Creating Renewable Energy From Livestock Waste: Overcoming Barriers to Adoption

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Agenda and Goals for Today

• The opportunity for livestock waste
• Barriers to adoption
• Conclusion
Opportunity for Livestock Operations

• Livestock operations have considerable energy generating potential
  – Biomass is low-cost
  – Collected in one spot
  – Consistently supplied
  – Proven technology to harvest the energy
  – Economics can be greatly enhanced by processing other organic materials
Manure Trivia

How much manure does a lactating dairy cow produce daily?

A) 50 lbs  
B) 100 lbs  
C) 150 lbs  
D) 200 lbs  
E) More than 200 lbs
Livestock Sector

- Economics drives towards CAFO’s
  - Large farms = large piles
  - Increasing pressure to treat
  - Increasing regulation
  - Waste is one limiting factor in drive to larger systems
Understanding the Agricultural System

- Sunlight
- Capital
- Nutrients
- Chemicals
- Energy
- Labor
- Genetics
- Transport and logistics

Recycled Nutrients

Food – Grains

NREL Biorefinery

KEY POINTS:

- Many potential synergies between system components
- Public perception and policy is an important driver of prices – renewable energy contains many non-market goods

Optimal output of the system determined by:

- Relative prices for each input/output
- Costs/technology for conversion of inputs to outputs
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 – air quality and nutrient capture
Anaerobic Digestion

- Works with wet material
- Well known and understood
- Biogas = 55-65% methane + impurities
- Various styles and approaches to technology
Anaerobic Digestion of Livestock Waste

- Breakdown of organic material in an oxygen free environment (air tight tank)
- Designed to handle high moisture products
- Methanogenic bacteria process organic materials to produce biogas (60-70% methane)
- Gas can be cleaned to be equivalent to natural gas
- Reduces odors in livestock waste
- Simple process creates a compost type fertilizer product
Anaerobic Digester
The Products of AD

- Renewable energy
  - Typically electricity
- Waste management
  - Odor control and intensive waste management
- GHG reduction
  - Methane gas destruction

Given the limited adoption of AD in the U.S. it is obvious that at current prices for these outputs, the incentives are insufficient for adoption.
Agricultural CO2e Emissions by Source, 2007

Total Emissions = 413.1 Tg CO2e

- Soil Mgmt: 207.9 Tg CO2e (50%)
- Enteric Fermentation: 139 Tg CO2e (34%)
- Manure: 58.7 Tg CO2e (14%)
- Other: 7.6 Tg CO2e (2%)

Manure methane is frequently viewed as an important potential ag offset.

Offset created by capturing andcombusting the methane (gwp = 21 vs. CO2 =1)

Percent of Manure Methane Emissions by Livestock Sector, 2007

- Dairy: 41%
- Swine: 45%
- Beef: 6%
- Poultry: 6%
- Others: 2%

Total Methane Emissions = 44 Tg CO2e

Room for More AD in the US?

- Digesters: 97 operating and 80 in planning in the US (2006 AgStar)
  - Germany today operates 1,900+ farm biogas plants
- Potential sites: 6,904 dairies and hog sites that are legitimate candidates (EPA)
  - Would result in a 66% methane reduction for these sectors
- For dairy alone manure methane emissions in dairy could be reduced by 50% with a carbon price of $15 per MT CO2e
What We Know About AD

• 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
Keys to Economical Biogas Systems

1. Scale appropriate for
   – Professional management
   – Modern technology
   – Competitive energy sale

2. Attractive energy sale option
   – Electricity or other use for gas
   – Willing (enthusiastic) buyer
   – Able to monetize environmental attributes

3. Ability to add wastes beyond manure
Barriers to Widespread Development
Barriers to Overcome

1. Site specific approach and technology
   - Manure has low energy density
   - Good for co-digestion
   - Limits number of economical sites
   - Many potential contaminants
   - Large number of farmers to work with

2. Different energy markets

3. Markets for positive externalities
Low Energy Density of Feedstock

Table 2. Energy Content and Value of Potential AD Feedstocks

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pounds of manure per ton</td>
<td>2,000</td>
</tr>
<tr>
<td>Volatile solids content (%)</td>
<td>11%</td>
</tr>
<tr>
<td>Solid conversion to biogas (%)</td>
<td>30%</td>
</tr>
<tr>
<td>Cubic feet of biogas per lb of volatile solid converted</td>
<td>20</td>
</tr>
<tr>
<td>BTU's per cubic foot of biogas</td>
<td>625</td>
</tr>
<tr>
<td>BTU’s per ton</td>
<td>850,000</td>
</tr>
<tr>
<td>Value per MMBTU ($'s)</td>
<td>7</td>
</tr>
<tr>
<td>Value per ton of waste ($'s/ton)</td>
<td>5.95</td>
</tr>
</tbody>
</table>

*Values derived from various sources including: Krich, et.al., Martin and Roos.*
## Energy Markets

<table>
<thead>
<tr>
<th>Market</th>
<th>Current Status</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-farm use</td>
<td>Well established in practice</td>
<td>Limited to energy used by individual farms.</td>
</tr>
<tr>
<td>Industrial process</td>
<td>Biogas substituted for natural gas by nearby industrial user. Few applications currently in practice.</td>
<td>Very limited/site specific.</td>
</tr>
<tr>
<td>Electrical</td>
<td>Sold to electrical grid. Commonly used in practice.</td>
<td>Large potential market. Each sale must be negotiated individually.</td>
</tr>
<tr>
<td>Natural gas transmission network</td>
<td>Biogas must be cleaned and compressed. Only a few applications in the United States.</td>
<td>Large potential market. Standards for biogas quality required are not well developed. Must negotiate with each utility.</td>
</tr>
<tr>
<td>Transport fuel</td>
<td>Biogas must be cleaned and compressed. Some use in Europe</td>
<td>Large potential market. Many technical and practical hurdles to adoption.</td>
</tr>
</tbody>
</table>
Environmental Attributes

• The size and outlook of the opportunity is dependent upon the extent to which consumers and the government remain willing to support the environmental benefits of biogas
  – Produces renewable energy
  – Environmental solutions
Approaches to Barriers

• Currently there are limited incentives with a mix of local, state, and federal policies
  – Construction subsidies – high cost (impact ?)
  – Loan guarantees – lower cost and high impact
  – Various state and local policies on net metering
  – Some utilities providing variable rate incentives
  – Voluntary market for environmental attributes
The Need

• Coherent policy
  – Variable rate incentives for electricity or gas
  – Mandate for renewable electricity – must allow flexibility
  – Clear environmental policy
  – National standards for biogas quality
  – Incentives for new technology development
  – Incentives for new markets (compressed biomethane)
  – Need for industry organization/representation
  – Research on prospects for using other substrates/crops
Questions
Supply of CO2 Offsets from Anaerobic Digestion on U.S. Dairy Farms, Million Metric Tons of CO2e

Offset Price ($/Metric Ton of CO2e)

Base Parameters:
Alpha = 10,000
Beta = 0.70
S = 1,100
kwh/cow/year
δ = 0.05
n = 20
γ = 0.035
P_g = 0.05

Million Metric Tons of CO2e

Offset Price ($/Metric Ton of CO2e)