Sustainable Gas Systems - New Business Models

Manure-based Anaerobic Digestion
In New York State: Where we were, Where we are, and Where we can be

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Manure Based Anaerobic Digestion

- Reduction of Greenhouse Gas Emissions
- Odor Reduction
- Conservation of Crop Nutrients
- Improvement in Crop Utilization of Manure Nutrients
- Improvement of Water Quality Protection
Manure Based Anaerobic Digestion

- Generation of Renewable Fuel/Energy
- Revenue Potential
- Pathogen Reduction
- Pre-treatment (for advanced manure treatment)
- Co-digestion (landfill organic matter diversion)
Despite all of the benefits anaerobic digestion provides to farms and society, adoption has not been widespread due to economic challenges.

Existing On-Farm Digesters facing major overhauls are reluctant to reinvest.

Electricity sold at the LMP – Demand Charges
# Anaerobic Digestion

<table>
<thead>
<tr>
<th></th>
<th>Directly Monetizable</th>
<th>Society Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor Control</td>
<td>n</td>
<td>Y</td>
</tr>
<tr>
<td>Pathogen Reduction</td>
<td>n</td>
<td>Y</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Greenhouse Gas Reduction</td>
<td>y</td>
<td>Y</td>
</tr>
<tr>
<td>Water Quality Protection</td>
<td>n</td>
<td>Y</td>
</tr>
<tr>
<td>Fertilizer for Field Crops</td>
<td>n/y</td>
<td>dc</td>
</tr>
<tr>
<td>Low Cost Manure Application</td>
<td>v</td>
<td>dc</td>
</tr>
<tr>
<td>Nutrient Conc./Exportation</td>
<td>p</td>
<td>dc</td>
</tr>
</tbody>
</table>
NYS 2030 Goal:
50% Generation of Renewable Energy

Milk Products

Sustainable Farming Recycling Nutrients and Energy

Food Processing

Post-Consumer Food Waste

Cow Bedding Recovered and Recycled to Barn or Exported as Compost

Manure-Based Anaerobic Digestion

Effluent

Solid liquid separation

Engine Generator

Biogas Produced

Storage

Recycled Nutrients for Crop

Crops Fed to Cows

NYS Goal: Organic Waste Diverted From Landfills

Purchased Fertilizer Use Reduced

Recycled Nutrients for Crop

NYS 2030 Goal:
40% reduction in Greenhouse Gas Emissions

Renewable energy

Renewable Energy to the Community

Not Included:
Heat needed and used
Farm
Greenhouse
Aquaculture
Milk Processing
Gas cleanup and processing
On-farm use
RNG (RINS)
Pipeline
Environmental Values
Carbon Credit
Manure
Nutrients
Food Waste
Odor Control

Crops for Food, Fiber and Biomass

Crops for Food, Fiber and Biomass

Manure

Nutrients

Food Waste

Engine Generator

Generator

Not Included:
Heat needed and used
Farm
Greenhouse
Aquaculture
Milk Processing
Gas cleanup and processing
On-farm use
RNG (RINS)
Pipeline
Environmental Values
Carbon Credit
Manure
Nutrients
Food Waste
Odor Control
AD technology is readily available to dairy farms making farmers well-positioned to be key partners with the State in achieving its *renewable energy*, *greenhouse gas reduction*, *landfill organic matter diversion*, and *economic development* goals.
Development of a manure-based anaerobic digestion industry in NYS is much more than just about renewable energy and greenhouse gas reduction, it is as importantly about helping to position the NYS dairy industry to be viable and competitive in the years to come.
Baseline Emissions from Dairy Farm with No Renewable Energy System
(Per cow per year)

Fossil Fuel Used for
Electricity: (1100 kWh x 0.000526 MT CO₂eq. per kWh)
0.58 MT CO₂eq.

Effluent Storage
Emissions: 4.00 MT CO₂ eq.

Dairy Facility → Manure slurry → Long Term Storage

Cropland

Baseline Emissions from Dairy Farm with No Renewable Energy System
(Per cow per year)
Considerations in Calculating Social Cost of Carbon (SCC) Saved for Manure-based ADG Systems

• EPA SCC = $47.82/MTCO$_2$e
  - Average 2017-2019 value used by PSC in Zero Emission Credit From EPA at 3% discount value and adjusted for inflation

• Base Condition: The GHG emissions of the existing system
  - Assumed to be long-term slurry storage (representative of NYS dairy industry situation)

• Losses from ADG technology that may be included
Basis of Calculating Social Cost of Carbon Saved for Manure-based ADG Systems

- Fossil fuel avoided:
  - \(((\text{Total kWh} - \text{Parasitic kWh}) \times 0.000526 \text{ MT CO}_2\text{eq. per kWh})\)
  - Parasitic electrical energy accounted for - electrical energy specifically used to operate an ADG system
  - 0.000526 MT CO\textsubscript{2}eq. per kWh (NYS specific value)

- SCC Saved = $47.82 \times (\text{Base Condition} - \Sigma(\text{Losses}) + \text{Fossil fuel avoided})
Scenarios

- CONSERVATIVE values are those for a digester under normal management with no emphasis on GHG control.
- OBTAINABLE values are those for a digester under normal management with an emphasis on GHG control.
- OPTIMUM values are those for a digester under excellent management with an emphasis on GHG control.
ADG System with Solid-Liquid Separation

(MT CO₂e cow⁻¹ yr⁻¹ unless otherwise noted)

Dairy Facility → Anaerobic Digester → Solid/liquid Separator → Long Term Storage

- Fossil fuel avoided (produced - parasitic): 0.78 1.16 0.99 kWh cow⁻¹ yr⁻¹
- Fossil fuel used for electricity: 0.58
- Renewable energy produced: 1590 2229 1955 kWh cow⁻¹ yr⁻¹
- Un-combusted CH₄: 2.5E-3 3.2E-3 3.1E-3
- CH₄ leaks: 1.41 0.00 0.14
- Effluent storage emissions: 2.98 0.50 1.87

Un-combusted CH₄ emissions (produced - parasitic): 0.19 0.00 0.03

Source: Wright and Gooch, 2017
OBTAINABLE ADG System (includes post-digestion solid-separation) and Emphasis on GHG Control

<table>
<thead>
<tr>
<th>Units</th>
<th>Obt</th>
</tr>
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<tbody>
<tr>
<td>Fossil Fuels Avoided</td>
<td>0.99</td>
</tr>
<tr>
<td>Engine unburnt CH₄</td>
<td>3.1E-03</td>
</tr>
<tr>
<td>Flare unburnt CH₄</td>
<td>0.03</td>
</tr>
<tr>
<td>ADSystem Leaks CH₄</td>
<td>0.14</td>
</tr>
<tr>
<td>Storage emissions CH₄</td>
<td>1.87</td>
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<tr>
<td>Total CO₂eq</td>
<td>1.06</td>
</tr>
<tr>
<td>Baseline</td>
<td>4.00</td>
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<tr>
<td>Reduction in CO₂eq</td>
<td>2.94</td>
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<tr>
<td>SCC Benefit $ per cow year</td>
<td>$140.52</td>
</tr>
<tr>
<td>Gross Electricity produced kWh/cow/year</td>
<td>1955</td>
</tr>
<tr>
<td>Social Cost of Carbon saved $ per cow year</td>
<td>$141</td>
</tr>
<tr>
<td>Value of E $/kWh</td>
<td>$0.072</td>
</tr>
</tbody>
</table>

Public Service Commission REV

\[ E_{value} = \text{Fossil fuels avoided} \]

Unwilling to look upstream

Reductions

Augmentations
<table>
<thead>
<tr>
<th></th>
<th>Capacity factor</th>
<th>GHG reductions factor</th>
<th>Total capital cost</th>
<th>Adjusted total capital cost&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wind</strong></td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 x (Fossil fuel avoided)</td>
<td>$3.2 million/MW&lt;sup&gt;2&lt;/sup&gt;</td>
<td>12.8 million/MW</td>
</tr>
<tr>
<td><strong>Solar</strong></td>
<td>0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 x (Fossil fuel avoided)</td>
<td>$3.8 million/MW&lt;sup&gt;3&lt;/sup&gt;</td>
<td>25.3 million/MW</td>
</tr>
<tr>
<td><strong>AD</strong></td>
<td>0.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3 x (Fossil fuel avoided and captured/combusted CH&lt;sub&gt;4&lt;/sub&gt; emissions)&lt;sup&gt;5&lt;/sup&gt;</td>
<td>$7.2 million/MW&lt;sup&gt;1&lt;/sup&gt;</td>
<td>8.0 million/MW</td>
</tr>
</tbody>
</table>

<sup>a</sup> Source: NYISO, 2017  
<sup>b</sup> Source: Biogas Weser-ems, 2014  
<sup>1</sup> Price in 2012 dollars  
<sup>2</sup> Price for commercial level installation, in 2012 dollars  
<sup>3</sup> Price for small commercial upstate, in 2012 dollars  
<sup>4</sup> Capital cost adjusted for capacity factor to show capital cost per average MW production.  
<sup>5</sup> Manure-based systems only  
(Source: Pronto et al., 2017)
Initiatives

- Governor’s Goals
  - 50% reduction of Renewable Energy
  - 40% reduction in GHG Emissions
- $0.12 kWhr Tariff for On-Farm Anaerobic Digestion
- NYSERDA Aggregation of Design and Operation
- Diversion of Organic Waste from Landfills
- Demand Charge Reduction
- Food Distributed Generation (CDG like)
# Incremental Cost of Implementing Dairy Sustainability
by increasing the price of Exported Renewable Electricity
from Manure based Anaerobic Digesters

<table>
<thead>
<tr>
<th>Date</th>
<th>Cows</th>
<th>KW</th>
<th># systems</th>
<th>MWh/yr.</th>
<th>Total cost/yr.</th>
<th>Incremental Increase/kWh consumed in NYS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimated</strong></td>
<td>2019</td>
<td>43,000</td>
<td>13,578</td>
<td>30</td>
<td>59,695</td>
<td>$2,900,604</td>
</tr>
<tr>
<td><strong>All Large Farms</strong></td>
<td>2025</td>
<td>301,101</td>
<td>74,222</td>
<td>156</td>
<td>564,375</td>
<td>$27,422,987</td>
</tr>
<tr>
<td><strong>All Medium Farms</strong></td>
<td>2030</td>
<td>364,066</td>
<td>89,016</td>
<td>229</td>
<td>687,494</td>
<td>$33,405,343</td>
</tr>
</tbody>
</table>
If the Economic Problem was Fixed...

229 NYS Operating AD Systems would...

• Reduce GHG emissions by 1,000,000 MTCO$_2$e annually, sufficient to remove 225,500 cars from the highway annually

• Generate 528,000 MWh of electricity annually

• Extensive off-farm organic matter imported for co-digestion increasing GHG reductions and renewable energy generation
Questions?

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