Economics of An Integrated Bio-Energy System

Northeast Sun Grant Regional Feedstock Summit
By
Brent Gloy
Applied Economics and Management
Cornell University
November 13, 2007

Agenda

- Background the current situation
- Integrated bio-energy concept
- An economic case study: integrating corn ethanol and livestock production

Background

Brent Gloy, November 2007

Why the Interest in Bio-Energy

+ (1) Rising energy prices
+ (2) Increasing concern over the environment
+ (3) Development of government incentives to jump start the industry
+ (4) Proven technology and willing capital markets

= Economic Opportunity

Brent Gloy, November 2007

Food, Fuel, or Both?

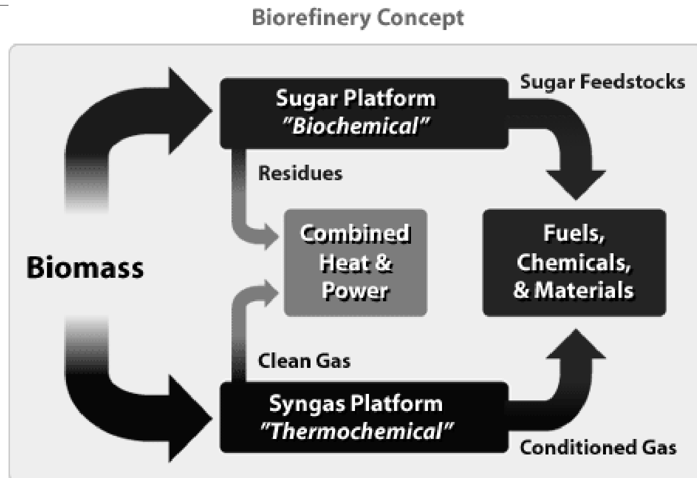
Your view of the system will likely influence the way it is designed

Is the system?

1. an energy system with feed by-products
2. a food production system with energy by-products
3. an integrated food and energy system

The Biorefinery Concept

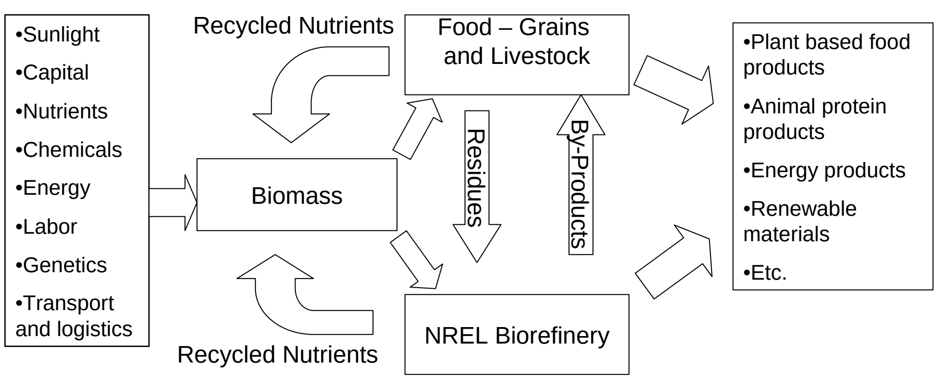
NREL's Biorefinery Concept



Source: National Renewable Energy Laboratory
http://www.nrel.gov/biomass/biorefinery.html

Brent Gloy, November 2007

Another Biorefinery Concept



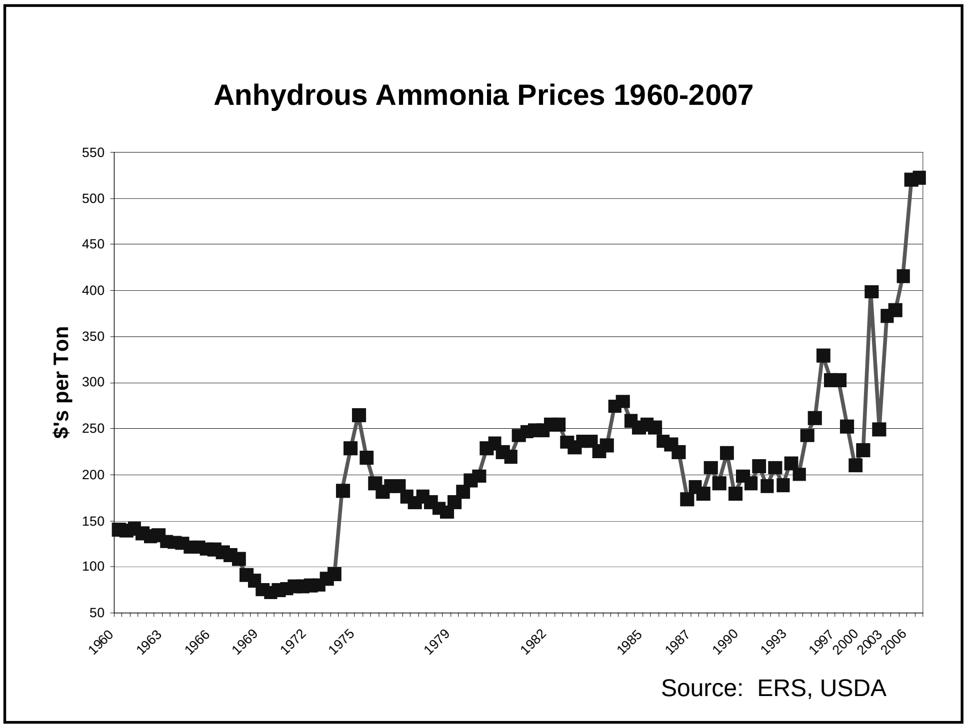
Brent Gloy, November 2007

Factors Influencing the Components of the Biorefinery

- Energy prices
- Government policy
  - Energy security
  - Environmental attitudes
- Technology development
  - Energy conversion
  - Nutrient recovery/waste processing
- Structural change in the livestock sector

Consider Manure

- On most farms manure is currently treated as a waste with a negative economic value
- This may soon change
  - Rising energy prices
  - Rising fertilizer prices
  - Improved technology for nutrient and energy recovery
  - Increasing scale of livestock operations
  - Increasing negative public attitudes toward livestock wastes



The Potential Value of Manure

WARNING: SUBSTANTIAL COSTS ARE REQUIRED TO COLLECT THESE REVENUES

- A 10,000 cow dairy operation produces
  - 259,077 tons of waste per year
  - 35,529 tons of dry waste per year
  - 1,699 tons of N = $1.02M @ $600/ton
  - 287 tons of P = $115k @ $400/ton
  - 442 tons of K = $115k @ $260/ton
  - 176k MMBTU's of renewable energy = $1.4M @ $8/MMBTU

Total Potential Revenue = $2.7 M

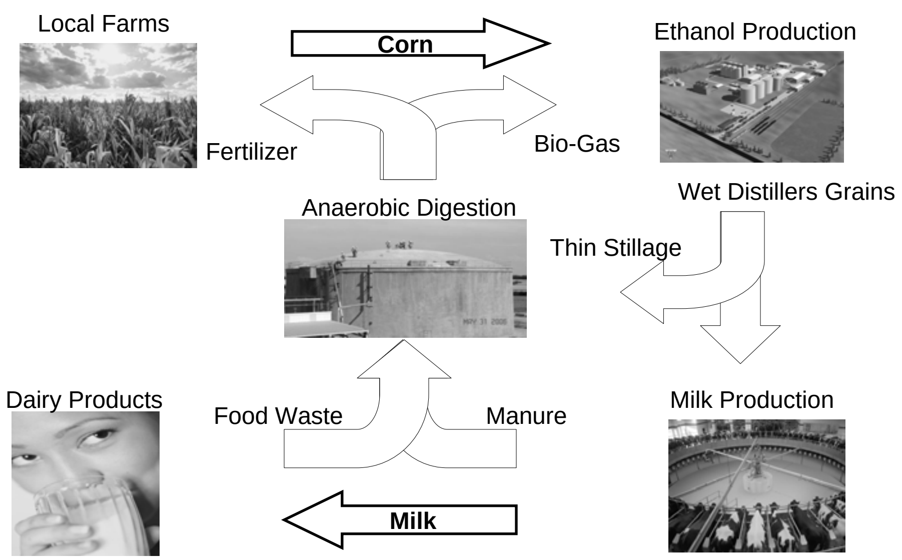
Brent Gloy, November 2007

Ethanol and Livestock Production

A Case Study of Integrated Bio-Energy/Food Production

Brent Gloy, November 2007

The Integrated Food and Energy System



Anaerobic Digester Drives Sustainable, Integrated System

The Benefits of Integration

1. Ability to market wet vs. dried distillers grains
2. Transportation cost savings on distillers grains
3. Anaerobic digestion of dairy manure
4. Carbon credits from manure
5. Anaerobic digestion of thin stillage

Brent Gloy, November 2007

Increased Costs of Co-Location

7. Corn basis tightening – increased feed costs
8. Additional capital costs required for integration and coordination

Total Benefits of Integration

Type of Benefit	Annual Benefit	Capitalized Value
Wet Distillers Grains as Opposed to Dry	$3,600,000	$18,000,000
Transportation Cost Savings	$922,098	$4,610,491
Anaerobic Digestion of Dairy Manure	$2,745,944	$13,729,722
Carbon Credits from Manure	$511,597	$2,557,987
Anaerobic Digestion of Thin Stillage	$1,342,520	$6,712,601
Total Benefits of Co-Location	$9,122,160	$45,610,801

Benefits for a 30 million gallon ethanol system and 18,000 cow dairy operation

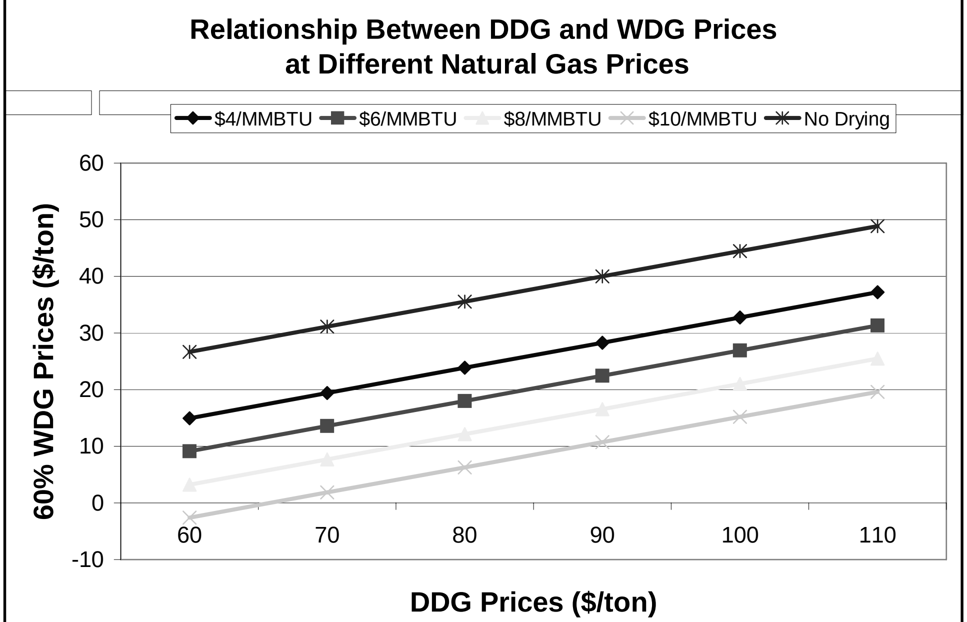
Brent Gloy, November 2007

1. Ability to market wet vs. dried distillers grains

Natural Gas Price ($/MMBTU)	4.00	6.00	8.00	10.00
BTU's Required to Dry	20,000	20,000	20,000	20,000
$/gal	0.080	0.120	0.160	0.200
$/bu	0.22	0.34	0.45	0.56
$/ton WDG (60% moisture)	11.71	17.57	23.42	29.28
$/ton DDG (10% moisture)	26.35	39.53	52.71	65.88
$/million gal eth	80,000	120,000	160,000	200,000
$/30 million gal ethanol	2,400,000	3,600,000	4,800,000	6,000,000

- Benefit increases as natural gas price increases

Brent Gloy, November 2007



Brent Gloy, November 2007

3. Anaerobic digestion of dairy manure

Key assumptions:

- 51,000 btu's/cow
- Heifers and beef 21,600 btu's/hd
- 30% conversion of solids to methane
- 625 btu's per cf of bio-gas
- Operating costs of $178,000 per year

Brent Gloy, November 2007

3. Anaerobic digestion of dairy manure

Natural Gas Price ($/MMBTU)	$4	$6	$8	$10
1,000 cows per day	$204	$306	$408	$510
Associated young stock per day	$93	$139	$185	$232
1,000 Cows and young per day	$297	$445	$593	$742
1,000 Cows per year	$74,460	$111,690	$148,920	$186,150
Associated young stock per year	$33,834	$50,751	$67,668	$84,586
1,000 Cows and young per year	$108,294	$162,441	$216,588	$270,736
18,000 Cows per year	$1,340,280	$2,010,420	$2,680,560	$3,350,700
18,000 cows and young per year	$1,949,296	$2,923,944	$3,898,592	$4,873,241

- Off-spring produce 45% of the methane of a lactating dairy cow
- ½ of operating costs reduce benefit by $178k/yr

5. Anaerobic digestion of thin stillage

Key assumptions:

- Value of heat from T.S. reduces parasitic heating needs
- 6.12 pounds of DM from T.S.
- 9 cubic feet of 1,000 btu methane per pound of T.S. sent to digester
- Benefit = heat provided by T.S.
  + revenue gained from gas
  - revenue forgone

5. Heat provided by thin stillage

Value of Heat Provided by Thin Stillage

	Natural Gas Price ($'s/MMBTU)			
	4	6	8	10
10% of BTU's Produced by Manure	194,930	292,394	389,859	487,324
15% of BTU's Produced by Manure	292,394	438,592	584,789	730,986
20% of BTU's Produced by Manure	389,859	584,789	779,718	974,648
25% of BTU's Produced by Manure	487,324	730,986	974,648	1,218,310
30% of BTU's Produced by Manure	584,789	877,183	1,169,578	1,461,972

- Benefit is variable depending on system – many will utilize heat from electrical generation in a similar fashion

Brent Gloy, November 2007

5. Anaerobic digestion of thin stillage – WDG Revenue Foregone

WDG Revenue Foregone

Table 8. Revenue Lost by Sending Thin Stillage to Digester.

Price of 60% Moisture WDG ($/ton)	20	30	40	45
Equivalent 10% Moisture DDG price ($/ton)	45	67.5	90	101.25
Price of DM ($/lb)	0.0250	0.0375	0.0500	0.0563
Revenue lost per bushel ground ($/bu)	0.153	0.2295	0.306	0.34425
Revenue lost per gallon of ethanol ($/gal)	0.05	0.08	0.11	0.12
Revenue lost per 1 million gallons of ethanol ($)	54,643	81,964	109,286	122,946
Revenue lost on a 30 million gallon plant ($)	1,639,286	2,458,929	3,278,571	3,688,393

- Revenue lost through digestion depends on price of DDG/WDG

Brent Gloy, November 2007

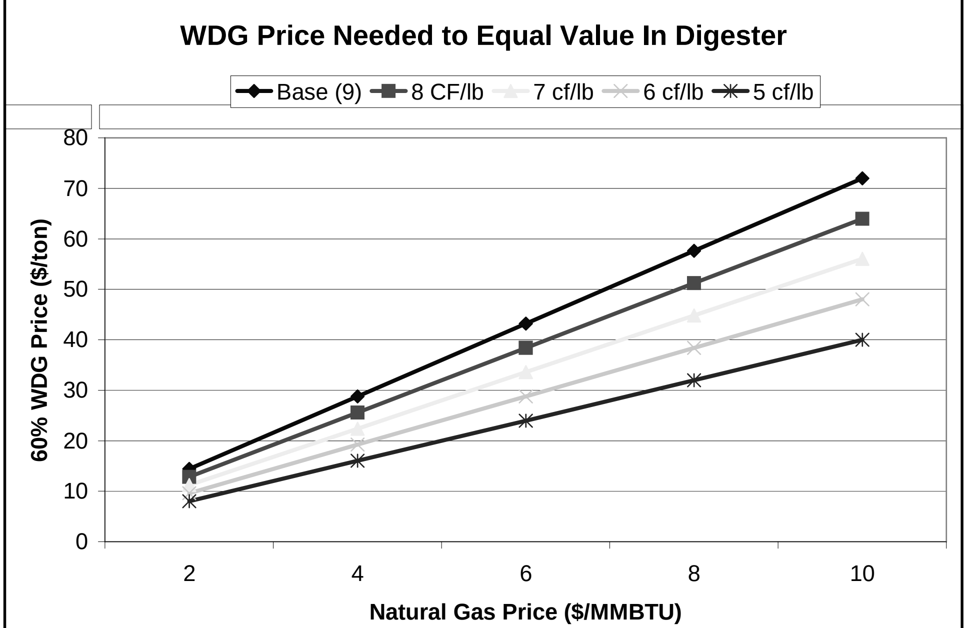
5. Net value of solids in digester

Table 9. Revenue and Break-Even Analysis of Anaerobic Digestion of Thin-Stillage.

Natural Gas Price ($/MMBTU)	4	6	8	10
Value of TS in Digester ($/lb)	0.0360	0.0540	0.0720	0.0900
Value per 1 million gal of ethanol ($)	78,686	118,029	157,371	196,714
Value per 30 million gal of ethanol ($)	2,360,571	3,540,857	4,721,143	5,901,429
Net Revenue Gain from Digestion for a 30 Million Gallon Plant @ $30 WDG	(98,357)	1,081,929	2,262,214	3,442,500
Break-Even 60% WDG Price ($/ton)	28.80	43.20	57.60	72.00

- As gas price increases value in digester increases
- As WDG price rises net value falls
- Gas yield is the wildcard
- ½ of operating costs reduce benefit by $178k/yr

Brent Gloy, November 2007



Brent Gloy, November 2007

Conclusion

- There are substantial benefits to developing a more integrated bio-energy system
- Relative prices are key to determining the economic opportunity
- System thinking about food and fuel is required to maximize economic efficiency