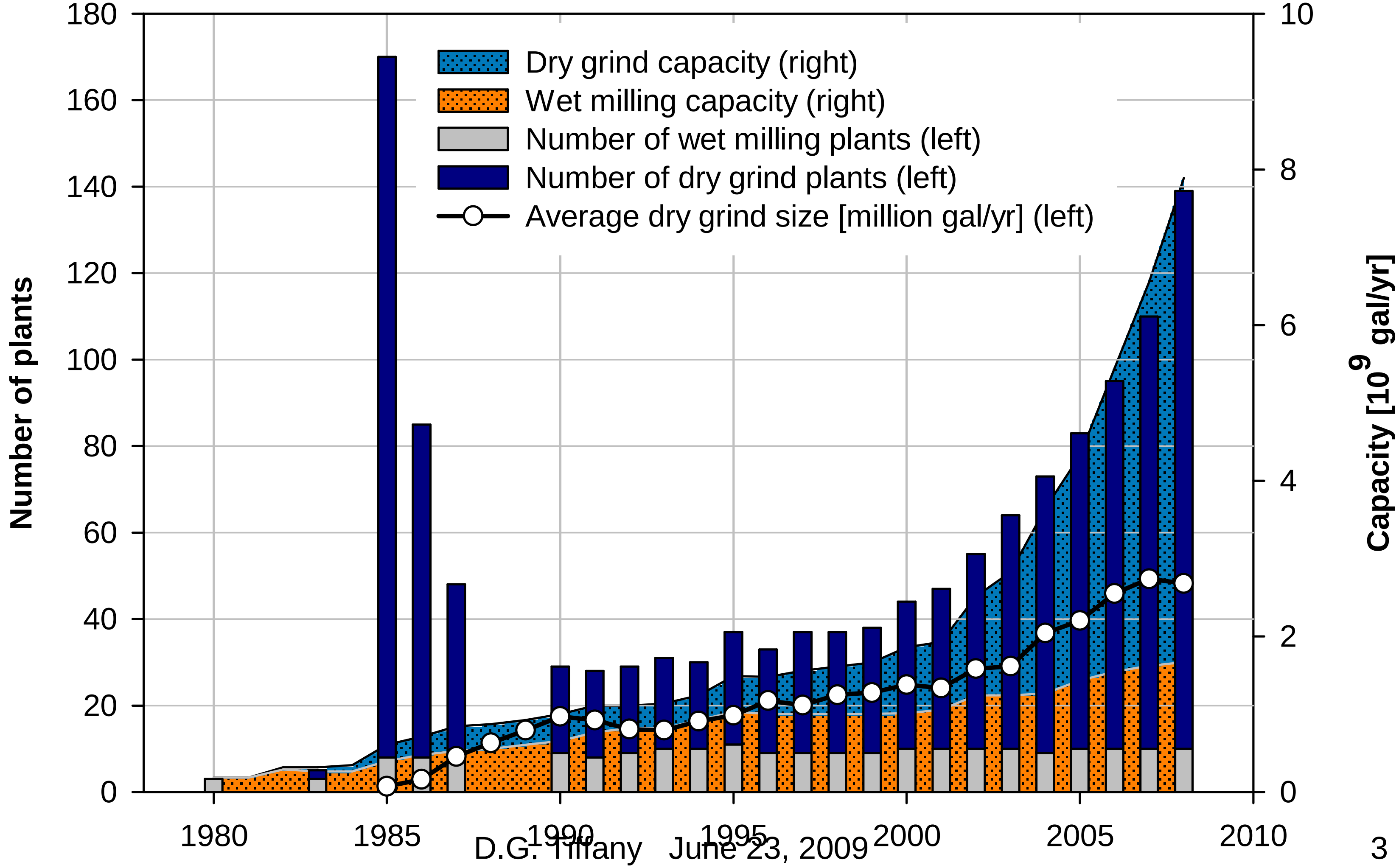
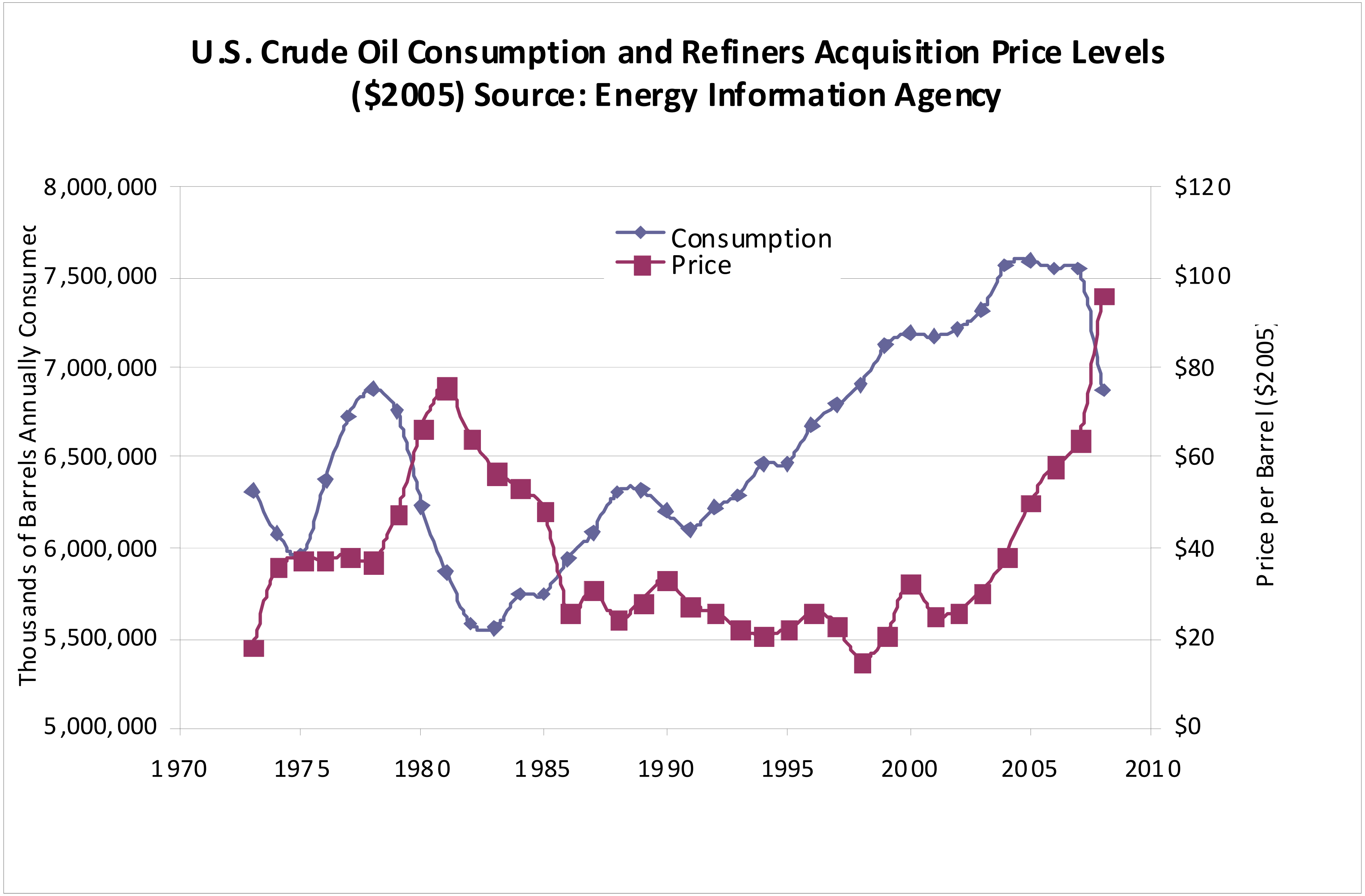
Today's Topics

- Review history of firm failures
- Consider Challenges of Advanced Biofuels
- Current densification & logistics of Stover
- On-going research using IGCC to produce even more electricity for sale to grid

In Remembrance of Numerous Small Dry-Grind Ethanol Plants in the mid 1980's

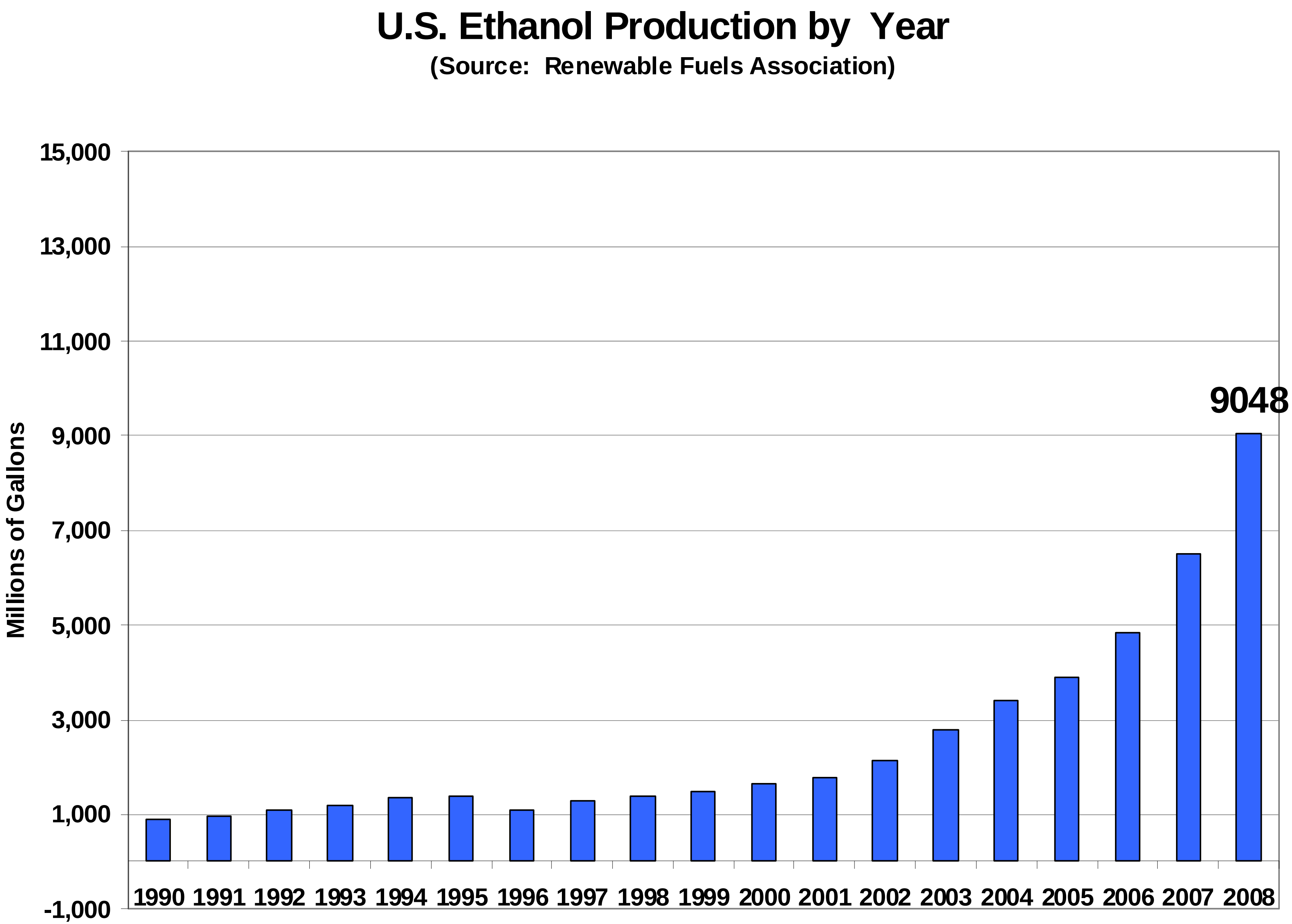


Historical View: Crude Oil Prices and Use



Other Troubling Attributes

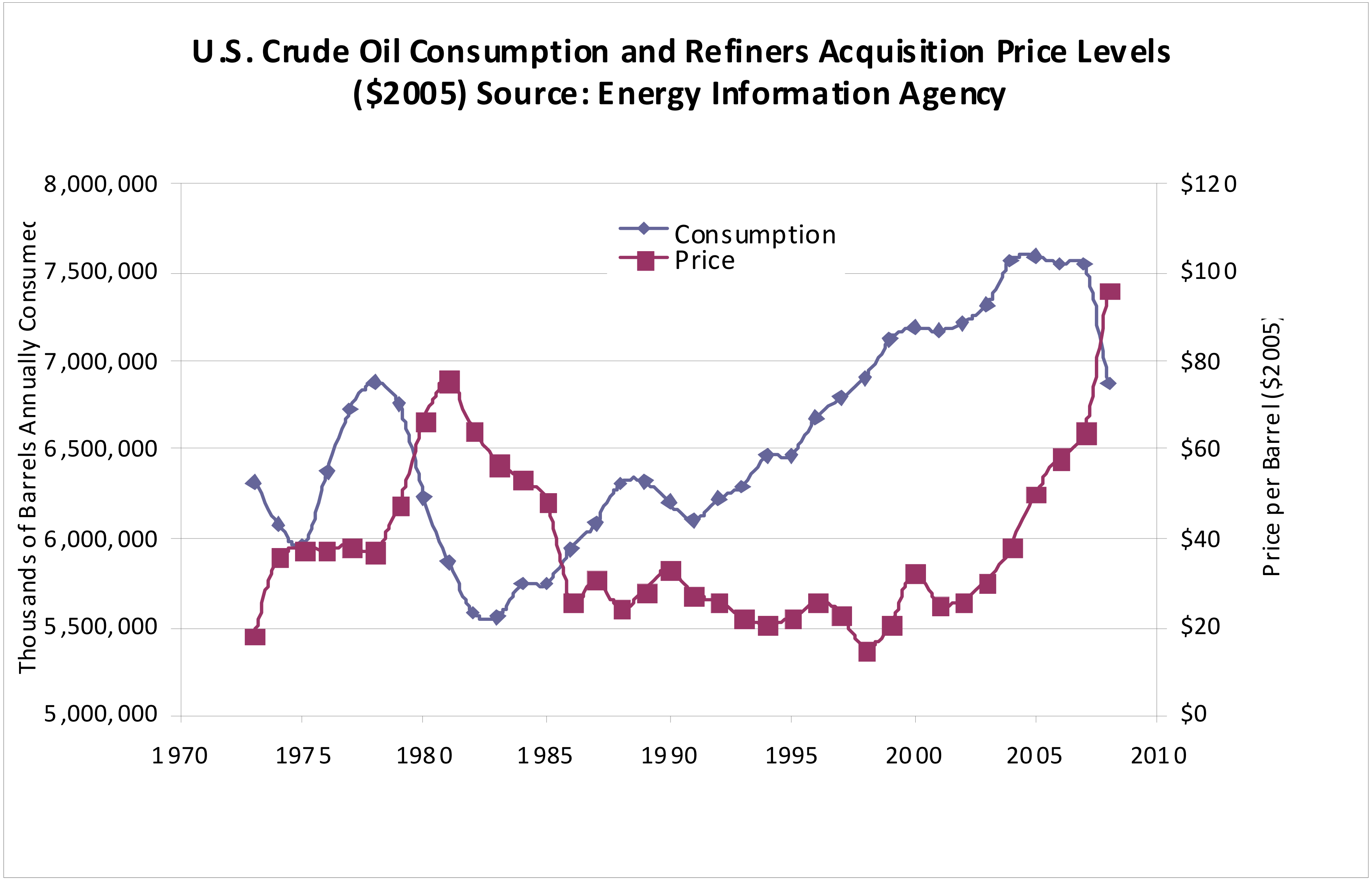
- Too small for acceptable process controls
- Poor operator safely
- Poor utilization of by-products
- Insufficient capital to improve and control process
- Bankers were uninterested in financing "stills on the hills."


U.S. Ethanol Production by Year
(Source: Renewable Fuels Association)
Millions of Gallons
15,000
13,000
11,000
9,000
7,000
5,000
3,000
1,000
-1,000
9048
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008

In the 1990's

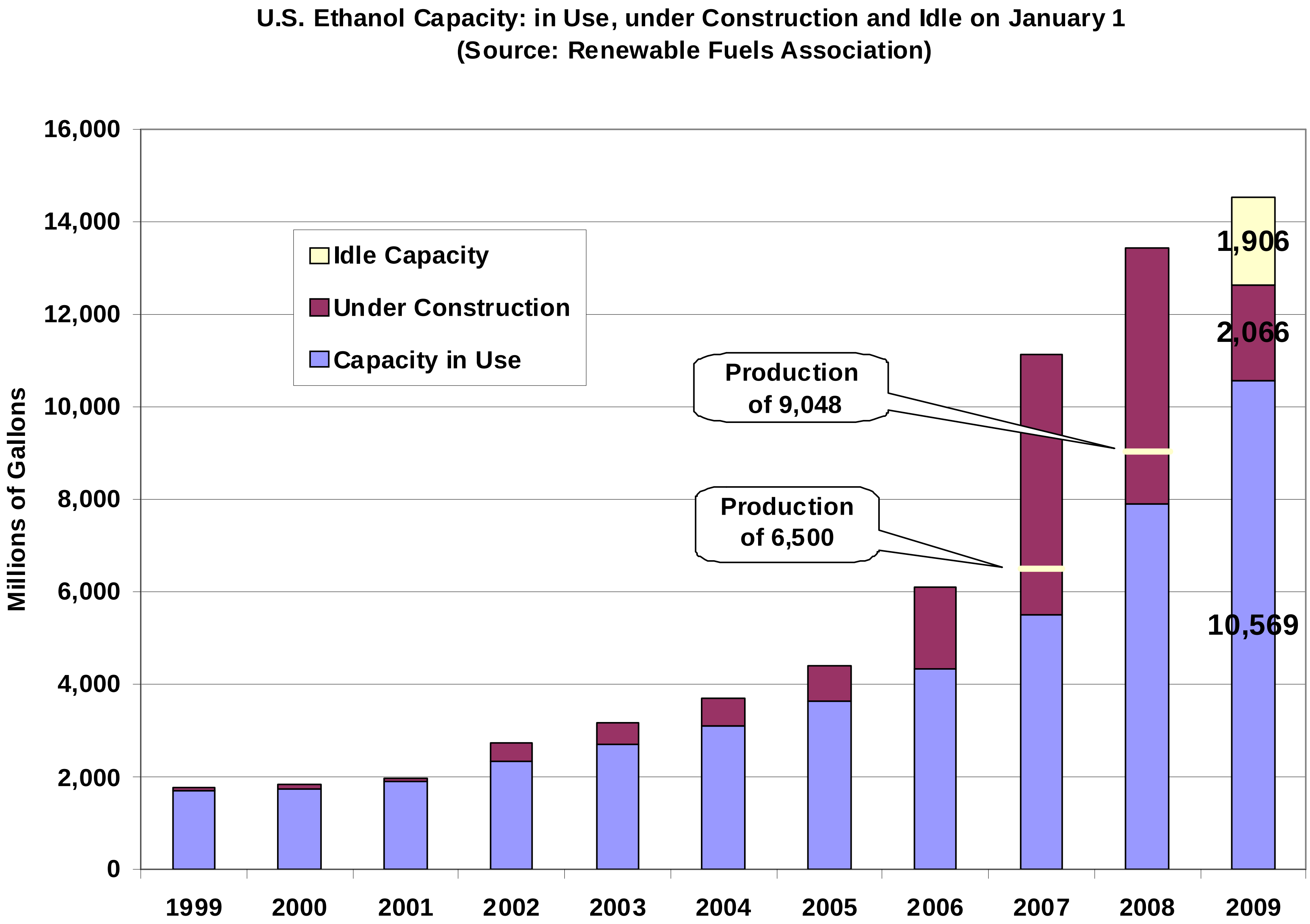
- More favorable economies of scale were realized.
- Mandated markets- 1990 Clean Air Act and state measures established a base.
- Better business models emerged (LLCs)
- Farmers were highly motivated to invest in value-added enterprises.
- State incentives put bankers at ease.
- Rising crude oil prices helped industry from 1993 on.

Historical View: Crude Oil Prices and Use



Since 2000

- Crude Oil price increases continue
- VEETC and tariff on imports protect domestic producers.
- MTBE is banned by many states and loses liability protection as an oxygenate.
- Hurricane Katrina contributed to cheap corn, higher energy prices for late 2005-2006.
- Publicity battles for industry
  - Blamed for Food Costs Rises
  - Indirect Land Use Change
  - Unrecognized Value in Reducing Price of Gasoline


U.S. Ethanol Capacity: in Use, under Construction and Idle on January 1
(Source: Renewable Fuels Association)
Millions of Gallons
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Idle Capacity
Under Construction
Capacity in Use
Production of 9,048
Production of 6,500
1,906
2,066
10,569
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

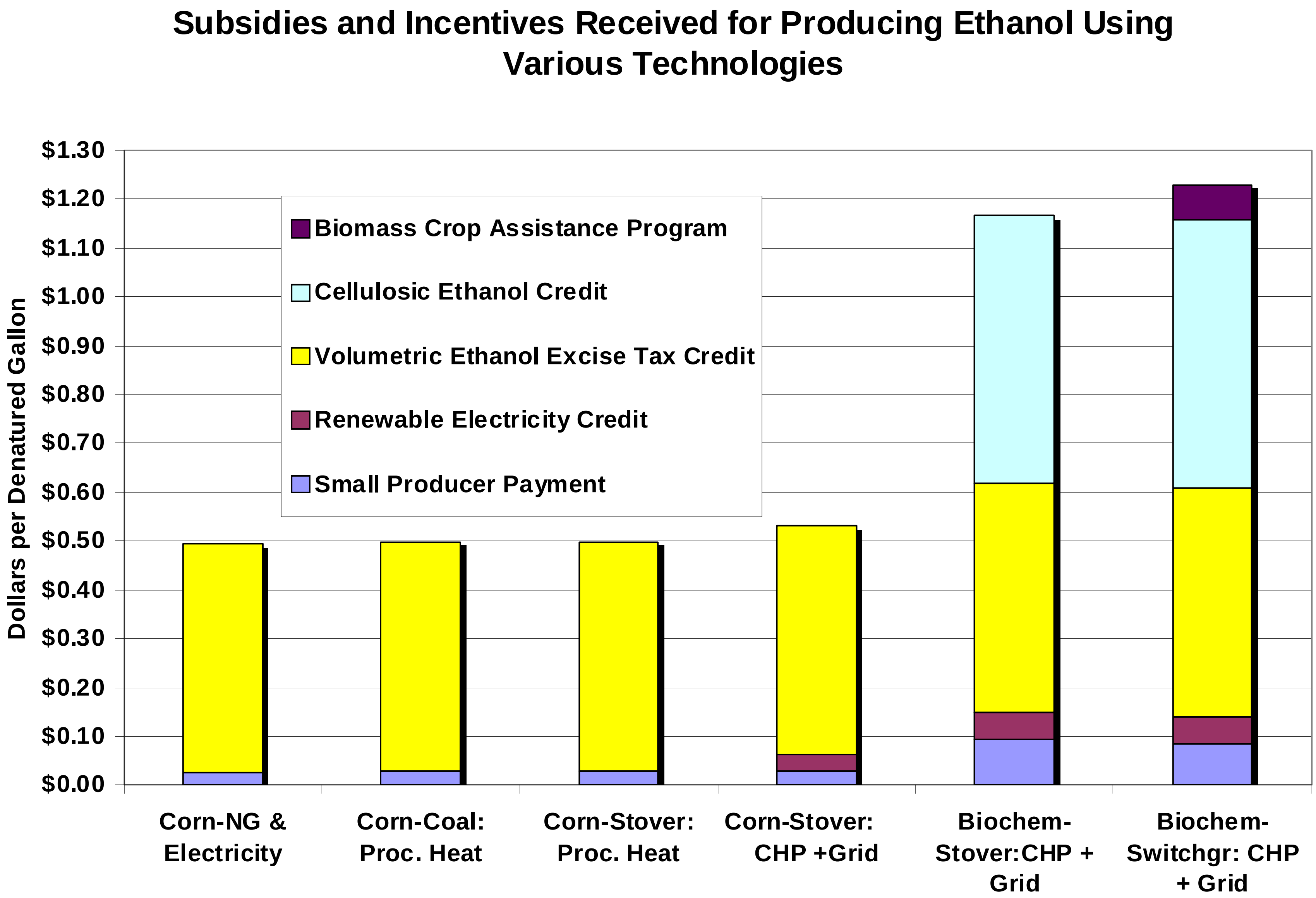
Considering Advanced Biofuels

- Avoid "blend wall" by drop-in fuels
  - Dimethyl ether
  - Biobutanol

  (Avoid issues with Reid Vapor Point)
- At this time there are tougher technical issues with biochemical and thermochemical ethanol production.
  - R & D situations are not as well-suited to farmer-investors as established processes.

Technical and Economic Issues

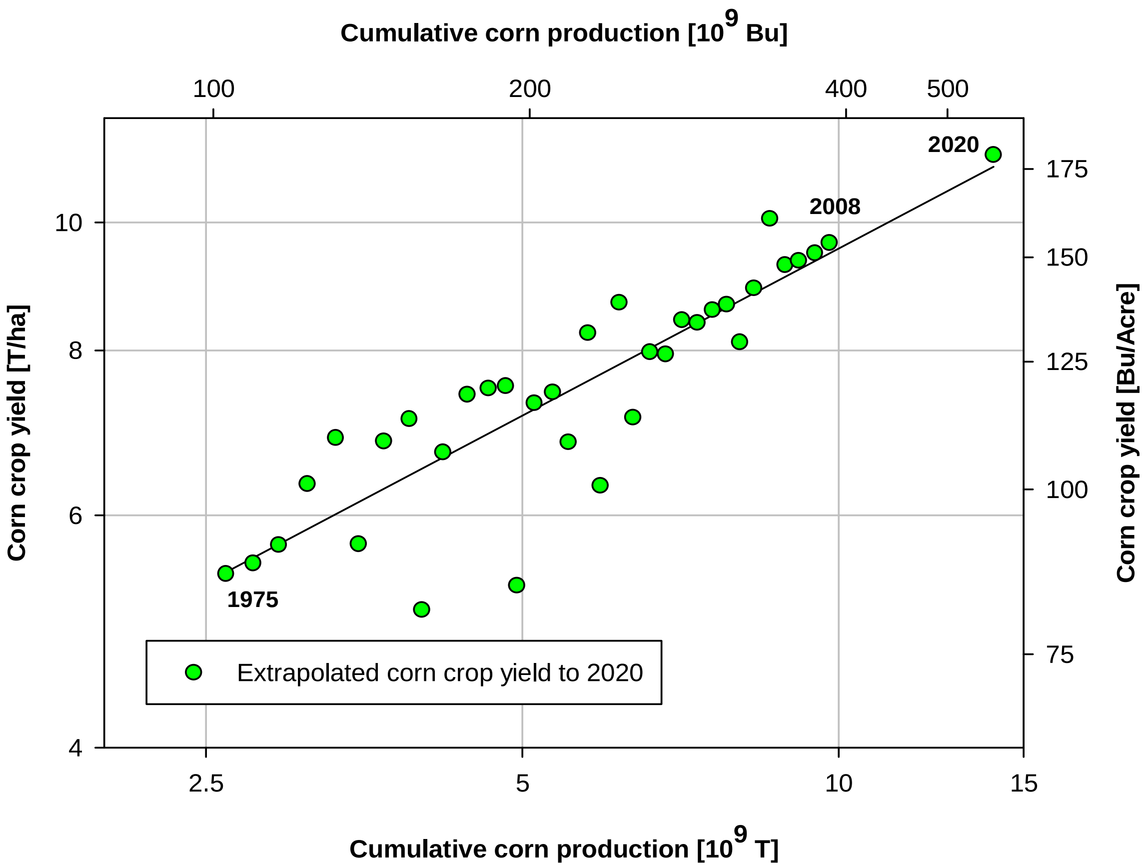
- Pretreatments and organisms are often incompatible
- State of Technology estimates represent "dream team" yields.
- Over-optimism for "cheap feedstocks."
- Biomass feedstocks lack
  - Market grades
  - Opportunities to hedge
  - Market middlemen for procurement


Subsidies and Incentives Received for Producing Ethanol Using Various Technologies
$1.30
$1.20
$1.10
$1.00
$0.90
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Dollars per Denatured Gallon
Biomass Crop Assistance Program
Cellulosic Ethanol Credit
Volumetric Ethanol Excise Tax Credit
Renewable Electricity Credit
Small Producer Payment
Corn-NG & Electricity
Corn-Coal: Proc. Heat
Corn-Stover: Proc. Heat
Corn-Stover: CHP +Grid
Biochem-Stover:CHP + Grid
Biochem-Switchgr: CHP + Grid

Advanced Biofuels Face Competition from Corn

Corn dry-grind plants can be vastly improved w/ less tech. & operational risk.

Corn Crop Yield Learning Curve

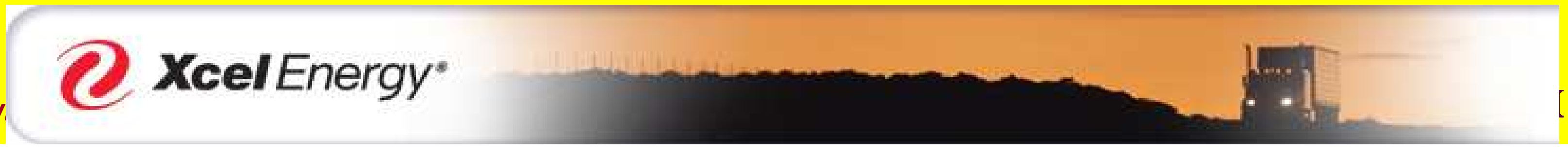


Project Objectives

Determine Technical Feasibility of Using Biomass to Provide Process Heat and Electricity at Ethanol Plants

Determine Economic Sensitivity of Using Biomass with Appropriate Technologies under Various Economic Conditions

www.biomassCHPethanol.umn.edu



Biomass Fuel for Dry-Grind Plants

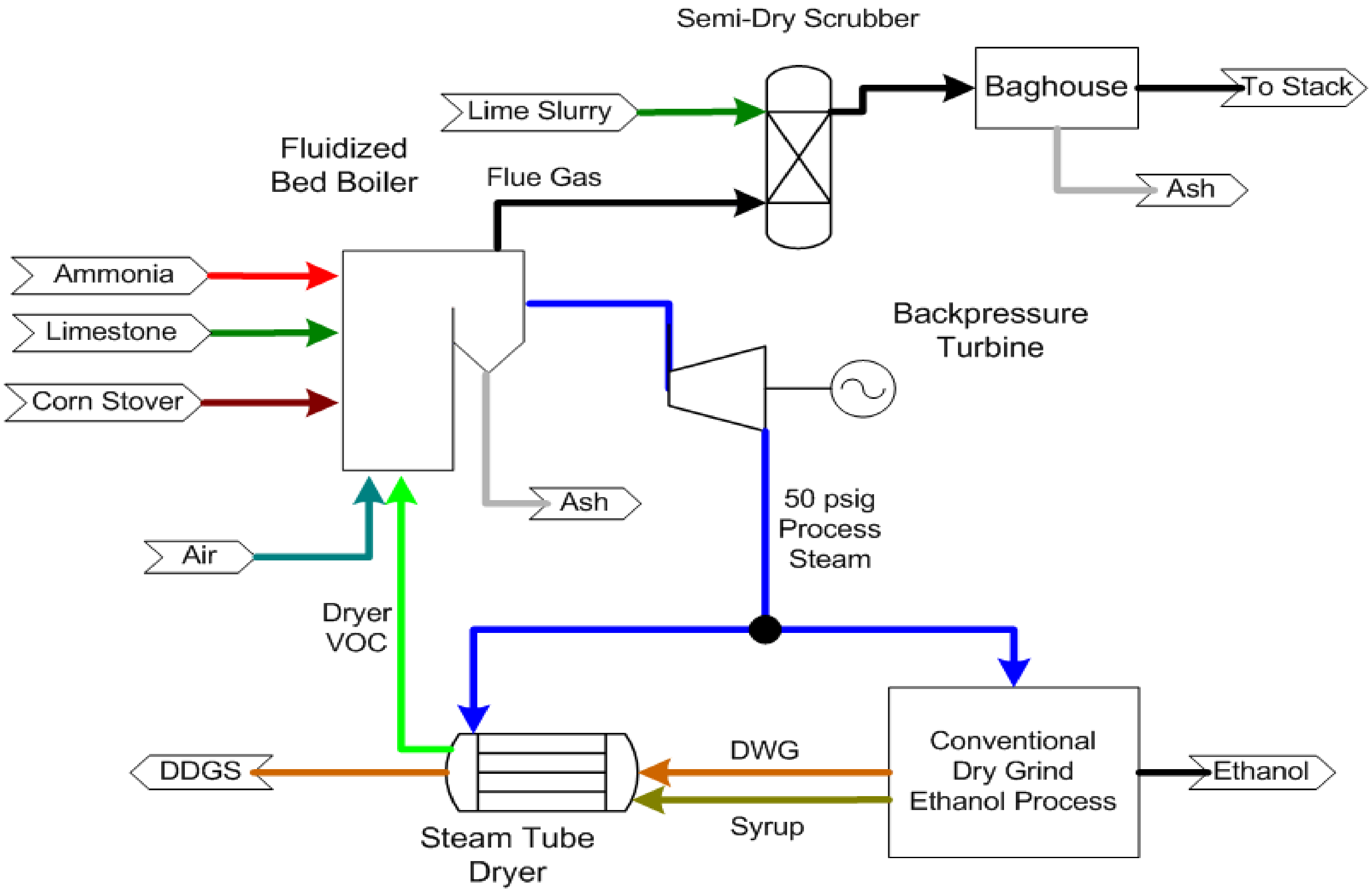
- Reduce energy costs, Improve ROI--$$$
- Generate reliable power for the grid
- Improve Renewable Energy Ratio
  - – Defined as: Energy Out / Fossil Energy In
- Lower the overall greenhouse gas emissions from ethanol production

3 Biomass Fuels and 3 Levels of Intensity of Use

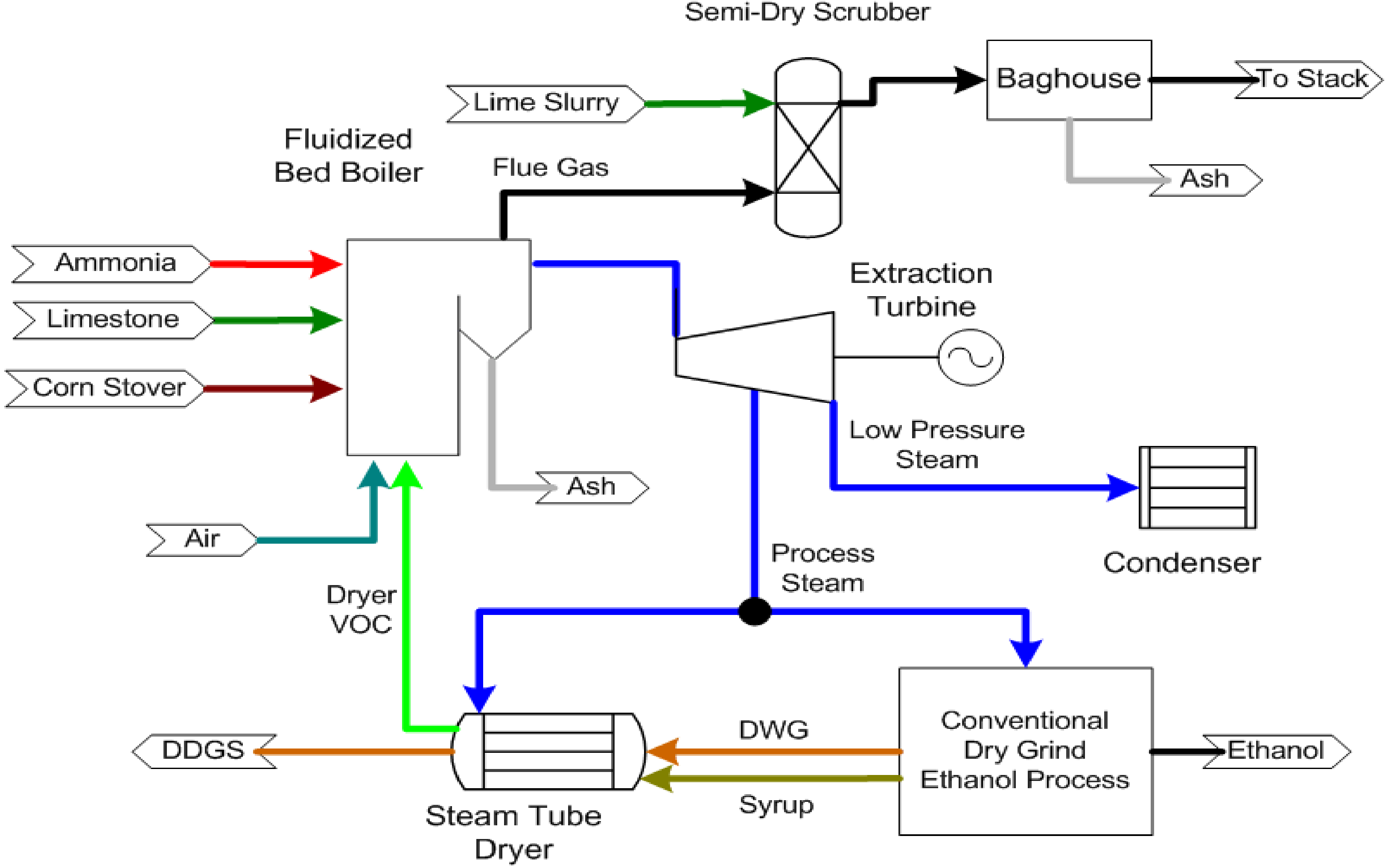
- **Corn Stover Combusted in Fluidized Bed**
- **DDGS Gasified in Fluidized Bed**
- **Syrup + Stover Combusted in Fluidized Bed**

- **Process Heat**
- **Combined Heat and Power (CHP)**
- **CHP + Sales of Power to the Grid**

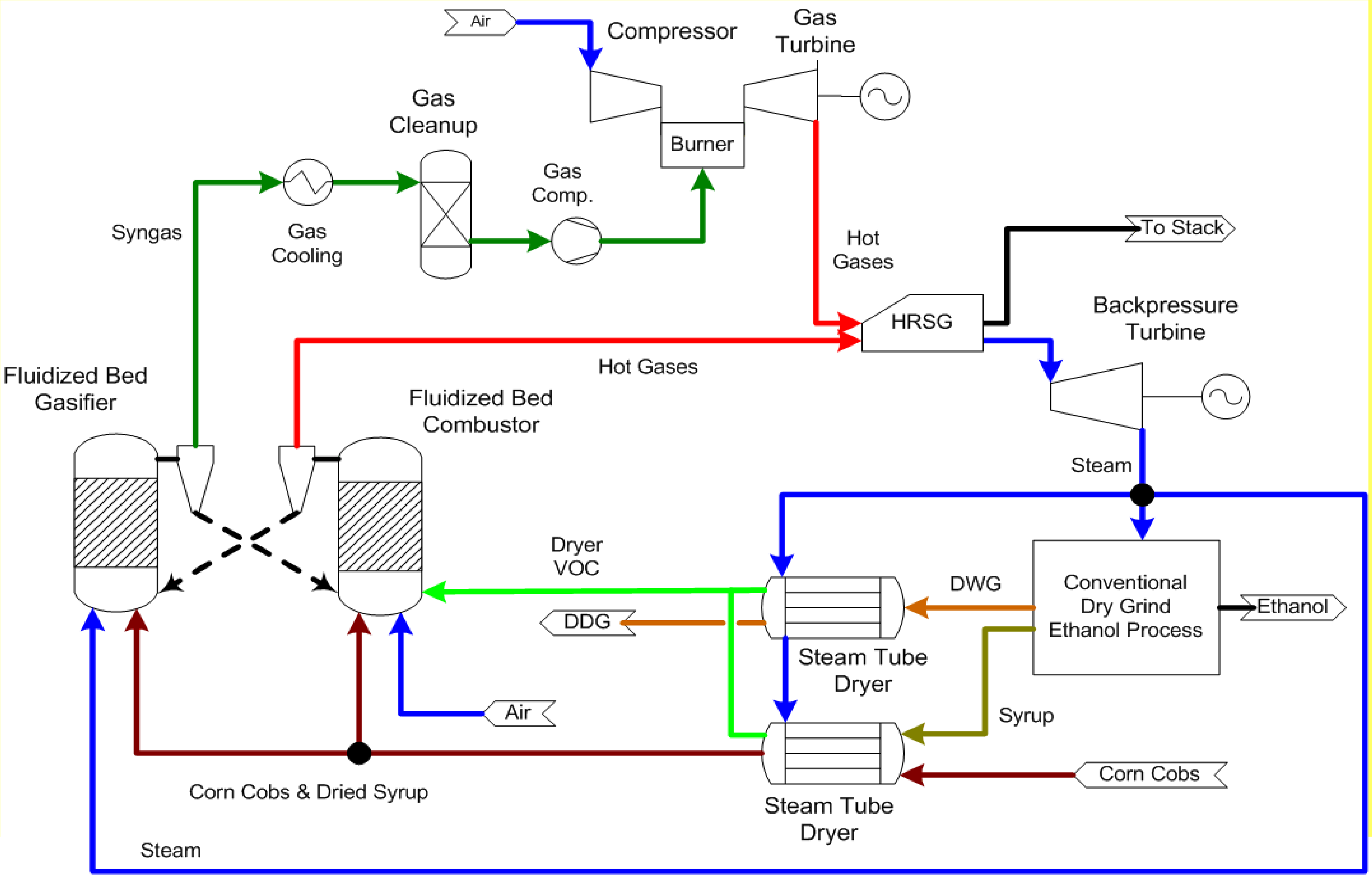
Corn Stover Combustion, Level 2: CHP

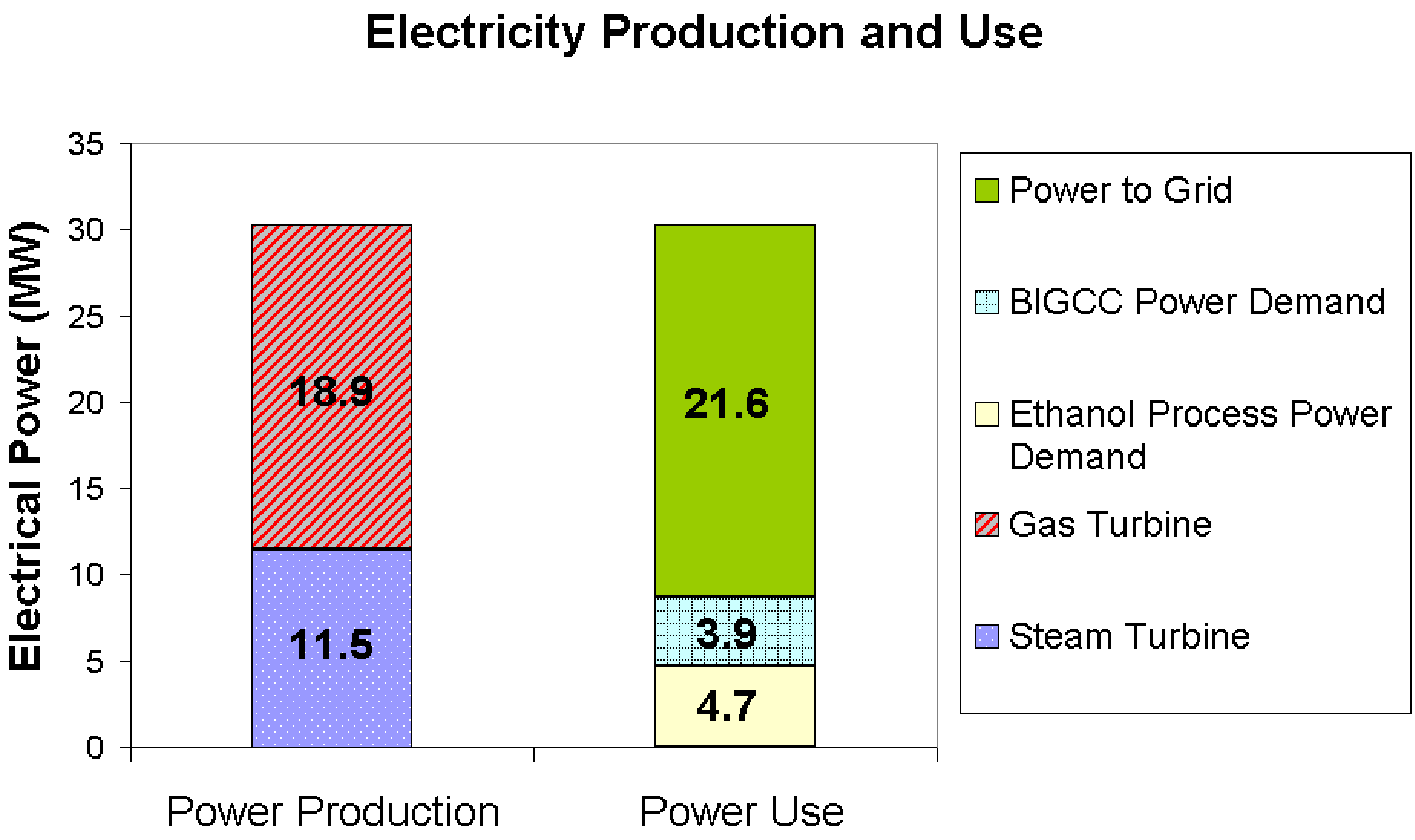


Corn Stover Combustion, Level 3: CHP + Grid



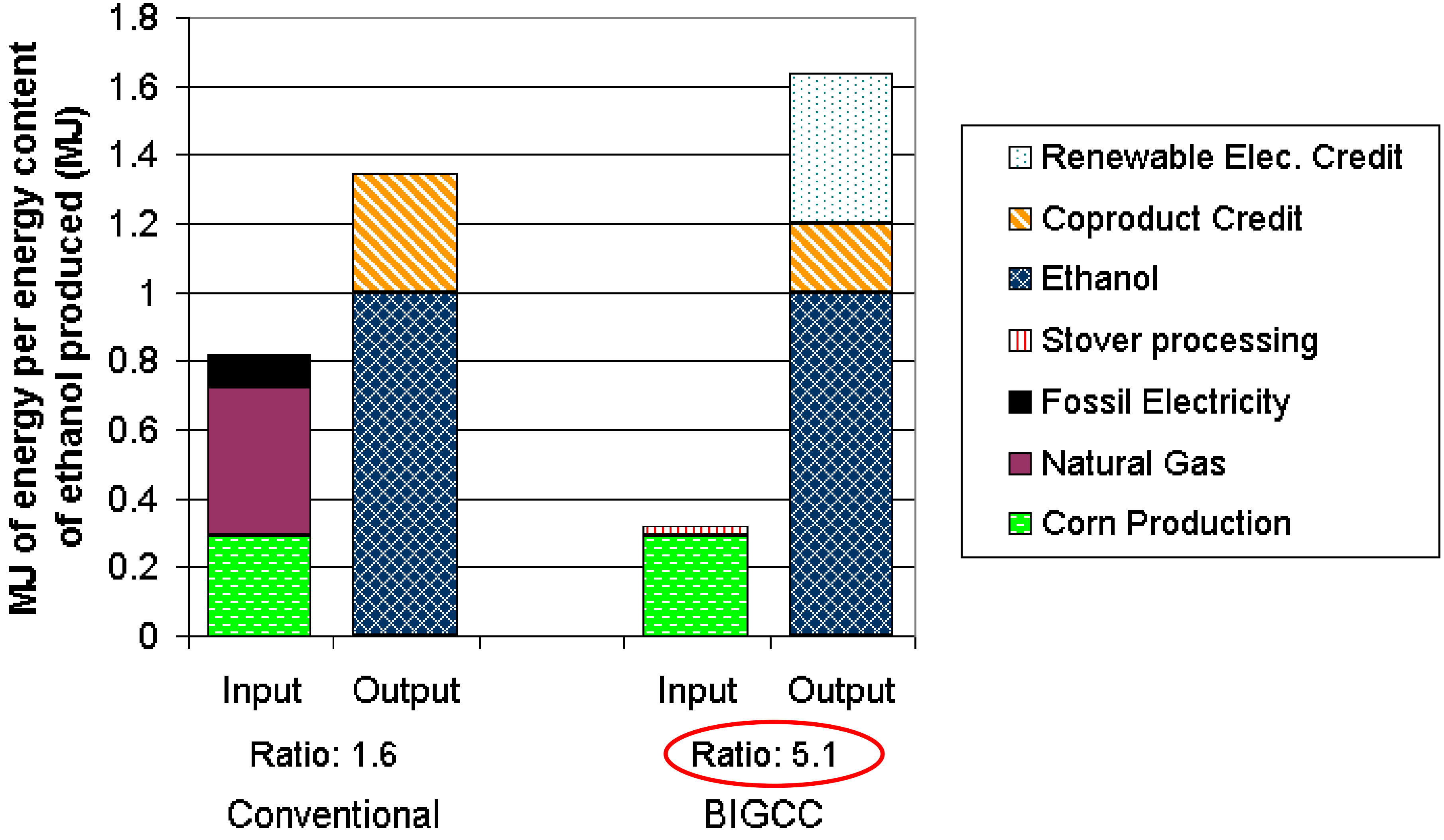
Integrated Gasification Combined Cycle (FERCO SilvaGas™ Process)





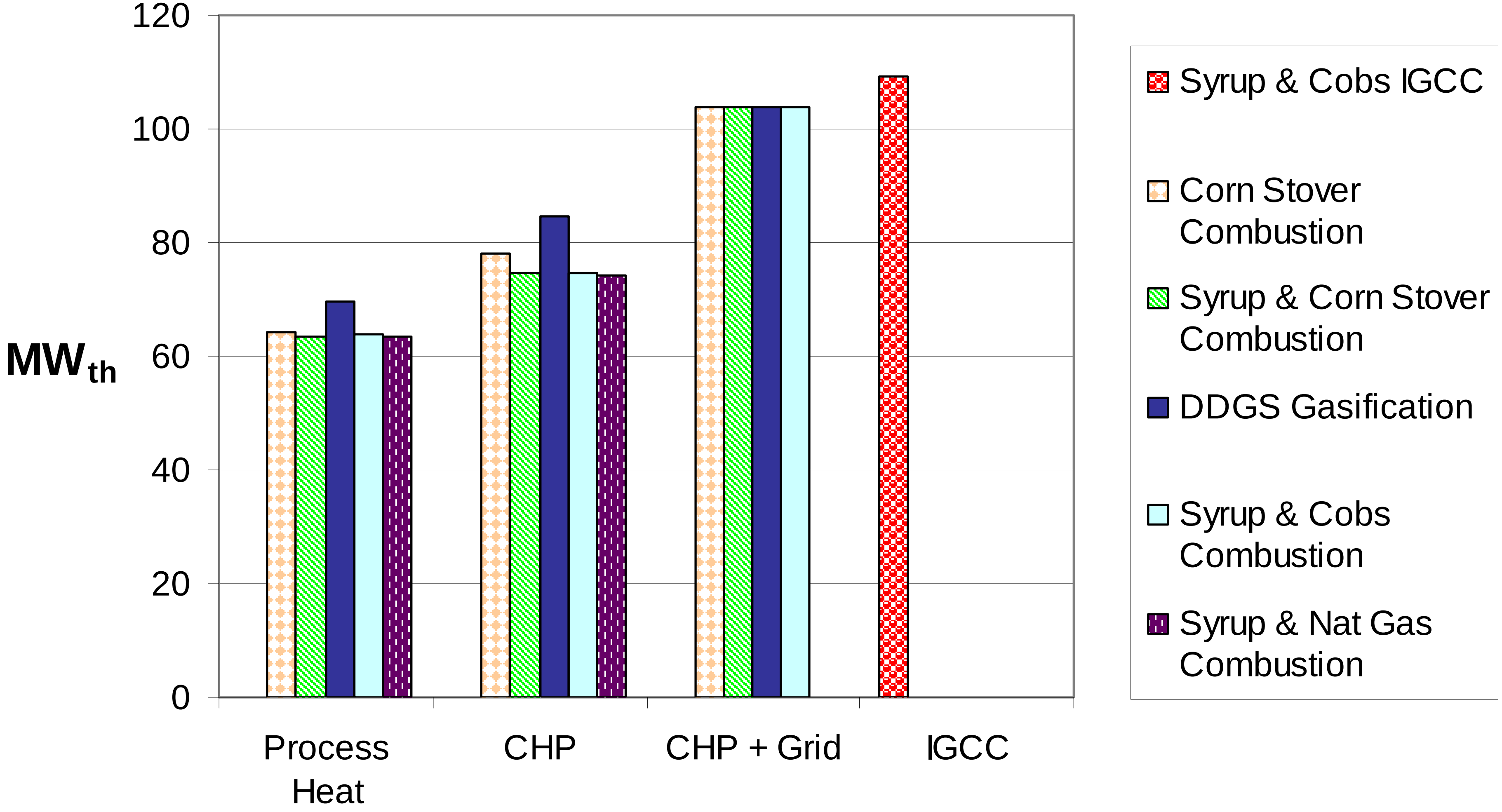
190 million liter (50 MMgal) per year ethanol facility

Energy Balance

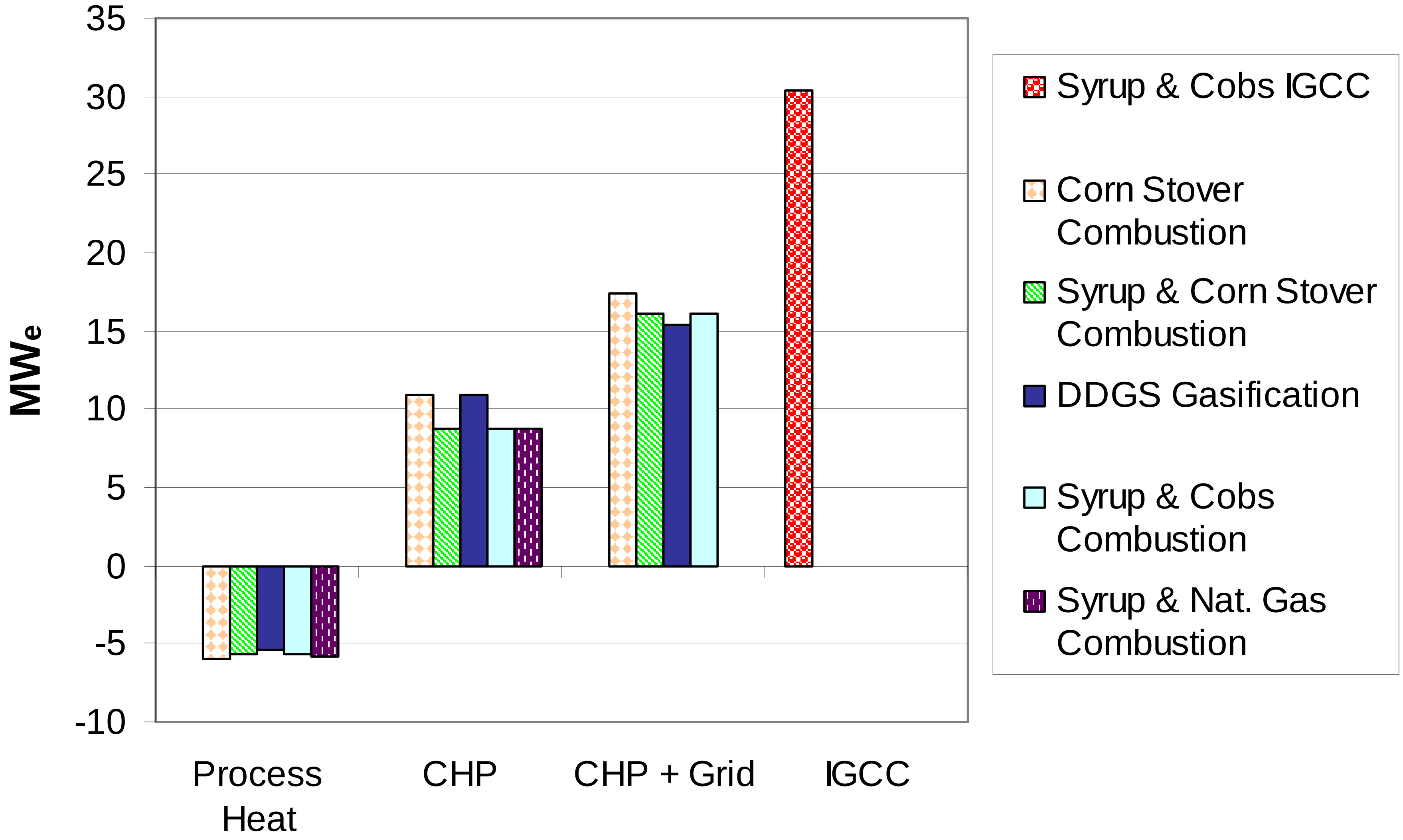


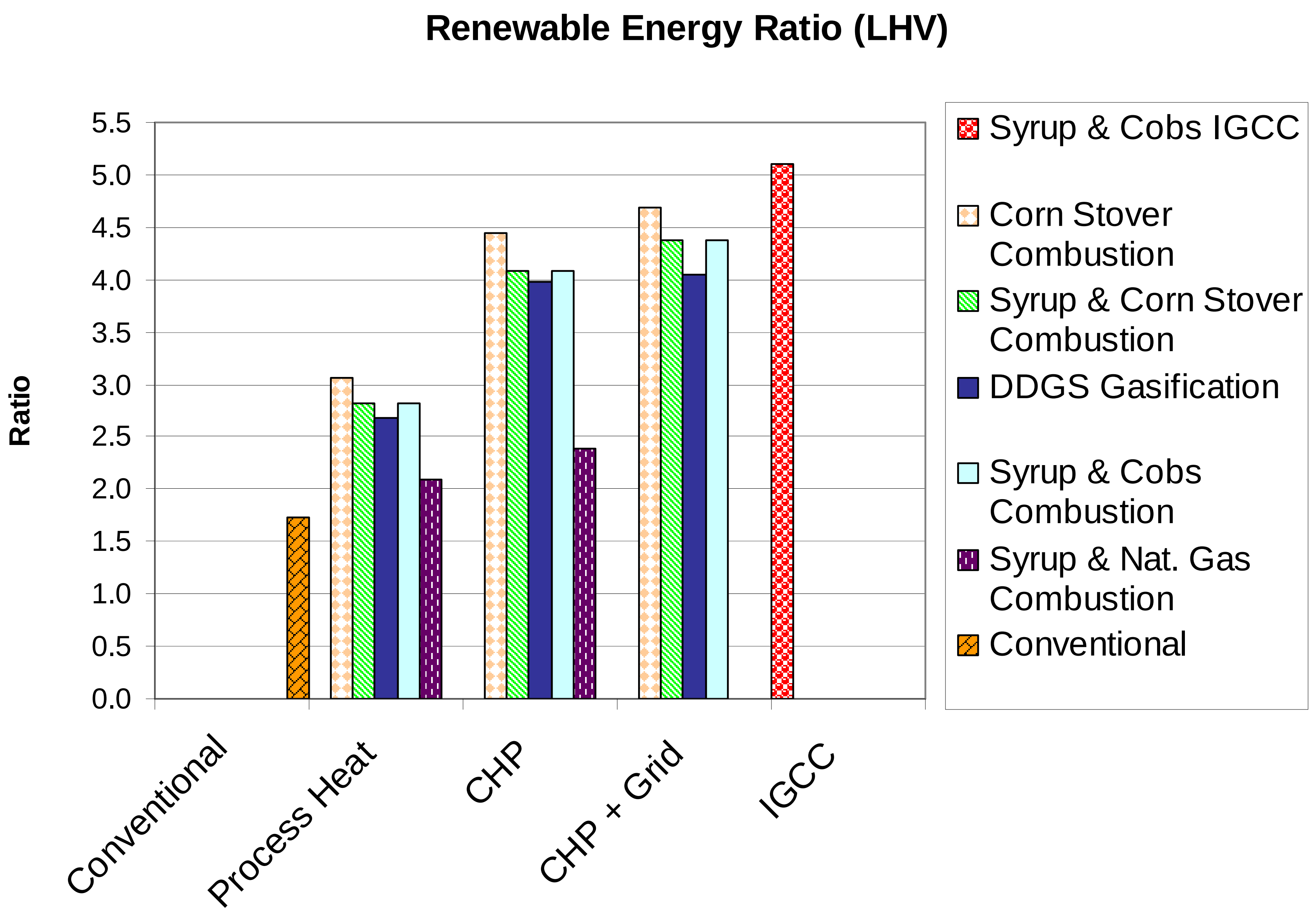
Fuel Energy Input Rate

190 ML/yr ethanol facility



Gross Electricity Generation (and Use)

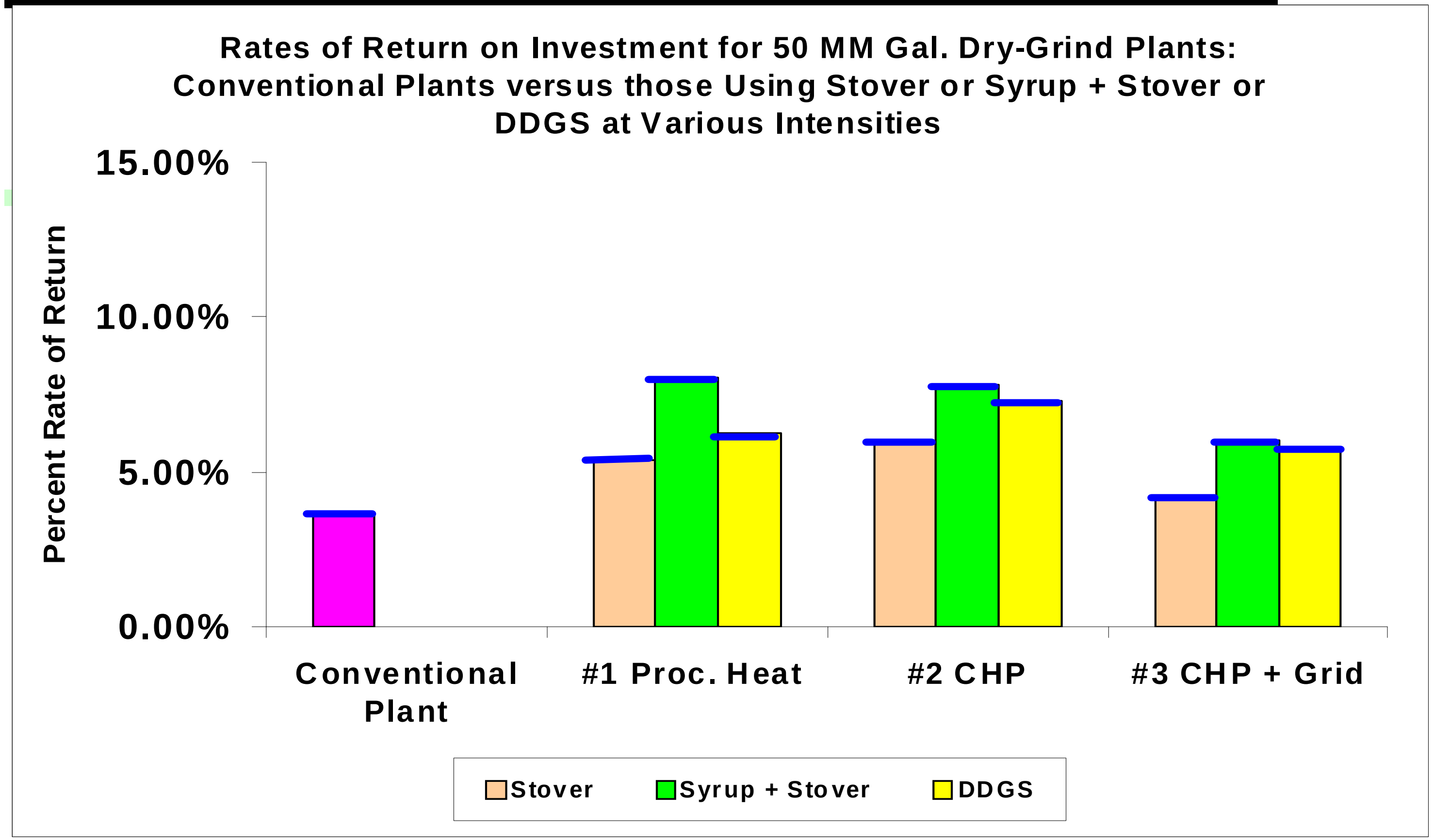




Renewable Energy Ratio (LHV)
Ratio
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Conventional
Process Heat
CHP
CHP + Grid
IGCC
Syrup & Cobs IGCC
Corn Stover Combustion
Syrup & Corn Stover Combustion
DDGS Gasification
Syrup & Cobs Combustion
Syrup & Nat. Gas Combustion
Conventional

Baseline ROR's for 50 MM Gallon Plant

Conventional Plant	#1 Proc. Heat	#2 CHP	#3 CHP + Grid		50MM Gal
3.66%	5.40%	5.97%	4.21%	Stover	
	8.04%	7.80%	6.05%	Syrup + Stover	
	6.25%	7.28%	5.79%	DDGS	



Use of Biomass at Ethanol Plants

- **<u>Technically feasible</u>** and **<u>fiscally prudent</u>**, especially when policies favoring low carbon fuel standards are adopted.
- **<u>Improves energy balance</u>** and **<u>drastically reduces the carbon footprint</u>** of ethanol produced from corn.
- Each 1 Billion gallons of ethanol capacity can produce 300 MWe for the grid, probably 450 MWe for IGCC.
- Use of biomass as a fuel at ethanol plants can be a **<u>bridge technology</u>** to other technologies for biofuels production.

Stover Harvest, Densification &Transport to Plant

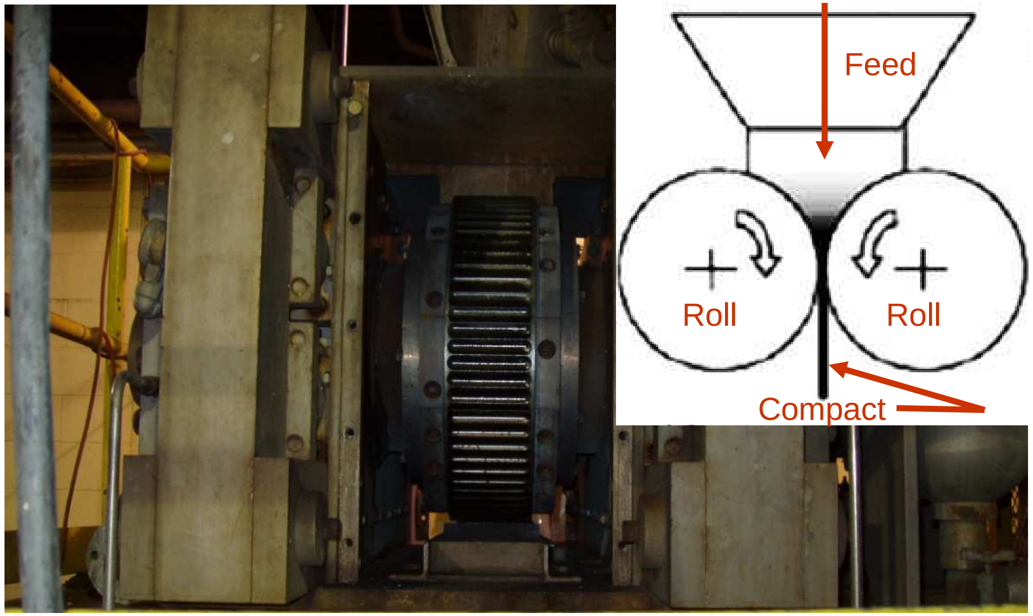
Agricultural –
One harvest per year

Industrial –
Requires supply throughout the year

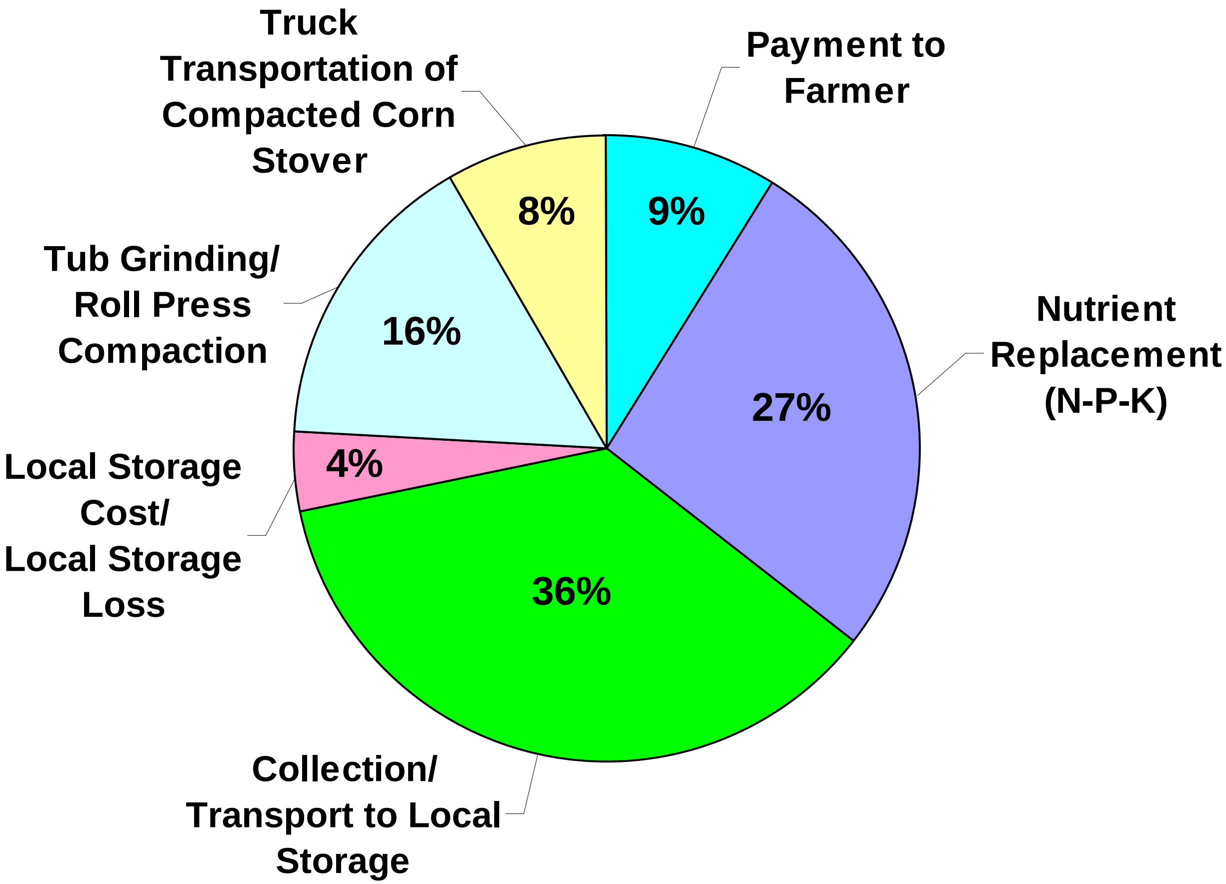
Harvesting/Local Storage

- Major participation from Nalladurai Kaliyan and David Schmidt occurred on the densification and logistics aspects of this research.

Tub-Grinding/Roll-Press Compaction



Total Cost

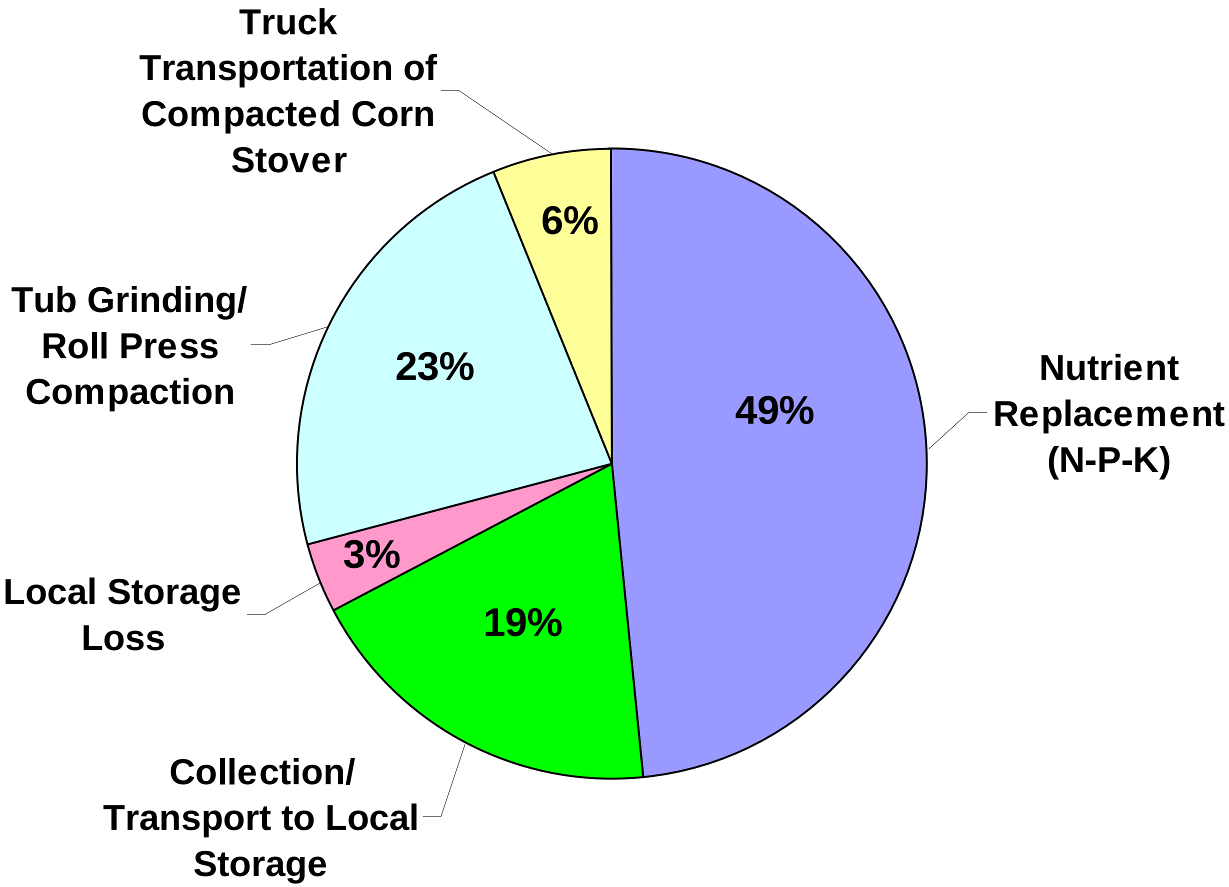


$77/ton of corn stover delivered (MC = 15% w.b.)

History of Fertilizer Prices

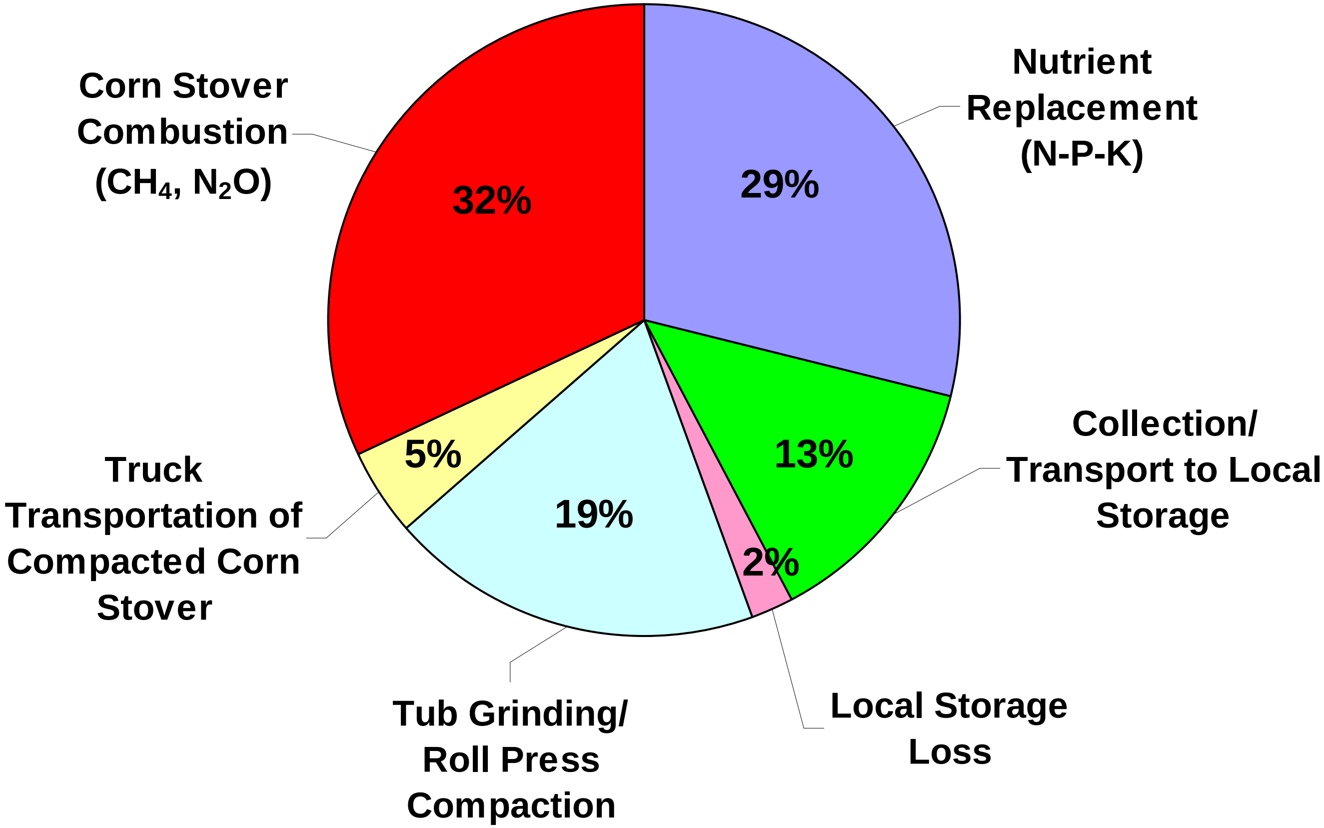
Fertilizer Prices (Source: Meadowlands Cooperative June 10, 2009)				
		Prices per Ton of Product		
	Analysis	**Jun-08**	**Jun-09**	**Fall App. 2009**
Anhydrous Ammonia	82-0-0	$ 870.00	$ 691.98	$ 435.00
Urea	46-0-0	$ 460.00	$ 480.00	$ 305.00
Potash (K2O)	0-0-60	$ 670.00	$ 649.97	$ 683.00
Diammonium Phosphate	18-46-0	$ 865.00	$ 629.85	$ 351.00
		Prices per Ton of Major Nutrient		
Price per lb. of Nitrogen	Anhydrous Ammonia	$ 0.5305	$ 0.4219	$ 0.2652
Price per lb. of Nitrogen	Urea	$ 0.5000	$ 0.5217	$ 0.3315
Price per lb. of K	Potash (K2O)	$ 0.5583	$ 0.5416	$ 0.5692
Price per lb. of P2O5	Diammonium Phosphate	$ 0.9207	$ 0.6642	$ 0.3685

Life-Cycle Fossil Energy Consumption



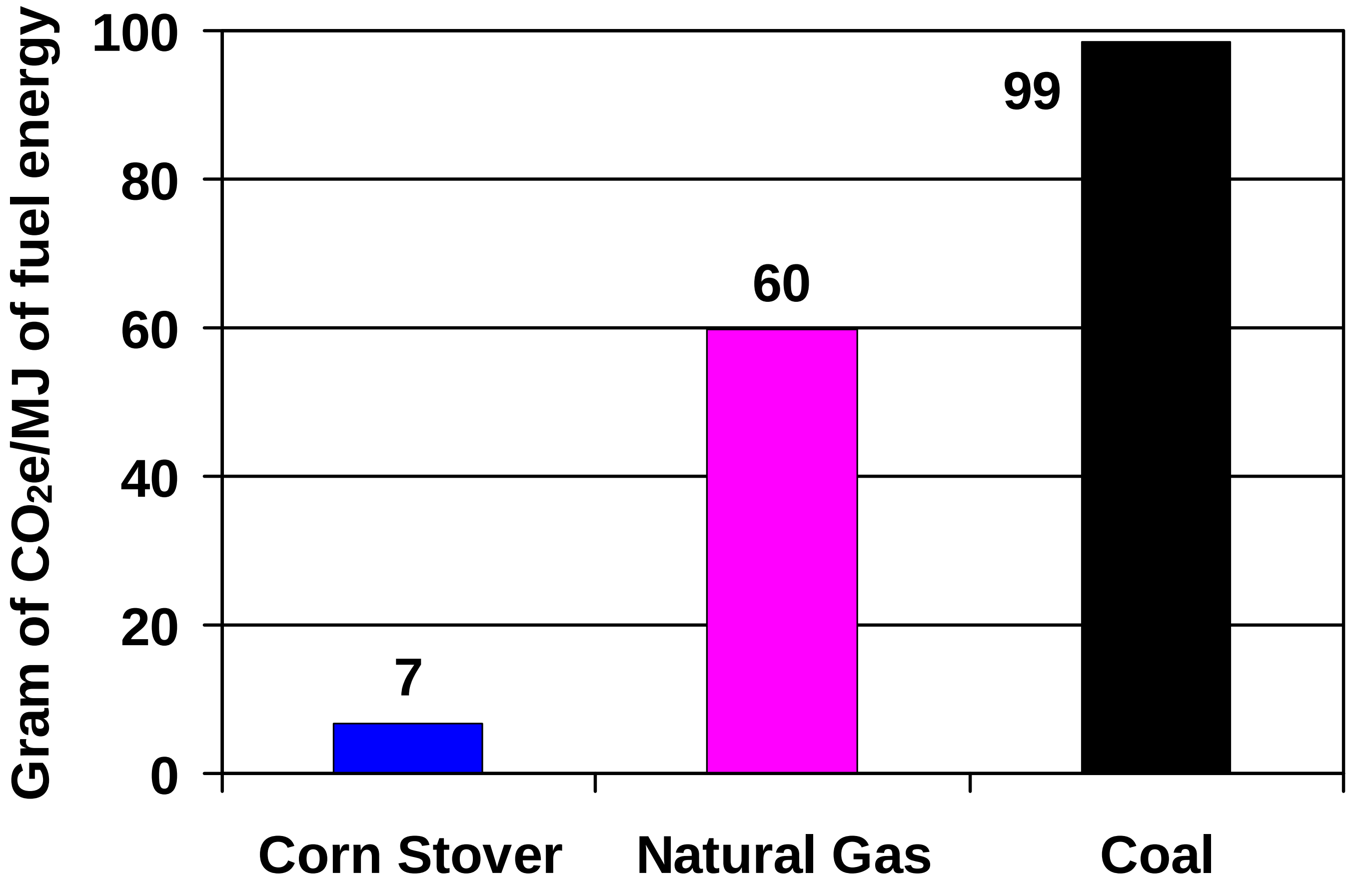
1017 MJ/dry tonne (i.e., 7% of dry corn stover energy)

Life-Cycle GHG Emissions



102 kg of CO_2e/dry tonne of corn stover
(includes combustion emission, but not SOC)

Life-Cycle GHG Emissions



7 g of CO_2e/MJ of dry corn stover
(includes combustion emission, but not SOC)

GHG Emissions of Ethanol using Corn Stover as a Fuel using BESS*

	Convent. Corn Ethanol	CHP	CHP + Grid	BIGCC
GHG Reduction	52%	82%	92%	115%
GHG Reduction with CO_2 Sequst.	85%	116%	126%	149%

Amount of Biomass Required, %

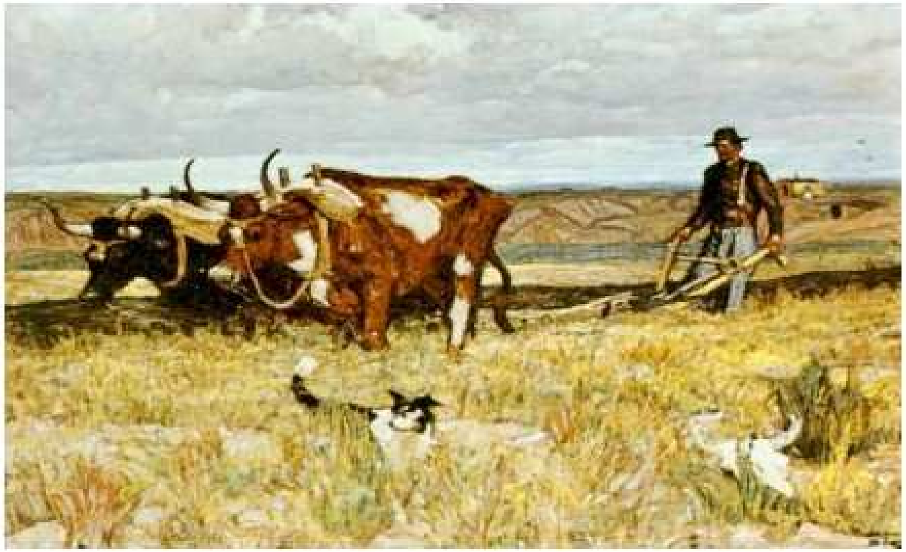
	DDGS	Corn stover		Syrup + stover	
		Ethanol corn acres	All corn acres*	Ethanol corn acres	All corn acres*
Process heat	70%	27%	9%	9%	3%
CHP	80%	30%	10%	12%	4%
CHP + grid	100%	40%	13%	27%	9%

*Assumes 1/3 of corn acres go for ethanol

Will Logistical Requirements be too difficult? No!!!

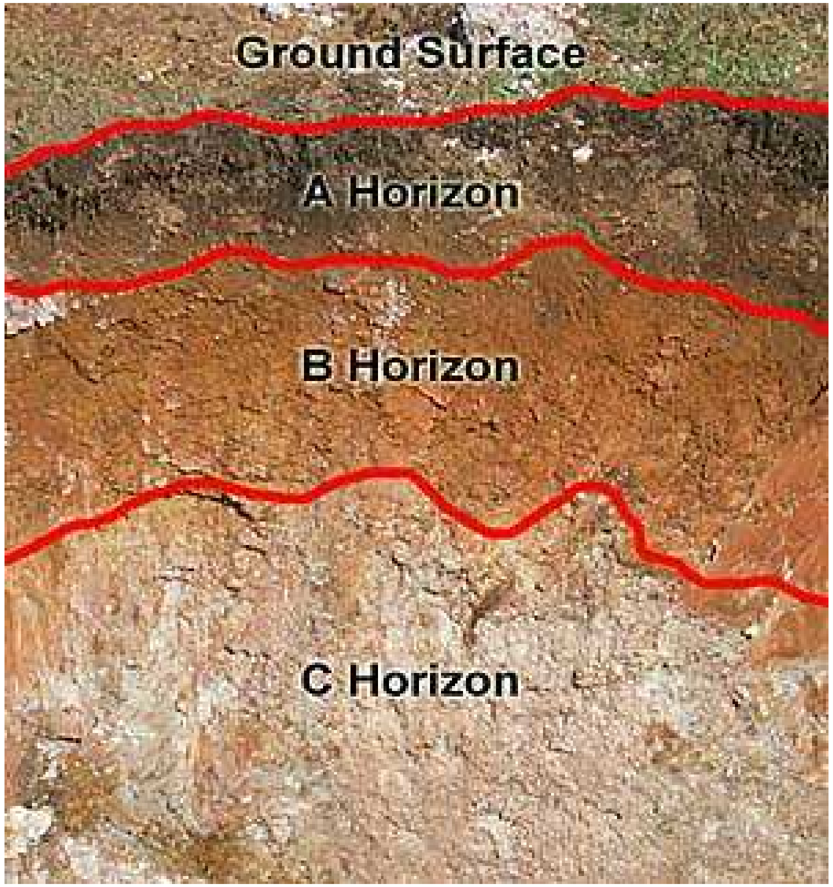
- Heat and Power using Stover for 50 million gallons ethanol per year
- 400 to 500 tons per day of stover
  - 16 to 20 truckloads (25 tons each) of briquettes or pellets per day or
  - 640 to 800 bales (1250 lbs each) per day
- 60 truckloads of corn per day
- 20 truckloads of DDGS per day

Changes on the Land and in the Soil



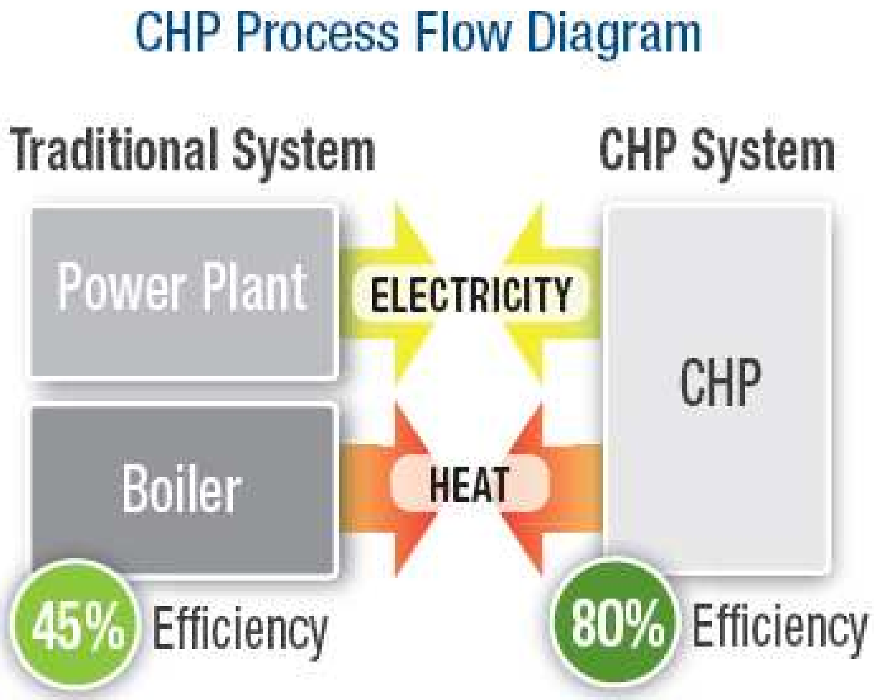
Biomass Harvest Rates Must Consider Maintenance of Relic Soil Organic Carbon

- Preservation of relic soil organic carbon is key issue associated with biomass harvest

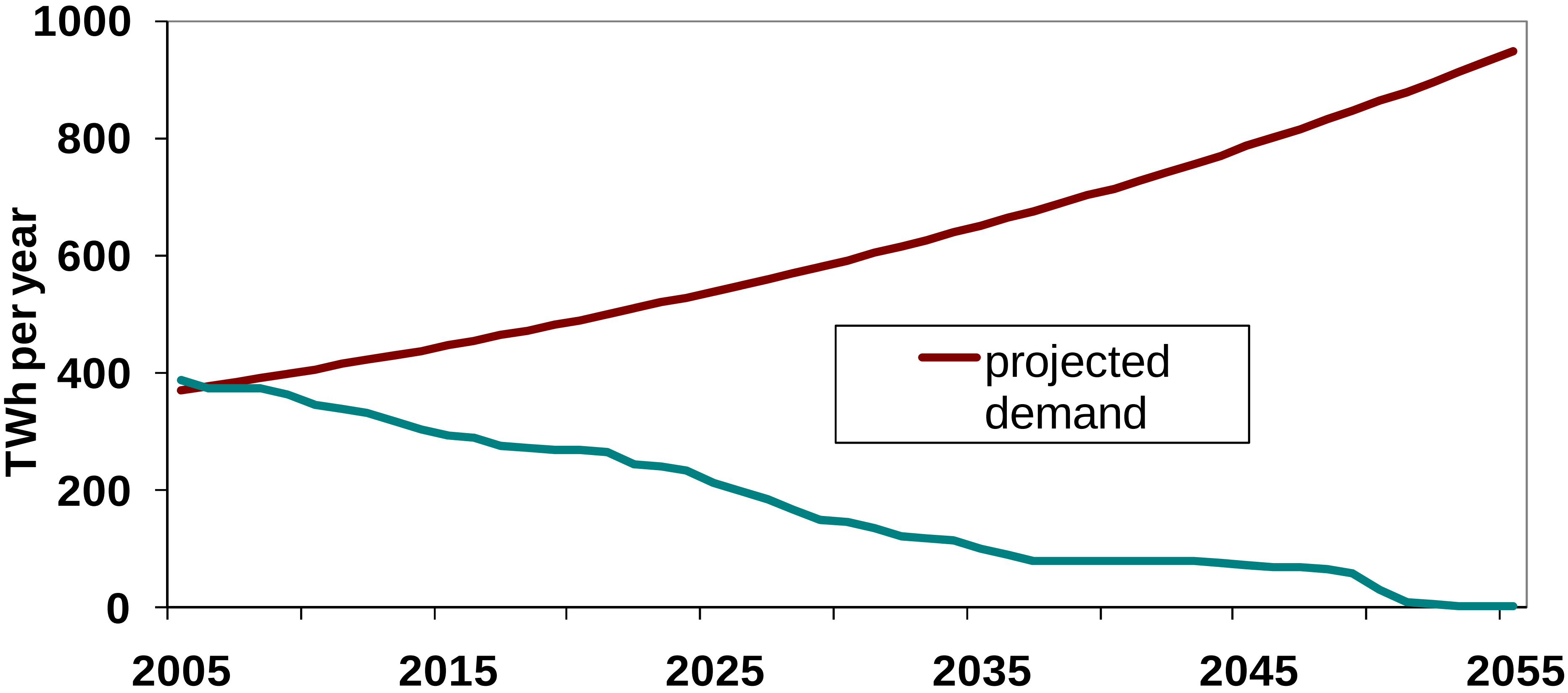


U.S. Dept. of Energy Encourages CHP

- Utilize Process Heat before or after using to generate electricity- cuts GHG by 53%.
- Requires greater investment, coordination with power utilities.
- Source: Combine Heat and Power: Effective Energy Solutions for a Sustainable Future, ORNL. http://www.osti.gov/bridge



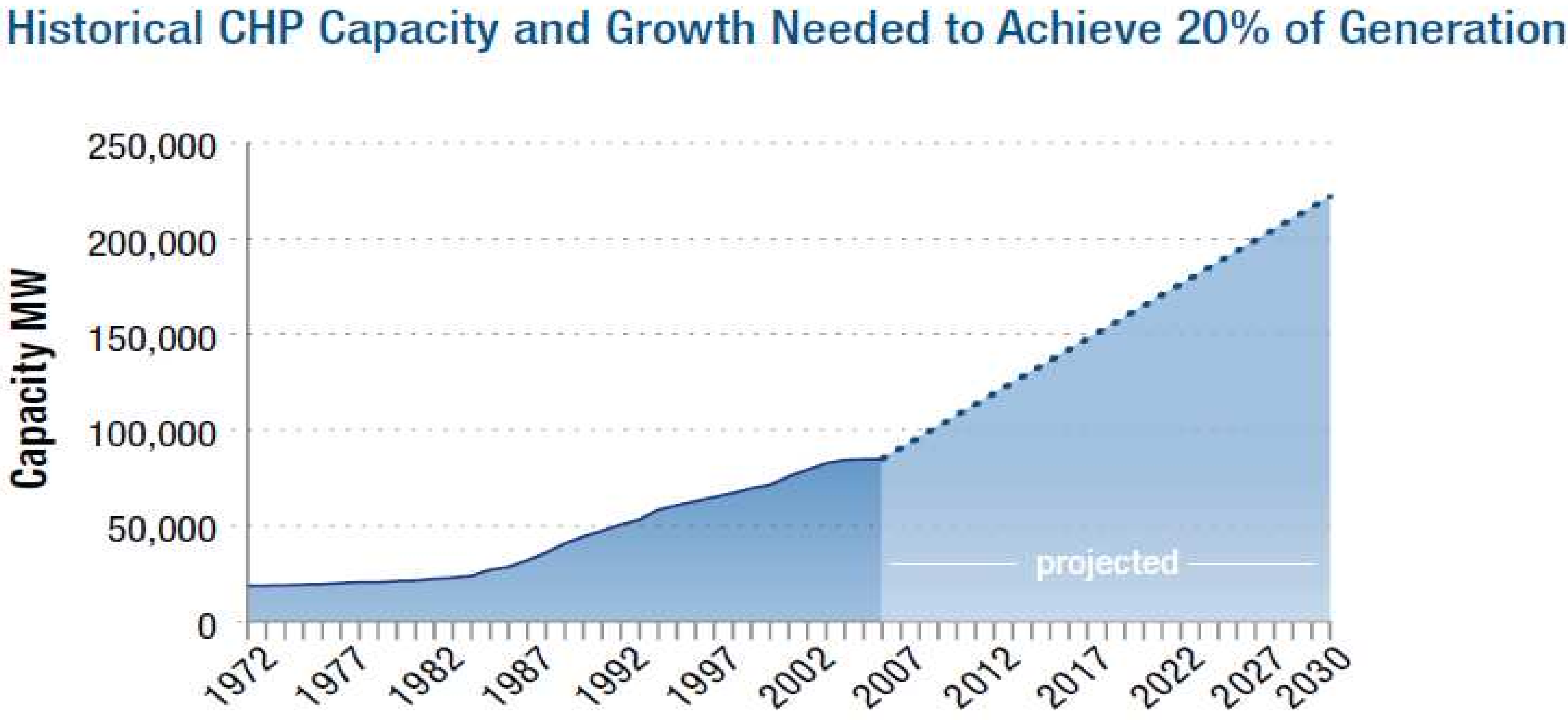
Growing Demand and Retirements



Source: Jones et al., 2006

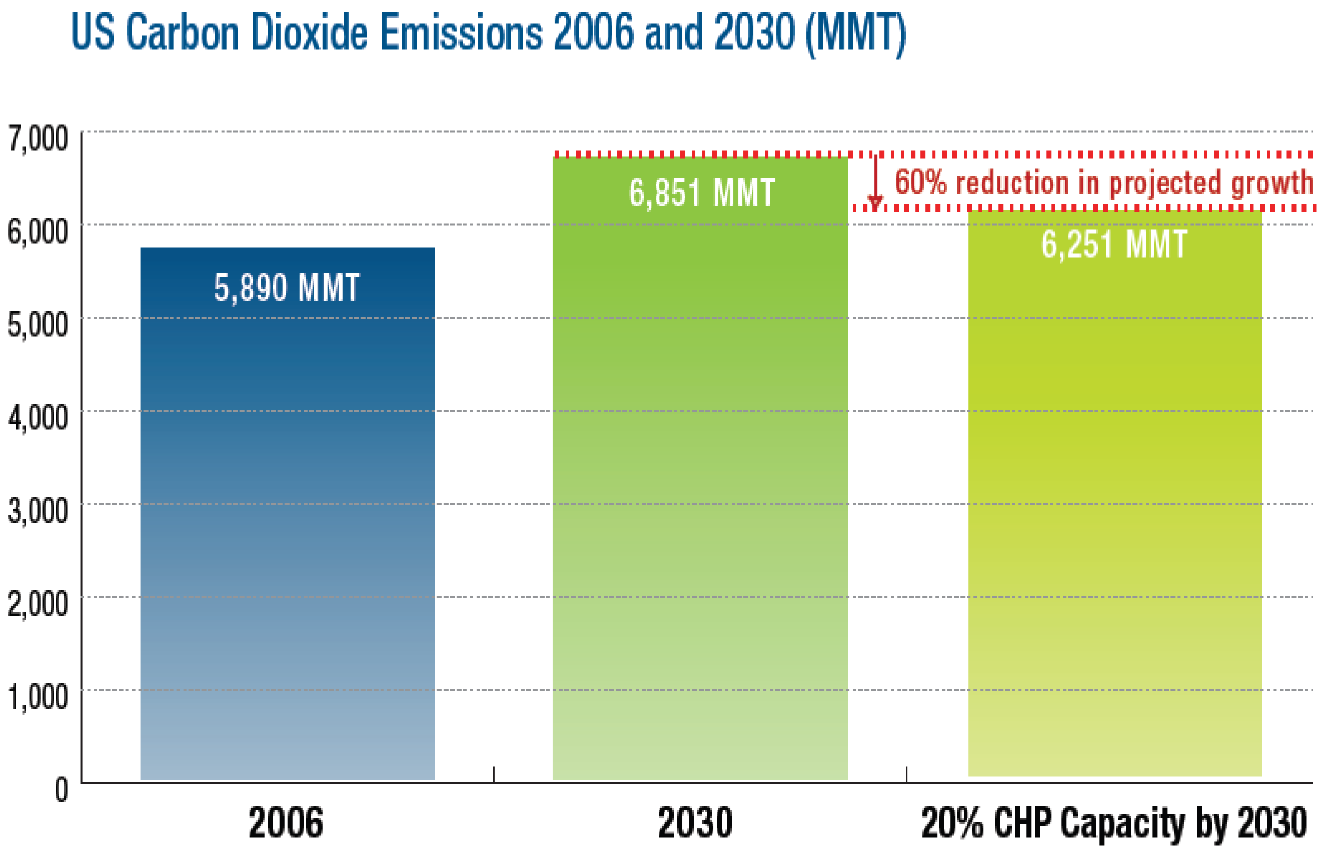
DOE Goal: CHP Expansion from 9% to 20% of U.S. Capacity by 2030

Source: Combine Heat and Power: Effective Energy Solutions for a Sustainable Future, ORNL. http://www.osti.gov/bridge



U.S. CO2 Emissions 2006-2030 and Effect of 20% CHP

Source: Combine Heat and Power: Effective Energy Solutions for a Sustainable Future, ORNL. http://www.osti.gov/bridge



Source: DOE EIA AEO 2008 and internal analysis

Summary

- 2nd Generation biofuels may suffer stigma as poor investment from adverse publicity directed toward corn dry-grind facilities.
- Using biomass as a fuel producing CHP requires implementation of known technologies.
- Plentiful amounts of biomass are at the plants or nearby.
- Logistics are not a deal-breaker, but expect stover to cost about $80 per ton as a densified product at the plant.
- GHG emissions of the ethanol produced can be vastly improved when CHP is implemented at dry-grind plants.

Thank you!

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