Wisconsin Energy Innovation Summit
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Options for Digester Gas End-Use

1. Do nothing - flare

2. Use for process/building heat

3. Combined heat and power (cogeneration)

4. Produce vehicle fuel (bioCNG, rCNG)

5. Produce pipeline quality natural gas
Renewable Fuel Standard (RFS)

- Congress created the RFS program to reduce greenhouse gas emissions and expand the nation’s renewable fuels sector.

Renewable Identification Numbers (RINs)

- Under the RFS, obligated parties (refiners or importers of petroleum) must:
  - Blend with renewable fuel
  - Obtain RINs to meet their obligation

- RINs are “credits” used for compliance and are the “currency” of the RFS program

- Renewable fuel producers generate RINs (e.g., CNG production at WWTPs)
  - Only generated for qualifying feed stocks/fuel types!

- Obligated parties obtain and then ultimately retire RINs for compliance with the RFS program
D3 vs. D5 RINs

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Feedstock</th>
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</thead>
<tbody>
<tr>
<td>D3</td>
<td>Renewable Compressed Natural Gas, Renewable Liquefied Natural Gas, Renewable Electricity</td>
</tr>
<tr>
<td>D5</td>
<td>Renewable Compressed Natural Gas, Renewable Liquefied Natural Gas, and Renewable Electricity</td>
</tr>
</tbody>
</table>
Historical RIN Values

Value of D3 RIN ~ $2.46 vs. D5 RIN ~ $0.50 (5/9/18)

Source: ECOENGINEERS
Des Moines, IA
Total Value of Digester Gas

Gas Value Per Million BTUs

- D3 RIN ~ $30
- Low Carbon Fuel Std. ~ $8.00+
- Gas ~ $3.00

Total ~ $33 - $41 per MMBTU (if D3)

Source: ECOENGINEERS
Des Moines, IA

Applies if Gas Sales Contracted To California End-Use (can very significantly) (other programs available)
City of Dubuque
Dubuque Digestion Facilities

- 11 mgd DAF WWTP
- Significant industrial loadings
- New temperature phased anaerobic digestion (2013)
- 2014 cogeneration startup (microturbines)
- Significant co-digestion of high-strength wastes
- Hydrogen sulfide and siloxane removal already installed
Dubuque Gas Conditioning
Dubuque Cogeneration with Microturbines

Microturbines
3 @ 200 kW = 600 kW

Heat Recovery
Dubuque Pipeline Quality Gas Project

• Third party provider is at risk; rights to all digester gas

• 15-year term + option for 5 years

• Use existing gas conditioning system/facilities (moisture, $H_2S$ and siloxane removal)

• PSA to remove carbon dioxide; inject into utility pipeline

• Developer believes all RINs are D3 [caution]
Dubuque Pipeline Quality Gas Project

- Third party provider will provide to the City:
  - Percentage of gross revenue – RINs and Gas Sales
  - Pipeline natural gas for cogen and facility use
  - Lease payment
  - Operational costs above current (electricity, gas cleaning media, labor, etc.)
PSA System for CO$_2$ Removal (Dubuque)
Estimated Gross Revenue to 3rd Party

- Digester Gas Production: 250,000 ft³/day
- Energy Value: 150 MMBTU/day
- Gross Sales: $2.5 million/yr
- Net Revenue: $2.0 million/year
Anticipated Benefits to Dubuque

<table>
<thead>
<tr>
<th></th>
<th>$100,000/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue Sharing:</td>
<td>$100,000/yr</td>
</tr>
<tr>
<td>Lease + Operations:</td>
<td>$20,000/yr</td>
</tr>
<tr>
<td>Additional COGEN:</td>
<td>$60,000/yr (~200 kW)</td>
</tr>
<tr>
<td>Total Value:</td>
<td>$180,000/yr</td>
</tr>
</tbody>
</table>

- No upfront capital and no additional O&M costs to City
- Improved microturbine life
- Ability to add 4th and 5th microturbine if successful
- Bond/agreement to make the City whole if system is discontinued
Dubuque Project Status

- Start-up late March 2018
- Long delay getting system installed and approved
- Third party was not accustomed to working in the municipal WWTP realm
Gas production ~ 280,000 ft³/day
All D3 RINs by definition
Currently no digester gas use except for process heat
Low electrical costs ~ $0.05/kWH (cogen not considered)
Requires H₂S, moisture, siloxane and CO₂ removal
  • Utilize membrane CO₂ removal system
WWTP Gas: Current vs. Potential Value

Gas Value Per Million BTUs

- Heating Fuel: $3.00
- COGEN: $8.00
- D5 Trans Fuel: $12.00
- D5 + LCFS: $20.00
- D3 Trans Fuel: $33.00
- D3 + LCFS: $41.00
## Project Costs and Revenue

<table>
<thead>
<tr>
<th></th>
<th>Continue with Boilers</th>
<th>Produce RNG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital Costs</strong></td>
<td>$0</td>
<td>$6,100,000</td>
</tr>
<tr>
<td><strong>Gas Conditioning O&amp;M</strong></td>
<td>$0</td>
<td>$340,000/yr</td>
</tr>
<tr>
<td><strong>Relative Power</strong></td>
<td>$0</td>
<td>$120,000/yr</td>
</tr>
<tr>
<td><strong>RIN+LCSF (80% of total)</strong></td>
<td>$0</td>
<td>($1,700,000/yr)</td>
</tr>
<tr>
<td><strong>Boiler Maintenance</strong></td>
<td>$20,000/yr</td>
<td>$20,000/yr</td>
</tr>
<tr>
<td><strong>Annual Cost (Revenue)</strong></td>
<td>$20,000</td>
<td>($1,240,000)</td>
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<tr>
<td><strong>Opinion of 20-Yr Present Worth</strong></td>
<td>$300,000</td>
<td>($12,770,000)</td>
</tr>
<tr>
<td><strong>Direct Payback</strong></td>
<td>NA</td>
<td>~5 years</td>
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</tbody>
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Closing Thoughts

- Digester gas end-use should consider RNG production in addition to cogeneration.

- Cogeneration is maintenance intensive and has lower value recovered per MMBTU.

- There are low-risk (and lower value) RNG opportunities available through turn-key providers.

- RIN values have and will fluctuate – it’s a market that will have its ups and downs.
Closing Thoughts

- Many “experts” believe the RIN market will survive the Trump administration because of the RFS tie to ethanol production and energy independence for the US.

- Diversification into the Low Carbon Fuel Standard program is important; more states are looking at similar programs to California.
Questions & Discussion

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