What Kinds of Digesters Fit into What Kinds of Farms and How Do They Work?

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Presentation Overview

• What are anaerobic digesters?
• What makes them work?
• What kinds of systems are there?
• Where do they make sense?
• What benefits do they offer?
• What do they cost?
• What is the status of US livestock digester?

Introduction: Farm Processes
What are Anaerobic Digesters?

Biological treatment/stabilization systems applicable to liquid, slurry, and semi-solid waste that collect and combust off-gases. Digesters separate manure treatment from storage functions which can result in lower initial installation costs for new or expanding farms.

Typical Digester Configuration

What Makes Digesters work?

Anaerobic digestion is a biological process. It occurs in an oxygen-free environment.

Methanogens

Industry Interest in Anaerobic Digestion Technologies

1) Offer Air Quality benefits
   - Control odors from storage and field application
   - Reduces Greenhouse gases (methane)
   - Controls other emissions (H₂S)

2) Offer Water Quality benefits
   - Stabilize manure organics (BOD)
   - Significantly reduce pathogens
   - Provide nutrient management predictability and flexibility

3) Offer return on Investment
   - Energy revenues
   - Carbon Markets
   - Greenhouse Production
   - Peat market (dairy only)
   - Bedding offsets (dairy only)

Example Retrofit Project

Retrofit Plan

Before After

Anaerobic Digester Types

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Lagoon</th>
<th>Complete Mix Digester</th>
<th>Plug Flow Digester</th>
<th>Attached Film</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestion Vessel</td>
<td>Deep Lagoon</td>
<td>Round/Square Digestion</td>
<td>Rectangular/Flue</td>
<td>Tank</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Harvest</td>
<td></td>
</tr>
<tr>
<td>Level of Technology</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Supplemental Heat</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Total Solids</td>
<td>0.5 - 3%</td>
<td>3 - 10%</td>
<td>11 - 13%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Solids Characteristics</td>
<td>Fine</td>
<td>Coarse</td>
<td>Coarse</td>
<td>Very Fine</td>
</tr>
<tr>
<td>HRT (days)</td>
<td>40-80</td>
<td>15+</td>
<td>15+</td>
<td>2+</td>
</tr>
<tr>
<td>Farm Type</td>
<td>Dairy, Hog</td>
<td>Dairy, Hog</td>
<td>Dairy Only</td>
<td>Dairy, Hog</td>
</tr>
<tr>
<td>Optimum Climate for Energy Production</td>
<td>Temperate and Warm Climates</td>
<td>All Climates</td>
<td>All Climates</td>
<td>Temperate and Warm Climates</td>
</tr>
</tbody>
</table>
Selecting a Digester

- Hog and Dairy industry constitute >90% of market potential

Covered Anaerobic Lagoons

USDA Practice Standard 365, Ambient Temperature

Lagoon Considerations

- Sized to maintain bacterial populations to ensure year round manure treatment and gas production
  - Loading Rate and Hydraulic Retention Time are key
  - Dairy requires separation
Cover Considerations

- Functions to continuously move gas to a gas take-off point

- Three considerations:
  - Fabrication: Cover assembly and installation critical
    - Quality, non-leaking seams are key (air intrusion)
  - Materials: Need to resist sun, temperature extremes
    - Tearing, blistering, and de-lamination
  - Design: Stress caused by wind rain and other natural occurring events
    - Rainfall accumulation can interrupt gas flow
    - Stress can tear or sink covers causing catastrophic failure

Cover Types

- **Bank-to-Bank**: Field fabricated cover completely spans lagoon surface and edges secured in perimeter trenches
  - All off-gases are captured
  - All precipitation is excluded from lagoon
  - Requires proper floatation

- **Modular**: Uses smaller multiple cover sections over 50-90% of lagoon surface area, secured w/ tether ropes, cable, or perimeter trenches
  - Modules fabricated off-site and assembled on-site
  - Can be installed in stages reducing one-time capital outlay
  - Rainfall is not excluded
  - Requires proper floatation

Cover Types: Illustrated

- Bank-to-Bank
- Modular Cover
Material and Design Failures

Plug Flow Digester
USDA Practice Standard 366, Controlled Temp.

Complete Mix Digester
USDA Practice Standard 366, Controlled Temp.
US Background

Digester Distribution 2005

- @100 operational
- @90 in planning

Project Types

- **On-Farm or Farm Scale**: System is owned and operated by farm owner/manager
  - Currently the predominant project type in the U.S.
- **Regional or Centralized Digesters**: Off farm management and operation with a third party
  - Ideally located at a large energy (electric or heat) consuming source or interconnection point (feed mills or utility substation)

General Costs: Livestock Basis

<table>
<thead>
<tr>
<th>Digester Type</th>
<th>Cost per Cow (1,400 lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attached Media</td>
<td>$500-800</td>
</tr>
<tr>
<td>Complete Mix</td>
<td>$400-700</td>
</tr>
<tr>
<td>Covered Lagoon</td>
<td>$300-1,000</td>
</tr>
<tr>
<td>Plug Flow</td>
<td>$400-700</td>
</tr>
</tbody>
</table>

Swine equivalents:
- 4 sows = cow
- 10 feeder pigs = cow

Most important factor affecting Covered Lagoon cost is process water

Higher HRT = larger lagoon = more surface area to cover = higher cost

Note: Cost assumes all manure is collected and include engine gensets and separators (dairy systems)
Cost Ranges Can Be Larger

Financial Performance
Costs of 35 Commercial Digester Projects

Breakeven Price (kWh)

Cost per kW Installed

AgSTAR Resources

Thank You

AgSTAR National Conference, Sacramento, Nov. 27-28
See the AgSTAR Website at www.EPA.GOV/AGSTAR