Stranded biogas decision tool for fuel cell co-production

Michael Ulsh, Robert Remick
National Renewable Energy Laboratory
May 18, 2009

This presentation does not contain any proprietary, confidential, or otherwise restricted information

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC
# Overview

## Timeline

- **Period**: 12-24 months
- **% complete**: N/A

## Barriers

- Eliminate non-technical barriers to the commercialization of fuel cells and hydrogen technologies (Market Transformation)

## Budget

- **Total project funding (to date)**:
  - $25,000
- **Funding received in FY08**:
  - $25,000
- **Funding received in FY09**:
  - $TBD

## Funded Partners

- **TBD**
Overview

Overall Project Concept

[Diagram showing biomass feedstocks, conversion process, fuel cell, heat, and hydrogen]

Used with permission from Fuel Cell Energy
Overview

Fuel Cell Value Proposition

• **Increased energy efficiency**
  – 42 to 47% net electrical efficiency
  – Cogenerate heat to offset natural gas purchase
  – Combined electric + heat \( \approx 80\% \) efficient

• **Emissions savings**
  – Low NOx and SOx
  – 40% lower GHG emissions compared to grid

• **High availability and reliability**
  – Single unit availability >97%
  – Multiple unit availability exceeds five 9’s.
Relevance

Policy Drivers

• American Recovery and Reinvestment Act of 2009:
  – A fueling facility tax credit, which increases the dollar cap of the 30% hydrogen fueling infrastructure tax credit from $30,000 to $200,000.
  – Grants for energy property (in lieu of tax credits), which allow facilities with insufficient tax liabilities to apply for grants instead of claiming investment or production tax credits. Only entities that pay taxes are eligible.
  – A manufacturing credit, which creates a 30% credit for investment in property used for manufacturing fuel cells and other technologies.
  – A residential energy-efficiency credit, which raises the investment-tax-credit dollar cap for residential fuel cells in joint occupancy dwellings to $3,334/kW.

• Emergency Economic Stabilization Act of 2008:
  – Investment tax credits for fuel cells—30% of qualified fuel cell property or $3,000/kW of the fuel cell nameplate capacity (i.e., expected system output), whichever is less.
  – Investment tax credit of 10% for combined-heat-and-power-system.

• Section 9007 of Farm Bill of 2008:
  – Rewards farmers, ranchers, and rural small businesses for installing renewable energy projects

• New Administration emphasis on CO₂ avoidance and job creation
Relevance

Availability

- 12.4MM tons of methane emitted from 540 landfills in US
- 0.5MM tons of methane emitted from 17,000 waste water treatment plants (WWTPs) in US
- Other sources: breweries, industrial food processing, animal farms and processing, soft drink production, bakeries, pulp and paper mills

Table 6. Characterization of U.S. Waste Water Treatment Facilities

<table>
<thead>
<tr>
<th>Waste Water Treatment Facilities</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>16,583</td>
</tr>
<tr>
<td>Using Anaerobic Digestion</td>
<td>3,500</td>
</tr>
<tr>
<td>Large Facilities (&gt;5 million Gallons per Day)</td>
<td>1,000</td>
</tr>
<tr>
<td>Using Anaerobic Digestion</td>
<td>544</td>
</tr>
<tr>
<td>Using Anaerobic Digestion to generate electricity and/or Combined Heat and Power (CHP)</td>
<td>106</td>
</tr>
</tbody>
</table>

Figure 2. Number of On-Farm Anaerobic Digestion Systems in the United States* (EPA AgStar)
Case Study: City of Tulare, CA, WWTP

- Facility size: 11.5 million gallons per day
- Biogas generated: 600,000 SCF per day
- Fuel cells: Three - 300 kW units
- Gas cleanup: Applied Filter Technology

Startup: September 2007
Total cost: $7 million
State & Federal Incentives: $4.05 million
Cost to city: $2.95 million
Payback period: 4.5 years

1 Fuel Cell Energy
Relevance

**Project objectives**
- Use NREL GIS capabilities to determine facility location and volume of methane based biogas.
- Evaluate three different scenarios for methane production and fuel cell delivery.
- Develop a biogas submodel to the discounted cash flow H2A model that will also serve as a prototype customer adoption/decision tool for fuel cell utilization of stranded biogas.

**Desired outcomes**
- Support fuel cell industry and create American jobs
- Improve energy security by reducing the load on strained US electricity transmission system and using renewable resources
- Reduce emissions of GHGs
- Take advantage of the economic and environmental benefits of using stranded renewable resources for on site generation of electricity and hydrogen.
Approach

• Gather data on sources of biogas, costs of biomass conversion, clean-up, and fuel cell technologies, real-life data from existing installations, and clean-up requirements for biogas into NG pipelines
  – EPA AgStar: http://www.epa.gov/agstar/
  – EPA Landfill Methane Outreach Program: http://www.epa.gov/lmop/
  – DHS HSIP database
• Use NREL GIS capabilities to map stranded biogas resources in CO and CA, and overlay infrastructure information to assist the evaluation of deployment scenarios
• Identify critical technical and cost parameters for each of the following scenarios:
  – fuel cell installed at source site
  – source biogas is cleaned-up on site and pumped into the natural gas pipeline
  – transport stranded biogas to a central location for clean-up and use in a fuel cell
• Identify relevant federal and state incentives and integrate into appropriate cost models
• Evaluate, select, and vet analysis tools with stakeholder roundtables and regional workshops
Progress

Initial GIS analysis of stranded biogas sources in Metro Denver and California
Progress

Initial data gathering on related infrastructure

Figure 6. Natural Gas Pipeline System
Progress

- Discussions and inputs from Xcel Energy and Colorado Governor’s Energy Office
- Visits and discussions with UTC Power and Fuel Cell Energy
- Initial information on impurities and required clean-up

<table>
<thead>
<tr>
<th>Table 6. Basic Pipeline Standards for Major California Distributors*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas Component or Characteristic</strong></td>
</tr>
<tr>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
</tr>
<tr>
<td>Oxygen (O₂)</td>
</tr>
<tr>
<td>Hydrogen sulfide (H₂S)</td>
</tr>
<tr>
<td>Mercaptan sulfur</td>
</tr>
<tr>
<td>Total sulfur</td>
</tr>
<tr>
<td>Water (H₂O)</td>
</tr>
<tr>
<td>Total inerts</td>
</tr>
<tr>
<td>Heating value</td>
</tr>
<tr>
<td>Landfill gas</td>
</tr>
<tr>
<td>Temperature</td>
</tr>
</tbody>
</table>

1 Grain = 64.8 mg
Potential Collaborations

- EPA AgStar
- EPA Landfill Methane Outreach Program
- EPA Combined Heat and Power Partnership
- Regional CHP Partnership Office
- Xcel Energy
- Colorado Governor’s Energy Office
- California Stationary Fuel Cell Partnership
Future Work

• Initiate tasks outlined in the Approach
• Use cost findings from biogas submodel in NEMS and MARKAL Hydrogen production cost analysis
• Refine customer adoption/decision tool with real data and educate stakeholders through regional workshops and roundtable meetings
Summary

- Stranded biogas is an abundant and underutilized renewable resource
- Fuel cells offer efficiency, emissions, and availability advantages for the co-production of hydrogen, heat and electricity
- Commercial fuel cells are currently being used for biogas energy conversion