Making Digesters Work: The economics of bedding and co-feeding

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Making digesters work…

- Technology
- Operational
- AD system profitability
U.S. on-farm AD’s

151 Total Systems, 450,000 MWh/yr

Profitability – traditional view

Anaerobic Digester

Biogas Utilization
Profitability – traditional view

- Energy production (electrical)
- Manure treatment
  - Odor control
  - Stabilization
  - Pathogen reduction
Profitability – modern view

Feedstock Source & Collection

Anaerobic Digester

Biogas Utilization

Digestate Management
Profitability – modern view

- Energy production
  - Electrical
  - Natural gas (CNG)

- Environmental attributes
  - Renewable energy certificates
  - Carbon credits

- Digester fiber (pathogen reduction)

- Manure treatment
  - Odor control
  - Stabilization
  - Pathogen reduction
Challenges with AD systems

- Operations
- Safety
- Capital cost
- Access to markets
  - Location
  - Utilities
- Revenue generation
  - Low value of products
  - Assessing value of environmental benefits
- Technological gaps
  - Nutrient separation/utilization
  - Liquid reduction
  - CNG vehicle conversion
Operational - bedding
Bedding and anaerobic digestion

- Increased volume
- Addition of inorganic material
  - Sludge/grit accumulation
  - Crusting
- Equipment wear
- Heating requirements
- Biogas production per unit volume
Bedding material costs

- Sand – $0.18 to $0.30/cow/d
  ($7-$12 per ton, 50 lb/cow/d)
- Wood shavings – $0.30/cow/d
  ($50 per ton, 12.1 lb/cow/d)
- Digester fiber – $0.08 to $0.19/cow/d
  ($15-$20 per ton, 19 lb/cow/d)
- Compost – $0.35 to $0.85/cow/d

1MSU Dairy Farm. 2010. Sawdust purchase price.
2Quantum Dairy and Willow Point Dairy data. 2010.
### Bedding & dairy performance

Table 3. Sand-bedding benefits compared with mattress herds for 62 freestall herds investigated by our Food Animal Production Medicine group since 2001.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mattress Herds</th>
<th>Sand Herds</th>
<th>Sand Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHA milk production per cow (lb)</td>
<td>24,260</td>
<td>25,926</td>
<td>+1,666</td>
</tr>
<tr>
<td>Somatic Cell Count ('000/ml)</td>
<td>373</td>
<td>298</td>
<td>-75</td>
</tr>
<tr>
<td>Cow Case Mastitis Rate (%)</td>
<td>62</td>
<td>45</td>
<td>-17</td>
</tr>
</tbody>
</table>

Sand bedding & digestion

- Sand bedding can be used successfully on farms digesting manure
  - Green Meadows Farms, Inc
  - Fair Oaks Farms
  - Central Sands Dairy
  - Lake Breeze Dairy
  - Qualco Energy
Sand bedding & digestion

- Separation is essential
- Separation system characteristics:
  - Sand removal >90%
  - Mean particle size reduction
  - Minimal dilution water
  - Retention of organic material
Conceptual sand separation system for digestion

Sand Laden Dairy Manure (SLDM)

Primary Separation (coarse & medium grain)

Secondary Separation (fine & medium grain)

Tertiary Separation (fine & medium grain)

Digester

Solid/liquid Separation

Recycled Liquid
Sand separation components
Observations from Green Meadow Farms

- Sand separation operating for 12 years
- Digester operation since 2007
- Sand separation >90%
- Residual sand particle size reduced
- Volatile solids loss
- Volume increase
- No significant sand/sludge accumulation observed as of the fall of 2009
System profitability

Increasing revenue!
AD system cost

- Capital costs are highly variable
  - System type
  - Biogas utilization
  - Interconnection
  - Digester capital costs
    - $280 to $630 per cow
    - $452 to $1,173 per cow
    - $1,150 to $5,300 per cow

- O&M cost vary with technology
  - Digester - 2% of capital/yr
  - Generator - $0.01 to 0.02 kWh

4 Lazarus, 2010
Conventional sources of revenue

**Electricity**
- Electrical potential: 3 to 7 kWh/cow/d
- Electrical value: $0.04 to $0.09 kWh
- Revenue (offset): $44 to $230/cow/yr

**Carbon credits**
- Carbon credit potential: 2 to 5 Mton/cow/yr
- Carbon credit value: ?? $0.05 to $1 Mton ??
- Revenue: $0.1 to $5/cow/yr

*Values presented are only intended to indicate order of magnitude.*
Conventional sources of revenue

Renewable energy certificate (REC)
- REC value: $10 to $40/MWh
- Revenue: $11 to $100/cow/yr

Thermal energy*
- Thermal potential: 3 to 7 kWh/cow/d
- Thermal value: $0.025 kWh
- Revenue: $28 to $64/cow/yr
Increasing revenue - bedding
Additional sources of revenue (cost offset)

Digester fiber bedding

- Fiber value: $15-$20 per ton
- Bedding usage: 10 to 23 lb/d/cow
- Cost offset: $0.08 - $0.23/cow/d
  $29 to $84/cow/yr
Increasing revenue - co-feeding
Feedstock biogas potential

Kestutis Navickas. 2007. Bioplin Tehnologija in Okolje,
Additional sources of revenue

Co-feeding

- Fatty wastes = 400 m$^3$/mton (15,500 ft$^3$/t)
  - Methane = 8,500 ft$^3$/t
  - = 745 kWh /t
  - = $45/t @ $0.06 kWh
  - Tipping fee = 254 gal/t
  - = $15/t @ $0.06/gal

Tipping fees are variable & market driven
Co-feeding, cont.

- Fatty wastes = 400 m$^3$/mton (15,500 ft$^3$/t)
  - Revenue = $60/t
    = 5.4 t/cow/yr (@20%)
    = $320/cow/yr

- Disposal = $7.6/ton @ $0.03/gal
  = $40/cow/yr
# Digester revenue summary

## Conventional
- **Electricity**: $44 to $230/cow/yr
- **REC’s**: $11 to $100/cow/yr
- **Carbon credits**: $0.1 to $5/cow/yr

**Total**: $55 to $335/cow/yr

## Modern/additional
- **Heat**: $28 to $64/cow/yr
- **Bedding**: $29 to $84/cow/yr
- **Co-feeding**: $25 to $200/cow/yr

**Total**: $82 to $335/cow/yr

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**Capital Cost**: $500 to $1,200/cow
Other opportunities for added value products (revenue)

- Organic amendment
- Nutrient separation
- Finished compost
- Composite material
- Integrated energy production system
  - Ethanol
  - Combustion/gasification
  - Algae
Increasing revenue comes with costs

- Additional management/labor
- Permits
- Digester fiber bedding
  - Storage
  - Freestall management
  - Animal health / milk production
- Co-feeding
  - Consistency (quality & supply)
  - Market forces
  - Record keeping
  - Digestate management
  - Nutrient management
Others opportunities for improving profitability

- Feedstock blending
- Biogas utilization
  - Hydrogen sulfide
  - Conversion efficiency (CHP/IC)
  - Upgrading to CNG
- Value added use of digestate
  - Nutrient recovery
  - Biofiber
- System optimization
  - Configuration
  - Enzyme and nutrient additives
  - Microbial/algal community
- Integration of systems