Digester Economics and Financing

Cornell Manure Nutrient Management
and Renewable Energy Workshop

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Agenda

- Economic keys and evaluation
- Incentives
- Evaluation
- Conclusion

What We Know

- There are currently few biogas applications with very positive economic situations
- Traditional biogas systems have not fared well
- Technology is improving
- Energy prices are rising
- Economics of each project are highly dependent upon the situation

What We Know

In order to have a biogas project with extremely positive economics the following are required:

1. Large system to concentrate waste and justify technology and management
2. Good energy off-take
3. Ability to co-feed manure
4. Ability to provide waste management solution in livestock system

How Much Energy Can AD Produce?

- Lactating dairy cow – 50,000 btu's/cow/day
- 6,000 cow operation will conservatively produce/run
  - 105,000 MMBTUS per year
  - About 1 MW of electricity generation
  - About 900,000 gallons of gasoline equivalents (CNG)
  - Output could easily be doubled with intensive management and inclusion of additional waste streams

Current NYSERDA Incentives

Renewable Portfolio Standard (RPS) Customer-Sited Tier (CST) Anaerobic Digester Gas (ADG)-to-Electricity Program

New NYSERDA Incentives

- Capacity incentive
  - $500 per kilowatt to cover the total purchase and installation costs of new ADG-fueled power generating equipment
  - Includes controls, meters, biogas clean-up equipment, emissions control equipment, interconnection equipment and costs associated with engineering services
  - Lesser of $350,000 or 50% of total purchase, engineering services, and installation of new equipment

New NYSERDA Incentives

- Performance incentive
  - $0.10 per kWh for 3 years for new equipment
  - $0.02 per kWh for existing eligible equipment
  - Incentive paid up to peak connected load

Example

- New 220 rated kW system
  - Capacity incentive = 220kW*$500 = $110,000
  - Performance Incentive = 220kW * 8760 hours* 80% (capacity factor) * $0.10/kwh = $154,176 annually for 3 years

[illegible] PON 1146

An Evaluation

- Two tools have been developed to assist in project evaluation using:
  - Outputs of a FarmWare assessment
  - More flexible user inputs

Detailed and accurate inputs are key to sound analysis

Basic Inputs – See Handouts

- Number of dry and lactating cows
- Capital budget estimates
- Incentive participation or not
- Biogas production
- Inclusion of additional waste streams or not
- Farm power use
- Electrical pricing
- Carbon credit prices
- Operating expenses
- Financing assumptions

A Simple Example

- The details of the examples are available in your handouts
- Estimates based on FarmWare and Cornell Manure Management data
  - [illegible]
  - [illegible]
- Model includes performance incentives and various biogas production incentives

Basic Information

Parameter	"Base Example"	"FarmWare Example"
Lactating Cows	800	800
Dry Cows	200	200
Total Cows	1,000	1,000
Participation in NYSERDA Capacity Incentive	Yes	Yes
Participate in NYSERDA Performance Incentive	Yes	Yes
Other Grant Dollars	$0	$0

Key Components of the Evaluation

1. Capital costs
2. Operating revenues
3. Operating costs
4. Financial assumptions and analysis
5. Some cautions

1. Capital Costs

- Vary considerably based upon digester design
- Typical costs are in usually in the $600+ per cow range
- Estimates can be provided with FarmWare [illegible]
- Other estimates on Cornell manure management website: [illegible]
- Best approach is to get a price quote from vendor
- Consider any grants possible

1. Capital Costs

Key questions to ask:

- What type of system is appropriate? Complete mix/plug flow/cover/etc
- How much modification of existing facility is required?
- What type of equipment is needed for processing gas and waste?
- What grant programs are available?
- How much working capital is required?

Capital Budget Summary

Table 9. Capital Costs and Grant Income for the Base and FarmWare Examples.

Parameter	Base Case	FarmWare Case
Total Capital Costs	$970,250	$818,405
Total Costs Associated with Generation Equipment	$450,925	$54,752
Capacity of Generation Equipment (kW)	141	190
NYSERDA Capacity Incentive	$70,706	$27,376
Annual NYSERDA Performance Incentive (3 years)	$99,102	$133,152

Note differences in total capital required as well as amount for generation; impact incentives as well as general profitability

2. Operating Revenues

Depend upon:

- The amount of manure collected
- The amount of additional wastes processed and the content of the wastes
- The technology used for conversion
- The price received for the energy or gas produced
- The price paid for energy off-set in the operation
- Any environmental credits available

2. Calculating Energy Production

Milking Animals	
pounds of manure per cow/day	150.00
volatile solids content %	11.33%
Solid conversion to biogas	30%
CF of biogas per lb VS converted	16
Alt feedstock gas inflation factor	0%
btu's per cf of biogas	625
btu's per cow per day	51,000
CF methane per cow per day	51
CF biogas per cow per day	81.60

Make sure to consider the difference between milking animals and dry animals

Key parameters include: btu content, conversion rates, yield influence of alternative feedstocks

2. Calculating Revenue

- Must consider energy sale price and energy off-set by system
- Incentives provided for generation
- Consider amount of energy lost in generation and clean-up

Biogas Production Assumptions

Table 5. Energy and Biogas Production Assumptions, Base Case

Assumption	Value
Manure:	
Solid conversion to biogas (%)	30%
Cubic Feet of biogas produced per pound of volatile solid converted	16
BTU's per cubic foot of biogas	625
Other Waste Streams:	
Tipping fees per ton of waste (net of disposal costs)	0
Tons of other waste per day	0
Volatile solid content (%)	40%
Solid conversion to biogas (%)	30%
Cubic feet of biogas produced per pound of volatile solid converted	16
BTU's per cubic foot of biogas	625

FarmWare produces the electrical generation estimates directly

Electricity and Carbon Credit Assumptions

Electricity Conversion and Use Assumptions	Value
Thermal conversion efficiency of electricity generation equipment (%)	25%
Daily on-line percent for electricity generation equipment (%)	90%
Pre-system on-farm power requirement (kWh/year)	342,000
Power use of AD system (kWh/year)	54,750
Purchase price of electricity from grid ($'s/kWh)	$0.12
Sale price to grid ($'s/kWh)	$0.070
Carbon credit price ($'s/ MT CO_2)	$2.00
Type of existing manure storage	Anaerobic lagoon

Carbon credits based upon CCX rules

3. Operating Costs

Depend upon:

- Size of the system
- Technology employed
- Gas processing required
- Amount of management and labor required
- Maintenance
- Generation costs

Operating Expenses

Table 7. Operating Expense Estimates for the AD System, Base Case

Operating Expense	Value
Operating, Repairs, and Maintenance % of Capital	5.0%
Operating, Repairs, and Maintenance	Calculated if value above is non-zero
Property Taxes	0
Insurance	0
Office	0
Oil and Fuel	0
Accounting and Legal	0
Labor	0
Total Expenses	Calculated
Operating Cost per kWh ($'s/kWh)	Calculated

FarmWare estimates as a percent of capital – unlikely to be a good assumption
Must also include enough expense for capital replacement

4. Financial Assumptions and Analysis

- Must use discounted cash flow analysis technique
- Financial feasibility highly dependent upon grants and loan guarantees

Financial Assumptions

Table 8. Financial Assumptions for the Base and FarmWare Assessments.

Variable	Value
Percent Financing on Personal Property	65%
Term on Personal Property (years)	7
Rate on Personal Property (%)	8%
Percent Financing on Real Property	70%
Land percent financed	80%
Term on Long-Term Financing	20
Rate on L.T. financing	8%
Discount Rate	10%
Terminal Value Multiple	10
Terminal Value Implied by Discount Rate	Calculated

Terminal values can have a large impact of viability
Discount rate should be based on cost of capital

First Period Income Statements

Revenues	Base Case	FarmWare	% Difference
Energy value to dairy	$41,040	$41,040	0%
Energy Sales to Grid	$50,270	$67,307	34%
Performance Incentive	$99,103	$133,152	34%
Tipping Fees Net of Disposal Costs	$0	N/A	N/A
Carbon Credits	$8,340	$8,340	0%
Gross Revenues	$198,753	$249,838	26%
Operating Expenses			
Grant	-$70,706	-$27,278	-61%
O&M	$47,013	$39,430	-16%
property taxes	$0	$0	
Insurance	$0	$0	
Office	$0	$0	
Oil and Fuel	$0	$0	
Accounting and Legal	$0	$0	
Labor	$0	$0	
Depreciation	$59,344	$37,080	-40%
Interest	$51,364	$43,805	-15%
Total Expenses	$96,916	$92,995	-4%
Net Income	$101,838	$156,843	54%
EBITDA	$212,440	$227,793	7%

Cash Flows Over Time

Table 10. Net Cash Flows and Net Present Value for the Two Examples.

Year	Base	FarmWare
0	-$970,350	-$818,405
1	$222,446	$227,795
2	$151,739	$210,418
3	$151,739	$210,418
4	$52,637	$77,266
5	$52,637	$77,266
6	$52,637	$77,266
7	$52,637	$77,266
8	$52,637	$77,266
9	$52,637	$77,266
10	$52,637	$77,266
Terminal Value	$526,371	$772,663
Net Present Value	-$153,440	$280,486
IRR	6.3%	17.1%
NPV with Zero Terminal Value	-$336,086	$12,380
IRR No Terminal Value	-2.0%	10.5%

This analysis shows that profitability is marginal at best. Note the key differences and why they arise.

How Might Profitability be Improved?

- Perhaps on-farm energy use assumption is too low
  - More on farm energy use would result in a higher net price for energy
  - What does this do to NPV in the "base" example?

Impact of On-Farm Energy Use

Table 11. The Impact of Altering Existing On-Farm Energy Use on the Profitability of an AD System.*

Total Energy Use (kWh/yr)	Energy Use per Cow (kWh/yr)	Average Price Received ($'s/kWh)	Annual Energy Savings and Sales	NPV	% Change in NPV
342,000	342	0.0819	$91,310	-$356,086	0
500,000	500	0.0890	$99,210	-$287,544	14%
750,000	750	0.1002	$111,710	-$210,737	37%
1,000,000	1000	0.1114	$124,210	-$133,930	60%
1,250,000	1250	0.1200	$133,788	-$75,081	78%

* The analysis assumes the retail price of electricity is $0.12 per kWh and the wholesale sales price is $0.07 per kWh. Annual electrical output of the system is estimated at approximately 1.1 million kWh annually.

How Might Profitability be Improved?

- Perhaps the system can make more biogas
  - Would lower average price (more sold at wholesale)
  - Would increase total revenues through sale of more units

Increased Biogas Production

Total Biogas Output (MMBTU's/yr)	BTU's per Lactating Cow per Day	Average Price Received ($'s/kWh)	Annual Energy Sales	NPV	% Change in NPV
16,907	51,000	0.0819	$91,310	-$336,086	0
18,597	56,100	0.0808	$99,115	-$257,059	24%
20,288	61,200	0.0799	$106,919	-$178,032	47%
21,979	66,200	0.0792	$114,723	-$99,005	71%
24,097	[illegible]	0.0783	$124,500	$0	100%

* The analysis assumes annual on-farm energy consumption of 342 kWh per cow, $0.12 per kWh for retail electrical, and $0.07 per kWh for wholesale energy sales.

How Might Profitability be Improved?

- What about higher production and higher on-farm utilization?
  - On-farm energy use @ 750 kWh/cow/yr

Energy Use at 750 kWh/cow/yr and Higher Biogas Yields

Total Biogas Output (MMBTU's/yr)	BTU's per Lactating Cow per Day	Average Price Received ($'s/kWh)	Annual Energy Sales	NPV	% Change in NPV
16,907	51,000	0.1002	$111,730	-$210,737	
18,597	56,100	0.0975	$119,315	-$131,710	38%
20,288	61,200	0.0952	$127,319	-$52,683	75%
21,979	66,300	0.0932	$135,123	$26,344	113%
24,097	[illegible]	0.0912	$144,900	[illegible]	159%

* The analysis assumes annual on-farm energy consumption of 750 kWh per cow, $0.12 per kWh for retail electrical, and $0.07 per kWh for wholesale energy sales.

How Might Profitability be Improved?

- How about higher electrical prices?
  - Base price was $0.12 for retail and $0.07 for wholesale

Increasing Electrical Prices

Price Increase From Base	Average Price Received ($'s/kWh)	Annual Energy Sales	NPV	% Change in NPV
0	0.0819	$91,310	-$336,086	
10%	0.0901	$100,441	-$279,980	17%
20%	0.0983	$109,572	-$223,873	-6%
30%	0.1065	$118,703	-$167,767	50%
40%	[illegible]	[illegible]	[illegible]	[illegible]

* The analysis assumes a biogas energy yield of 51,000 BTU's per lactating cow per day and on-farm energy use of 342,000 kWh/year.

Break-even price under these assumptions is $0.131 per kWh

How Might Profitability be Improved?

- Adding additional waste streams to digester
  - May provide tipping fees
  - Increases gas production
  - Make sure to account for disposal costs

Adding Additional Wastes

Tons Per Day of Additional Waste	Average Price Received ($'s/kWh)	Annual Net Tipping Fees	Annual Energy Sales	NPV	% Change in NPV
0	0.0819	$0	$91,310	-$336,086	
3	0.0803	$10,950	$103,441	-$145,963	57%
6	0.0791	$21,900	$115,572	$44,160	121%
9	0.0781	$32,850	$127,703	$234,283	211%
12	0.0773	$43,800	$139,834	$424,406	301%

* The analysis considers various adding various amounts of an additional waste stream with 40% VS content, the same conversion rates to biogas as manure, $10 per ton net tipping fees, annual on-farm energy consumption of 342 kWh per cow, $0.12 per kWh for retail electricity, and $0.07 per kWh for wholesale energy sales. The analysis holds operating costs constant so should be interpreted with caution.

This assumption has the greatest apparent impact on profitability. Make sure to be realistic in the costs and revenues obtained.

Summary: Improving Profitability

- Solid understanding of energy use is necessary
- It appears that adequate profitability can be obtained under the right circumstances
  - Increasing net revenues
  - Increasing gas yields
  - Adding other wastes

Caution: These analyses did not alter operating costs. Nothing comes for free; make sure to account for this in your assessment.

5. Some Cautions

Be very careful in evaluating the benefits of:

- Bedding
- Nutrient stabilization
- Reduced waste hauling
  - In almost all cases a digester is not required to receive these benefits
  - As such the benefits should not accrue to the digester

Digestion Economics

- Good estimates of capital costs and outputs are absolutely necessary
- Need to be realistic about operating costs
- Conservative estimates likely the safest route
- Basic evaluation tool available if interested bg49@cornell.edu