Biogas Vehicle Fuel Project

- Dane County, WI  Rodefeld Landfill
- Developed with private, municipal and educational entities
- Purpose is to use biogas as a vehicle fuel on a small scale (100 gge/d).
- System installation - December 23, 2010
Overview of Biogas and Utilization as a Vehicle Fuel

- Biogas: Landfills, WWTP, Digesters
- National: CA, OH
  - Altamont Landfill - LNG California, 3,000 scfm, $15.5MM
  - SWACO Landfill - CNG Ohio, 200 SCFM, $4MM
- Small Scale System Availability?
The Anaerobic Decomposition Process

Organic Matter
“WASTE”

→ Acid Forming Bacteria

→ Organic Acids (Acetic Acid) $\text{CH}_3\text{COOH}$

→ Methane Forming Bacteria

$\text{CH}_4 + \text{CO}_2 + \text{Heat}$

50 to 65% 35 to 50%
Over 12,000,000 CNG vehicles in use worldwide and growing!

Source NGV America
Manufactures are Incorporating CNG into Vehicles

Dual Fuel CNG / Gasoline VW Passat
Cummins Westport Inc

8.9L ISL-G (in-line 6c, 2200 rpm engine)

• Stoichomteric combustion w EGR+3-way cat
• .2 NOx/.01 PM – 2010 compliant

• Engine Ratings

<table>
<thead>
<tr>
<th>Model</th>
<th>Horsepower</th>
<th>Peak Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>320</td>
<td>320 @ 2200</td>
<td>1000 @ 1300</td>
</tr>
<tr>
<td>300</td>
<td>300 @ 2100</td>
<td>860 @ 1300</td>
</tr>
<tr>
<td>280</td>
<td>280 @ 2000</td>
<td>900 @ 1300</td>
</tr>
<tr>
<td>260</td>
<td>260 @ 2200</td>
<td>660 @ 1300</td>
</tr>
<tr>
<td>250</td>
<td>250 @ 2200</td>
<td>730 @ 1300</td>
</tr>
</tbody>
</table>

• Refuse collection trucks
  • Crane Carrier LET, Autocar Xpeditor, Peterbilt LCF 320, Int’l/ALF Condor, Mack TerraPro LE;

• Work/Vocational Trucks
  • Freightliner M2-112; Kenworth T8SH and T440; Peterbilt 365 and 384;

Source NGV America
Project Considerations

- Evaluate biogas cleanup technologies
  - resulted in Patent Pending process

- Viability using biogas as a vehicle fuel as an add-on to an existing 6.4 MW LFGTE System

- As fuel demand grows blend Natural Gas and BioCNG (similar to biodiesel and ethanol)
Biogas Treatment Requirements / Considerations

- Moisture removal
- Hydrogen Sulfide removal
- VOC / Siloxane removal
- CO₂ removal
- Fuel requirements:
  - Engine Manufacturers Specifications, SAE J1616
What Next?

Ford 1998 CNG / Gasoline Pickup Truck
Purchased By Dane County February 22, 2010
Fabrication at Unison Solutions
Dubuque, Iowa
December 7, 2010
System mechanical and electrical connections completed December 27, 2010
Fueling Station, Fast Fill 60-GGE capacity
Biogas Vehicle Fueling Station
“The Clean Renewable Fuel”

CORNERSTONE
Environmental Group, LLC

ALLIANT ENERGY

UNISON SOLUTIONS

COUNTY OF DADE WISCONSIN

WARNING
STOP MOTOR
NO SMOKING
NO OPEN FLAME
PERMITTED
FLAMMABLE GAS

CNG EMERGENCY STOP BUTTON
### Rodefeld Landfill / BioCNG Gas Constituents

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Units</th>
<th>Inlet LFG</th>
<th>BioCNG</th>
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</thead>
<tbody>
<tr>
<td>CH₄</td>
<td>vol. %</td>
<td>55.0</td>
<td>90.0</td>
</tr>
<tr>
<td>CO₂</td>
<td>vol. %</td>
<td>39.5</td>
<td>0.3</td>
</tr>
<tr>
<td>O₂</td>
<td>vol. %</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>N₂</td>
<td>vol. %</td>
<td>5.0</td>
<td>9.6</td>
</tr>
<tr>
<td>H₂S</td>
<td>ppmv</td>
<td>250</td>
<td>ND</td>
</tr>
</tbody>
</table>

**Notes:**

1. Data is compiled from field and laboratory analysis of samples collected on January 4, 2011.
2. Cummins ISL G engine specifications call for a minimum methane number of 75 CH₄.
**Project Economics**

- 100 GGE/day replacing Gasoline at $3.25/gal
  - $110,000 / year avoided cost

- As Demand for Gas increases Natural gas can be blended at 10% BioCNG = 1000 GGE/day

- BioCNG production $0.50 to $1.00 / GGE
  - Potential for $0.50 / GGE tax credit

- Approximate 20 scfm System Cost
  - $300,000 to $400,000 for gas conditioning skid
  - $55,000 for CNG time fill fueling station

(Actual site conditions and SCFM will dictate System Cost)
What will be learned from the Project

- Is BioCNG a reliable vehicle fuel?
- Ease of production / blending?
- BioCNG production costs?
- Will staff use CNG vehicles?
- Public perception of BioCNG?
Contact Information

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