How a digester can help manage livestock manure/nutrient issues

Technical issues of digester integration into an energy/nutrient management system and cogeneration

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A webcast on Anaerobic Digesters as a tool for energy production, manure/nutrient management and revenue generation. October 26, 2011

Improving Lives. Improving Texas.
Covered Lagoon digester-Up to 3% solids (ambient temps)

Complete Mix (CSTR) digester 3-10% solids (Mesophylic- ~ 95 °F)

Plug Flow digester 11-13% solids

Schematics Source: AgSTAR-USEPA
Biogas plant with co-fermentation

Source: Biogas – an Introduction. 2009, Federal Ministry of Food, Agriculture and Consumer Protection, Germany
Typical Net Biogas Production and Fuel Equivalents

(Livestock waste facilities handbook, MWPS-18, 1985)

- 39 cubic feet (ft³) Biogas per day per 1000 lb body wt. or
- **51 cubic feet/1,300 lb cow/day**
- 54% methane
- 26,910 Btu/day/cow
  - Fuel Equivalents
  - Natural gas ~28 ft³/day
  - Propane ~ 0.29 gal/day
  - Diesel- 0.18 gal/day
  - ~1.6 kWh/day/cow @ 20% Conversion Efficiency (CE)

EPA-AgSTAR FarmWare V3.5, 2010

- 57.5% methane for dairy farms
- Electricity- 35% CE.
>40% CE possible with new generation ICE Generators. 
~ 3kWh/day/cow or ~1100 kWh/yr/cow **Electricity Production is possible**
A CHP generator produces 40-50% waste heat. Heat is recovered for heating the digester and for other uses on the farm. Heat exchangers may recover ~7,000 BTUs of heat per hour/kW load produced.~1,100 Deg. F
Electricity use and price, by region and commodity (Averages)

<table>
<thead>
<tr>
<th>Region</th>
<th>Per farm (kWh/yr)</th>
<th>Per head (kWh/yr)</th>
<th>Price ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>128,918</td>
<td>1,048</td>
<td>0.069</td>
</tr>
<tr>
<td>West</td>
<td>288,702</td>
<td>893</td>
<td>0.058</td>
</tr>
<tr>
<td>Midwest</td>
<td>101,175</td>
<td>1,102</td>
<td>0.064</td>
</tr>
<tr>
<td>South</td>
<td>159,349</td>
<td>791</td>
<td>0.065</td>
</tr>
<tr>
<td>Northeast</td>
<td>106,418</td>
<td>1,080</td>
<td>0.085</td>
</tr>
</tbody>
</table>


**Biogas to electricity potential - 1,100 kWh/yr/cow**
Total dairy electrical energy usage subdivided according to different parts of the operation.

Horizontal lines indicate the range of total electrical energy usage values estimated using the USDA farm energy calculator
(C1-C4 = Central Texas; P1-P2 = Texas Panhandle; E1 = Northeast Texas; D1-D2 = Northern San Joaquin Valley; W1-W5 = Central San Joaquin Valley).

In 2010
162 total ADs in USA
Source: AgSTAR-USEPA

Major Organic Substrates Used German Digesters
41% Animal Manure- 47% other biomass

Redline: Electrical Capacity, Mega Watt

Yellow bars
Number of Plants

Source: Biogas – An introduction. 2009. Federal Ministry of Food, Agriculture and Consumer Protection, Germany
**Corn feed and fodder Issues**

"Excuse me. I'm going to need this to run my car."

Michael Ramirez © IBDeitorsials.com/cartoons

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**Biomass Biogas Yield Potential**

Graph Source: Biogas – an Introduction. 2009. Federal Ministry of Food, Agriculture and Consumer Protection, Germany
Digester Influent Issues
Digester Feedstock and Nutrient Management Issues

Scraped and Piled
Soil (inert material) content.
Water requirements

Matching manure to digester
Matching digestate to nutrient management plan

Open lot Corrals ~30-40% of total manure generated on concrete apron?

Vacuumed Slurry-
Bedding type-Sand or biomass?
Nutrient quantities in raw and digested manure remain nearly unchanged.

Biochemical changes during digestion may enhance nutrient availability to crops.

For co-digestion, dry matter and nutrient content should be known for each substrate for proper nutrient management planning.
Nitrogen composition of raw and digested dairy slurry
(Ave. of 52 weeks of raw and digested slurry)       Source: IEA Bioenergy, Lukehurst et al., 2010.

<table>
<thead>
<tr>
<th></th>
<th>(g/kg)</th>
<th>(g/kg fresh)</th>
<th>(g/kg fresh)</th>
<th>(% Total N)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feedstock</strong></td>
<td>72.2</td>
<td>7.2%</td>
<td>3.5</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Digested</strong></td>
<td>59.3</td>
<td>5.9%</td>
<td>3.6</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Change</strong></td>
<td>−17.9%</td>
<td>+2.8%</td>
<td>+20%</td>
<td></td>
</tr>
<tr>
<td>Standard deviation feedstock</td>
<td>8.50</td>
<td>0.52</td>
<td>0.36</td>
<td>0.34</td>
</tr>
<tr>
<td>Standard deviation digestate</td>
<td>5.22</td>
<td>0.48</td>
<td>0.43</td>
<td>0.23</td>
</tr>
</tbody>
</table>

7 lb/ton

4 lb/ton

4.8 lb/ton
Digester Feedstock and Nutrient Management Issues…

- Increased nutrient content due to co-digestion may require more land due to increased N, P and K in the digested effluent
- Increased volume of total effluent from digester requires increased effluent storage volume
Digester Feedstock and Nutrient Management Issues…

- Produces a dryer and stackable fraction of solids for bedding, composting or distant hauling and spreading
- Provides opportunity to reuse the solids fraction as a co-digestion material
- Reduces the volume of liquid requiring storage
- May improve N uptake from liquid fraction
- Reduces the need for extended mixing/agitation of the liquid prior to land application
Operation and Maintenance Issues/Requirements

One trained person for up to 4 hours per day for \( \leq 500 \text{ kW} \) Generators
One trained person for more than 4 hours per day for \( > 500 \text{ kW} \) Generators

- Decanter Centrifuge
- Stacked belt drying
- Macerator
- Feedstock mixing feeding
In honor of Earth Day, she vowed to release no methane for 24 hours.