Biogas From Municipal WWTPs
Fuel Cells Viewed as a Value Proposition

Biogas and Fuel Cells Workshop
National Renewable Energy Laboratory
Golden, Colorado
June 12, 2012
WWTP Anaerobic Digestion

- Common method of processing sludge to reduce volume of solids & volatile content
- Reduces sludge disposal cost & increases outlets for disposal
- Since motivation is disposal rather than digester gas (DG) production, the DG is available at no cost
- This is unlike many other organic waste digestion facilities, where the energy project must bear cost of the digester(s)
WWTP Anaerobic Digestion

- WWTP anaerobic digesters require heat
- Typically a portion of the DG is used to produce steam or hot water to provide the heat
- The heat required varies seasonally, diurnally, and by climate
- Digester heating can consume up to 40% of the DG
WWTP Anaerobic Digestion

- Ways to increase DG production:
  - Inject fats, oils (vegetable) & grease into digester
  - Add processed food waste into digester

- Ways to conserve DG produced:
  - Use natural gas instead of DG for digester heat
  - Substitute another solid or liquid biofuel or biomass as the fuel for digester heat
  - Add solar hot water heating of the digesters
  - Use waste heat from on-site power generation
Beneficial Uses of DG

- Electric power generation by fuel cells, reciprocating engines, microturbines or combustion turbines
- Direct-use as a natural gas replacement at a nearby industrial, institutional or commercial natural gas consumer
- Conversion to pipeline quality gas
- Conversion to CNG/LNG for use as vehicle fuel
Why Fuel Cells?

• The other uses represent strong competition, many WWTPs already have some form of power generation

• Advantages of fuel cells are:
  – Much better heat rate (more efficient)
  – Ultra-low emissions
  – Minimal operator attention
  – Can be deployed in small incremental capacities
## Typical Heat Rates of Power Generation Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Heat Rate (Btu/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reciprocating Engine</td>
<td>9,500 to 10,500</td>
</tr>
<tr>
<td>Microturbine</td>
<td>11,500 to 13,000</td>
</tr>
<tr>
<td>Combustion Turbine</td>
<td>11,000 to 12,300</td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>7,850</td>
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</tbody>
</table>
## Typical Air Emissions of Power Generation Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Air Pollutant (lb/MWh)</th>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>Reciprocating Engine</td>
<td>1.51</td>
<td>2.52</td>
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</tr>
<tr>
<td>Combustion Turbine</td>
<td>0.83</td>
<td>3.45</td>
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</tr>
<tr>
<td>Microturbine</td>
<td>0.17</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>0.0001</td>
<td>0.0015</td>
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</tbody>
</table>
Disadvantages

• Fuel cells require advanced fuel cleanup

• High capital cost (though grants or other incentives may be available)
WWTP DG Project Experience

• SCS has completed three WWTP fuel cell projects:
  – Palmdale, CA – 250 kW (start-up 9/2004)
  – Santa Barbara, CA – 500 kW (start-up 11/2004)
  – Point Loma, CA – 300 kW (start-up 3/2012)
Palmdale & Santa Barbara Projects

- Fuel pressurization
- Gas treatment removes:
  - Moisture
  - VOCs
  - Sulfur compounds

Inlet Gas Quality

<table>
<thead>
<tr>
<th>Gas Constituent</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Methane</td>
<td>62</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>37.5</td>
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<tr>
<td>Nitrogen</td>
<td>0.4</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.1</td>
</tr>
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</table>
Point Loma Project

- Receives gas from a plant that converts DG into pipeline quality gas
- Provides power for the gas conversion plant

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<tr>
<td>Oxygen</td>
<td>Nil</td>
</tr>
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</table>
Project Capital Costs

• Palmdale (less fuel cell)
  $680,000 ($2,720/kW)

• Santa Barbara (less fuel cell)
  $1,150,000 ($2,300/kW)

• Point Loma – More difficult to breakout since the fuel cell uses only 38 scfm of the 580 scfm of product gas produced. On a ratio basis the fuel skid) cost would be $1,750/kW
Summary

• Other high-value uses compete for WWTP DG
• Other power generation technologies are less costly
• Pretreated DG costs less than natural gas; hence WWTP DG projects are more cost effective than natural gas fuel cell projects
• Currently a niche market where grants are available or air emission limitations make necessary