Renewable Fuels for Process Energy

Bert Bock
Eastern Region
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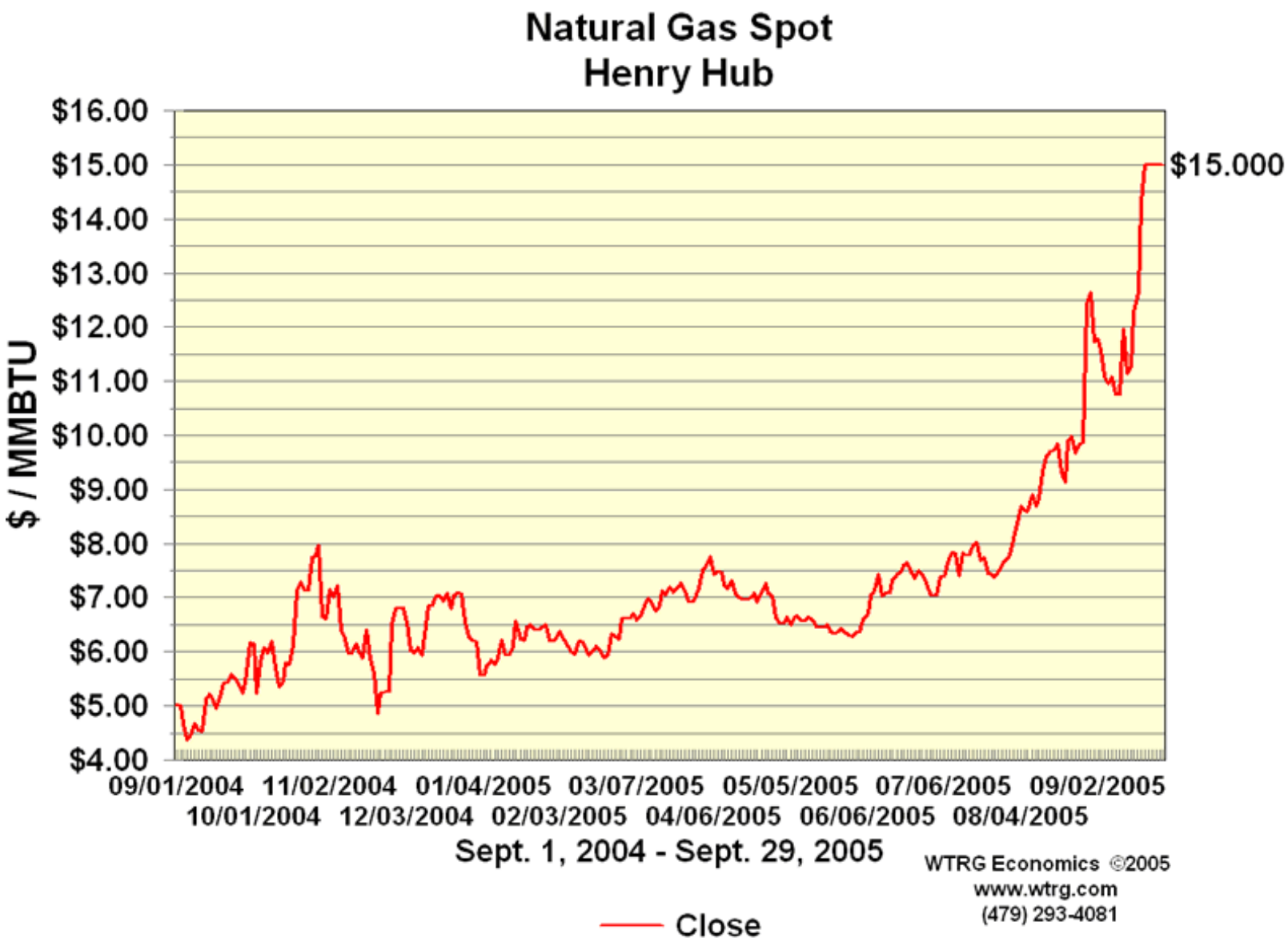
Why Renewable Process Energy for Ethanol Dry Mills?

- High and volatile natural gas prices
- Low-cost waste and byproduct feedstocks
- Lower or no thermal oxidizer costs
- Energy Bill incentives for “cellulosic biomass ethanol” (applicable to corn/ethanol when animal wastes or other wastes displace at least 90% of fossil energy normally used in production of ethanol)
  - RFS credit system provides 2.5 gallons credit/gallon ethanol produced with renewable process energy
  - Eligible for additional grants and loan guarantees
- Less fossil fuel input and lower GHG emissions


Natural Gas Spot
Henry Hub
$16.00
$15.00
$14.00
$13.00
$12.00
$11.00
$10.00
$9.00
$8.00
$7.00
$6.00
$5.00
$4.00
$ / MMBTU
$15.000
09/01/2004
10/01/2004
11/02/2004
12/03/2004
01/04/2005
02/03/2005
03/07/2005
04/06/2005
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Offsetting higher corn costs: North Alabama vs. Eastern Corn Belt

		$/denatured gal.
Δ corn price, $/bu	**0.30**	**0.107**
Energy cost savings via renewable energy:		
Δ NG price, $/MBtu NG replaced	2.50	0.085
Δ electricty price, $/kWh	0.03	0.023
	Total	**0.108**

Why Ethanol Plants as Energy Hosts? Renewable Energy Plant Perspective

- Good economies of scale for RE plants
- 24/7 operation
- Generally competing with natural gas
- Good ratio of process heat to electricity for cogeneration
- Potential for sharing resources with ethanol plant
  - Maintenance staff and resources
  - Administration—management, purchasing, personnel
  - Operator staff—shared backup for OSHA compliance
  - Scales and scales operator for weighing feedstock

Potential Feedstocks for Process Energy: Eastern US

- Wood wastes
- Forest thinnings/residuals
- Poultry litter
- Swine solids
- Crop residues
- Bran from fractionated corn
- CDS (syrup) normally included with DDGS
- DDGS
- MSW (RDF)
- Biosolids
- Yard waste
- Scrap tires
- Carpet residuals, post consumer carpet
- Hurricane debris

Fuel Properties

	Moisture	HHV	N	S	Ash	Alkali
	As-received		Dry basis			
	%	Btu/lb	%			lb/ MBtu
Sawdust	**11.5**	**7,415**	**0.03**	**0.01**	**0.3**	**0.1**
Forest residuals	48.9	4,429	1.03	0.11	4.0	0.5
Yard waste	38.1	4,341	0.85	0.24	20.4	1.2
RDF	4.2	6,396	0.77	0.33	25.0	0.5
Poultry litter	27.4	4,637	3.71	0.45	21.6	8.6

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Corn bran	12.0	8,000	1.76	0.08	3.0	0.2
CDS (Syrup)	70	4,000	4.20	0.65	--	0.9
Tire-D Fuel	0.6	16,250	0.24	1.23	4.8	--
Carpet-D Fuel	1.5	10,077	6.10	0.10	19.1	0.2

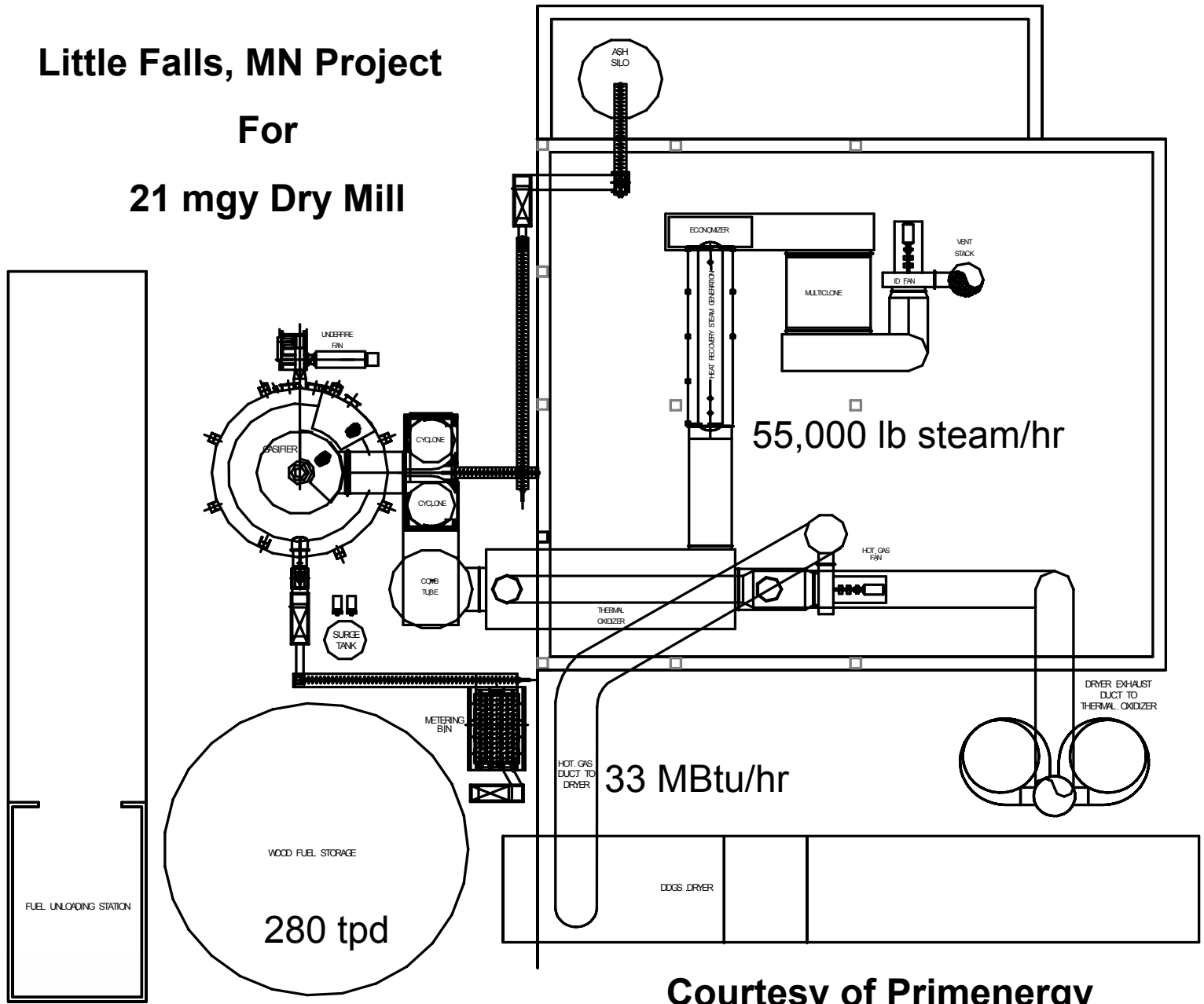
Energy Conversion Options

- Direct combustion
  - Sensible heat (hot flue gas); specialized heat recovery in place of standard package boiler, TO, NG drying
- Directly heated gasification with staged combustion
  - Low-Btu syngas and sensible heat; specialized heat recovery in place of standard pkg. boiler, TO, NG drying
- Indirectly heated gasification (e.g., steam reforming)
  - Medium Btu syngas for use in standard package boiler, TO, and DDGS dryer
- Fast pyrolysis
  - Bio-oil for use in std. pkg. boiler, TO, and DDGS dryer
  - Storable form of energy; enables decoupling of bio-oil production and use

Little Falls, MN Project

For

21 mgy Dry Mill



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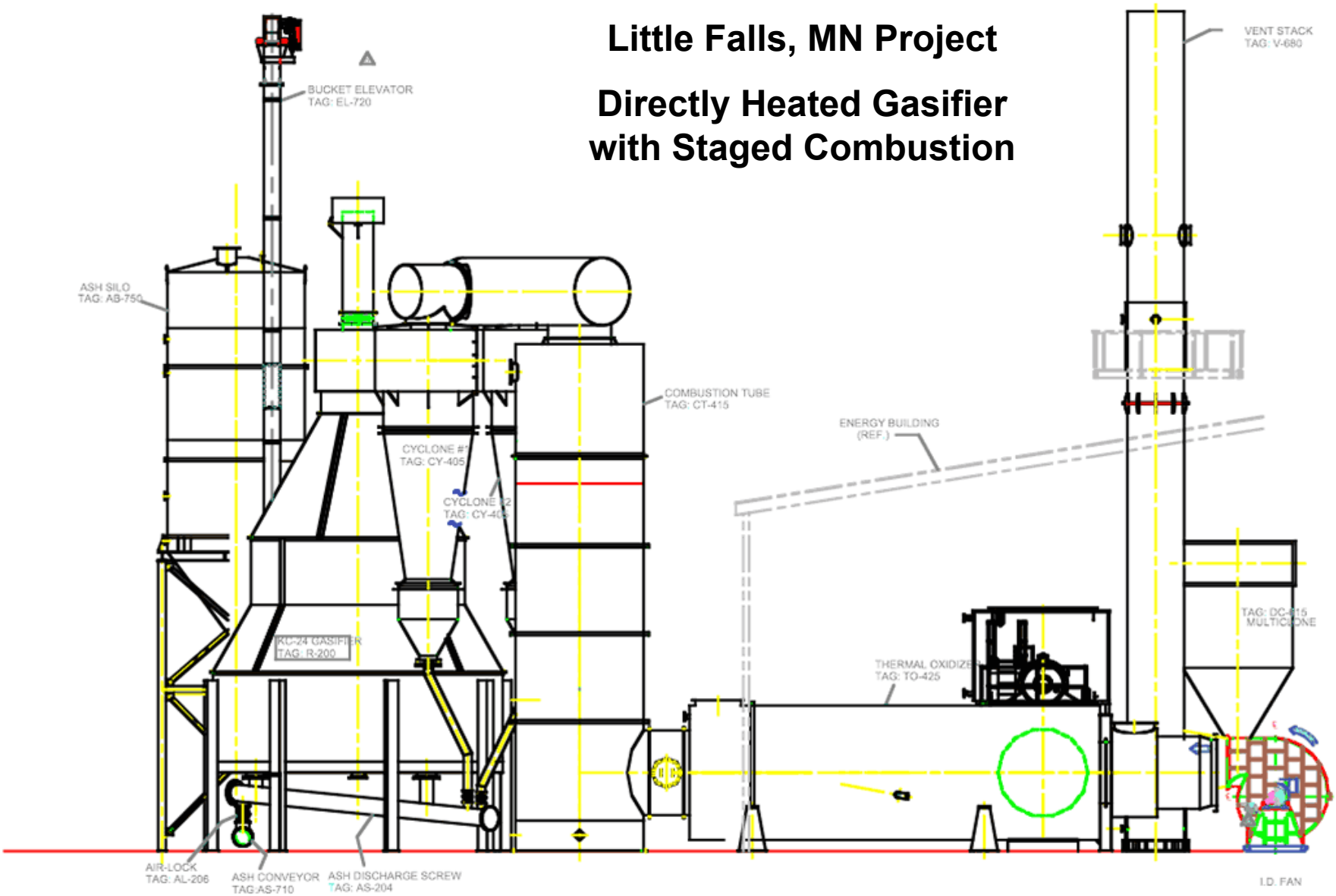
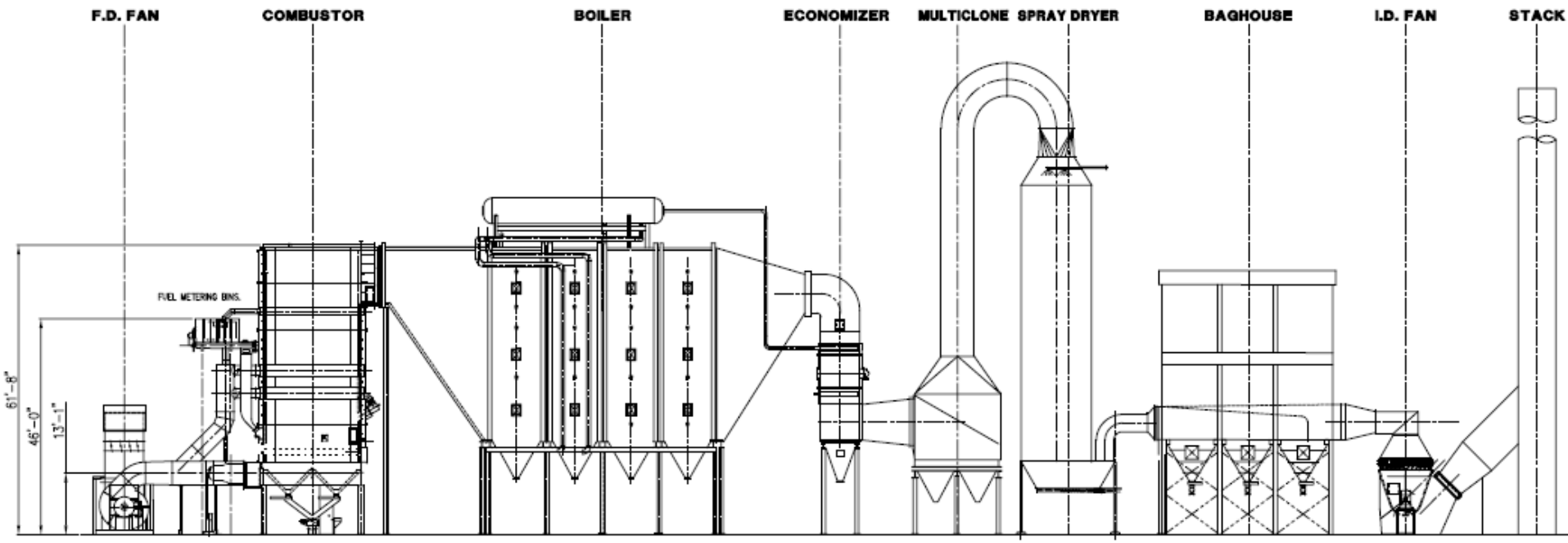
Little Falls, MN Project

Directly Heated Gasifier with Staged Combustion

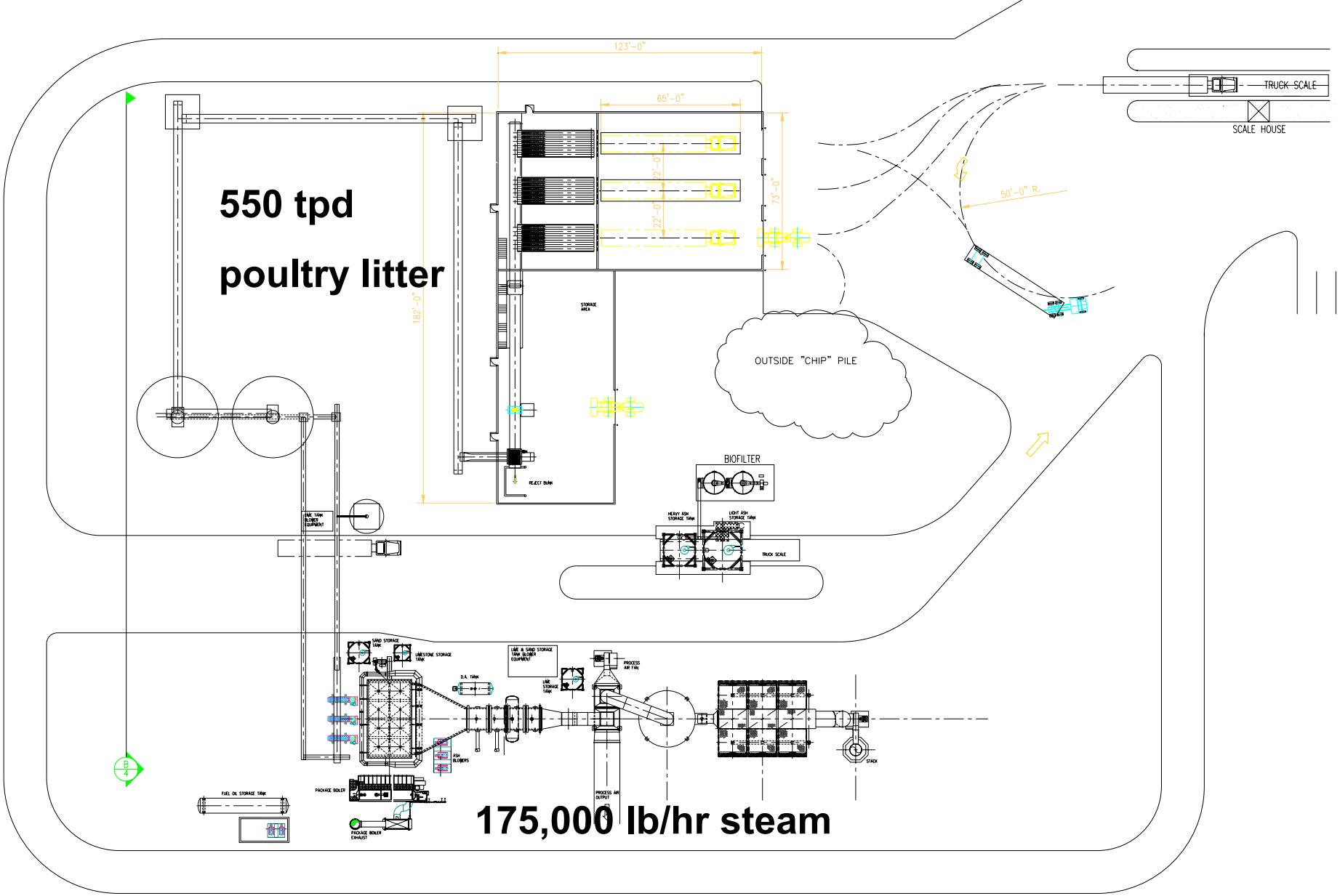


Courtesy of Primenergy

Direct Combustion Example for 50 mgy Dry Mill—175,000 lb process steam/hr

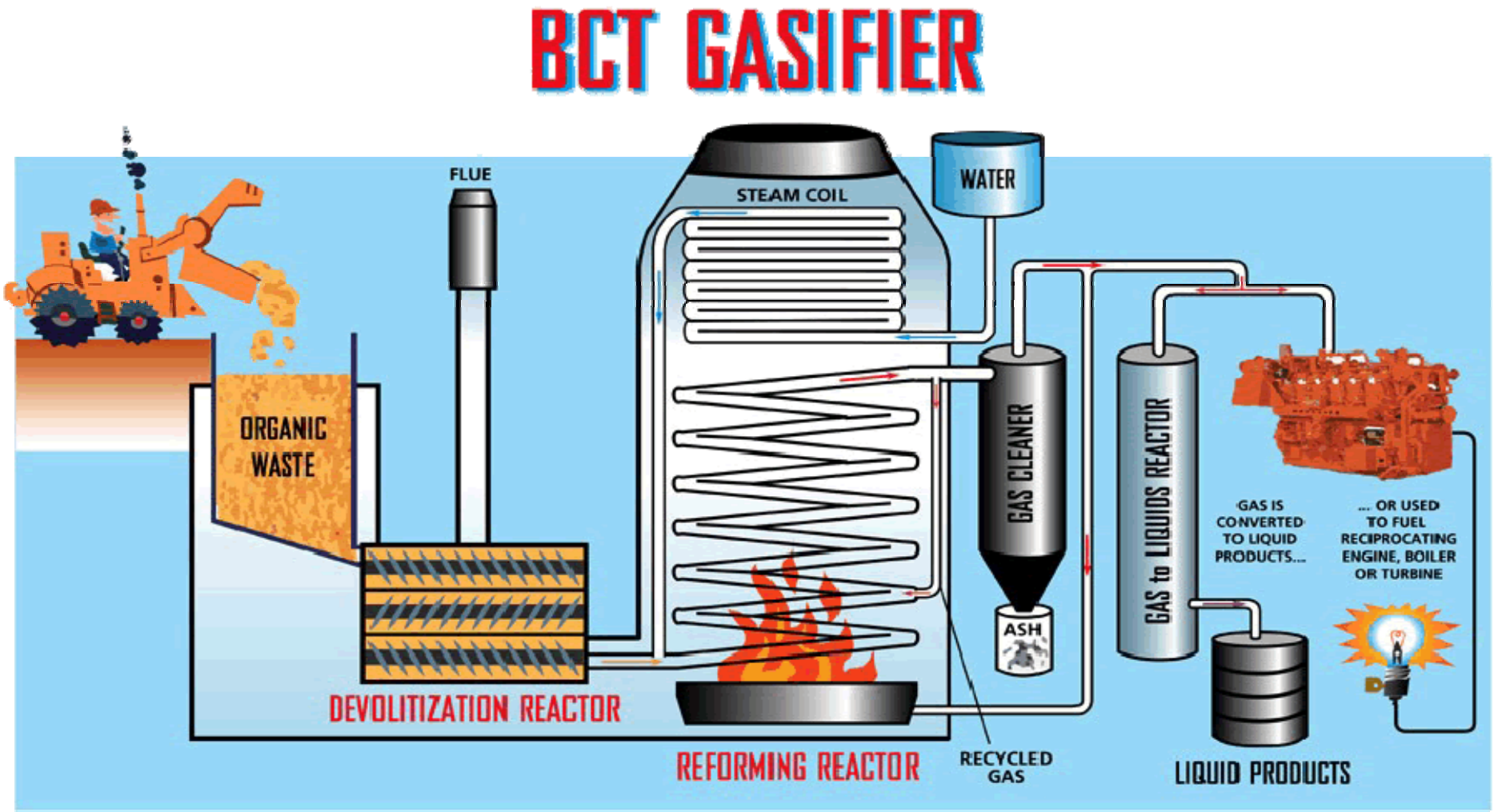


Courtesy of Energy Products of Idaho



Courtesy of TR Miles Technical Consultants

Indirectly Heated Steam Reforming Gasifier



Courtesy of BioConversion Technology

15 dry ton/day Indirectly Heated, Steam Reforming Gasifier

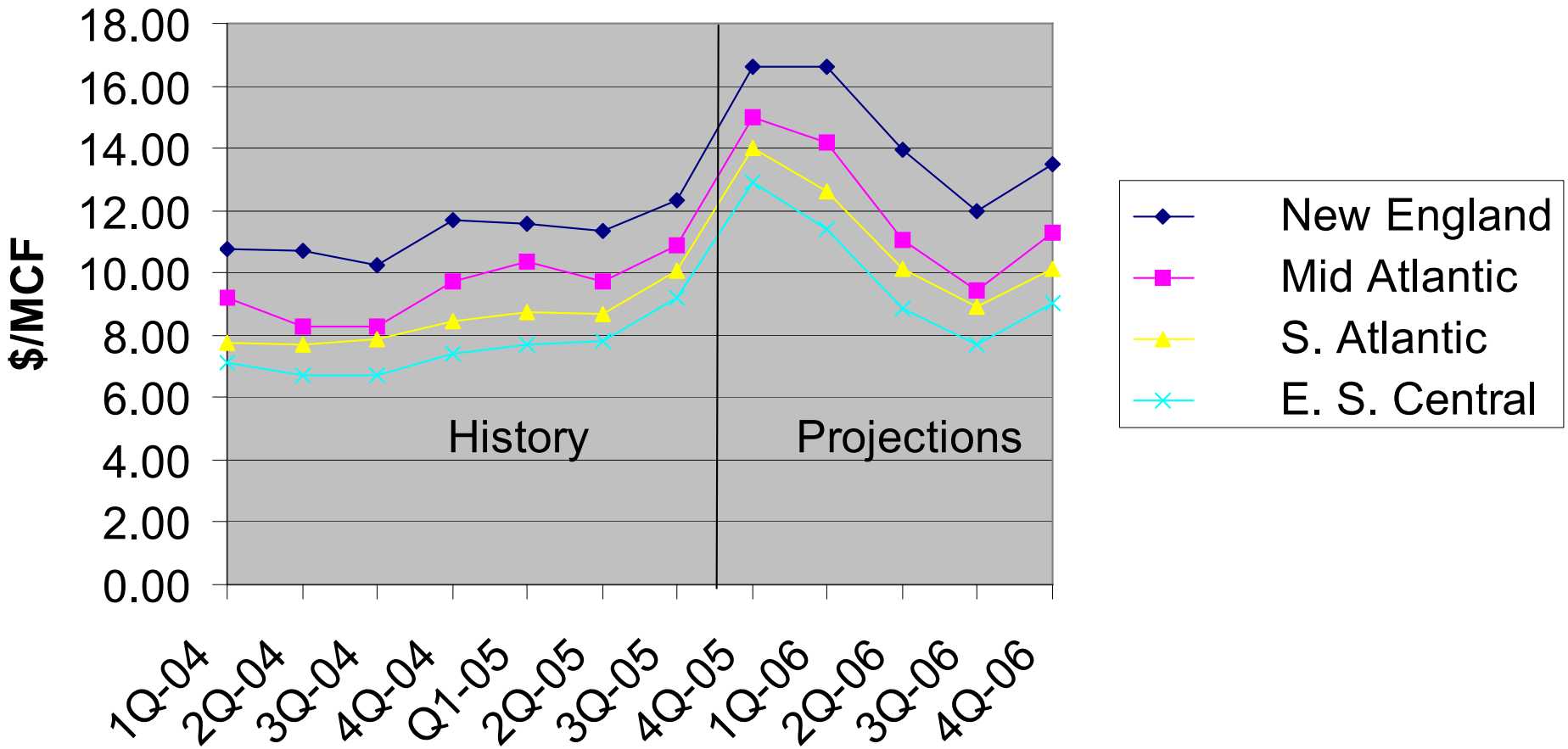
Courtesy of BioConversion Technology

Renewable Energy Economics Example

- Direct combustion example: process steam for 50 mgy dry mill
  - "Normal" process steam
  - Steam for drying DDGS
- Std. package boiler and thermal oxidizer retained as backup
- Steam DDGS dryer instead of natural gas dryer
- Thermal efficiency: 75% (feedstock to steam)

- Capital: $26.8 million
- O&M: $1.2 million (doesn't include feedstock cost)
- Equity: 40%
- Interest: 7.5%
- Loan: 10 year
  Depreciation: 7 year
- Corporate tax: 35%
- Net feedstock cost: $-1.00 to $2.00/MBtu

Industrial Natural Gas Prices--EIA (09/07/05)



Payback for Renewable Energy Investment: Direct Combustion Poultry Litter Example

Net feedstock cost, $/MBtu	Price of natural gas displaced, $/MBtu				
	7.00	**8.00**	**9.00**	**10.00**	**11.00**
	Payback, years				
-1.00	3.0	2.7	2.4	2.2	2.0
0.00	3.4	3.0	2.6	2.4	2.2
1.00	4.0	3.4	3.0	2.7	2.4
2.00	4.8	4.0	3.4	3.0	2.7

Internal Rate of Return (IRR) for Renewable Energy Investment

Net feedstock cost, $/MBtu	Revenue: $/MBtu NG displaced				
	3.00	**4.00**	**5.00**	**6.00**	**7.00**
	% IRR after 15 years				
-1.00	13.9	19.0	23.8	28.4	32.8
0.00	7.8	13.8	18.9	23.7	28.3
1.00	0.5	7.6	13.6	18.8	23.5
2.00	--	0.3	7.4	13.4	18.6

Conclusions

- Natural gas prices are likely to remain high and volatile in the foreseeable future
- There are increasing environmental pressures for alternative/beneficial uses wastes and byproducts
- Suitable energy conversion technologies are available and additional technologies appear ready for commercialization
- Renewable energy systems have good projected payback and return with low-cost feedstocks
- 2.5X RFS credit likely will provide additional benefits
- Renewable energy systems can play a significant role in helping eastern U.S. corn/ethanol plants compete with Corn Belt plants

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