Digester Technology: Trends & Costs

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Transition to a Bioeconomy: The Role of Extension

June 30 – July 1, 2009
Double Tree Hotel, Little Rock, Arkansas
Components of a Typical Digester System

Source: Thompson and Voell, Introduction to Anaerobic Digester Biogas Systems, Nebraska Methane Recovery Workshop, 4/3/09
Potential Sources of Value from a Digester

- Energy
- Odor Control
- Methane (Greenhouse Gas) Destruction
- Reduction in Pathogens and Oxygen Demand
  (If coupled with solids separation equipment)
- Solids (Fiber) for Bedding or as a Soil Amendment
- Phosphorus and Nitrogen Reduction
Digester Designs and Components

Covered lagoon digester

Complete mixed digester

Plug flow digester

Engine-generator set
Haubenschild Farms Plug Flow Digester, Princeton, MN
Fangel biogas digester in Denmark
## Digester Projects by Operational Status

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Operational</th>
<th>Construction</th>
<th>Planned</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>107</td>
<td>18</td>
<td>55</td>
<td>180</td>
</tr>
<tr>
<td>Swine</td>
<td>19</td>
<td></td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>Layers</td>
<td>3</td>
<td>1</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Duck</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Broiler</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Beef</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Mixed</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Veal</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>135</strong></td>
<td><strong>22</strong></td>
<td><strong>64</strong></td>
<td><strong>221</strong></td>
</tr>
</tbody>
</table>

Electrical generation equipment is installed on 113 of the 135 operational systems.

Source: AgSTAR
Today 125 Operating Manure Digesters

Source: Kurt Roos, Expansion of the U.S. Digester Market in the Dairy and Pork Sector, 2009
AgSTAR National Conference, Baltimore, 2/24/09
Number of Digesters Becoming Operational by Year (1979-2009)

Source: AgSTAR
Number of Digesters Becoming Operational Per Year (1979-2008)

Source: Thompson and Voell, Introduction to Anaerobic Digester Biogas Systems, Nebraska Methane Recovery Workshop, 4/3/09
How Much Can Biogas Contribute to the Energy Supply?

- The 35 MW generating capacity of the currently-operating U.S. farm digesters compares to total U.S. electrical generating capacity of 1,067,010 MW.
- AgSTAR estimates that 6,500 large dairy and swine operations could potentially operate profitable biogas systems and provide 802 MW (0.1% of the U.S. total).
- In Germany, over 3,700 biogas plants are in operation with a combined capacity of 1,270 MW. This would represent around 1% of Germany’s electricity needs.

Sources: EPA AgSTAR, EIA, German Energy Agency.
Assumptions for Economic Scenarios

**Investment Requirement:**
Regression equation based on 16 recent plug-flow digesters:

$678,064 + \$563/dairy cow

Utility connection charges and H2S treatment could add ~ 13%

Investment requirement at two example farm sizes:

- 700 cows - $1.2 million  $1,714/cow
- 2,800 cows - $2.5 million  $893/cow

**Capital cost** (6%, 20 year life): 9% of investment/year

**Operation and maintenance costs:** 5% of investment/year?

**Electricity output:** 1,000 KWH/cow/year
Sources: Investment equation from Crenshaw, electricity output from Gooch.
Typical Digester Electricity Pricing Arrangements

- Buy all – sell all
- Surplus sale with standby charges
- Net metering
Economic Scenarios

<table>
<thead>
<tr>
<th></th>
<th>700 cows</th>
<th>2,800 cows</th>
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</thead>
<tbody>
<tr>
<td>Investment</td>
<td>$1.2 million</td>
<td>$2.5 million</td>
</tr>
</tbody>
</table>

Electricity breakeven prices (cents/KWH)
- No subsidies or other value: 22 cents, 12 cents
- REAP grant 25% of investment: 18 cents, 10 cents
- REAP grant & bedding value: 14 cents, 6 cents

Electricity market
- Retail price (EIA, 4/09): U.S. average 9 cents
  range 5 cents (ID) to 16 cents (CT)
- Generation cost (my estimates): average 5.4 cents
  range 2 cents (ND) to 11 cents (CT)

Value of odor control, carbon credits, RECs, pathogen reduction, other??
Trends and New Developments

**Policy**
- Developing carbon markets, partly in anticipation of a U.S. mandatory policy
- Concerns about engine NOx emissions
- Tighter limits on nutrient emissions, emergence of water quality trading

**Technical**
- New designs, pretreatment techniques and larger digester sizes
- Cheaper systems for removing H2S and other biogas impurities
- More digesters on swine and poultry operations?
- Digesters integrated into further treatment systems to reduce nutrient emissions
- Co-digestion with organic wastes from off-farm sources
- Biogas injection into the natural gas grid or compressed for vehicle use

**Economic/information**
- More involvement of third parties in operation and ownership of digester systems
Thank you!

Questions?