CHP and Bioenergy for Landfills and Wastewater Treatment Plants: Market Opportunities

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Denver, Colorado

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The Opportunity for Alternative CHP Fuels

- High natural gas prices have decreased spark spreads and reduced CHP market potential
- Increasing natural gas supply or reducing demand substantially is unlikely
- Renewable portfolio standards, public benefit funding, and other renewable incentives are spurring investment in biomass fueled projects

Source: EIA and NYMEX
Alternative Solution: Develop Other, Cost-Effective Fuels

- Opportunity Fuel: any fuel that has the potential to be used for economically-viable power generation, but is not traditionally used for this purpose
- Opportunity fuels include:
  - Anaerobic Digester Gas
  - Biomass (General)
  - Biomass Gas
  - Black Liquor
  - Blast Furnace Gas
  - Coalbed Methane
  - Coke Oven Gas
  - Crop Residues
  - Food Processing Waste
  - Industrial VOC's
  - Landfill Gas
  - Municipal Solid Waste
  - Orimulsion
  - Petroleum Coke
  - Sludge Waste
  - Textile Waste
  - Tire-Derived Fuel
  - Wellhead Gas
  - Wood
  - Wood Waste
Why are Opportunity Fuels Not Used More Often?

- Availability of fuel source often inconsistent in volume and in quality, resulting in variations in fuel volume, BTU content, and contaminants.
- Often requires investment in power generating equipment and/or processing equipment (digester, filtration, gasifier).
- Site where fuel is located has little thermal and/or electric demand, and costs to transport fuel to ideal site is simply too high.
Currently, Opportunity Fuels Contribute Little to U.S. Generating Capacity

2006 Nameplate Capacity (1076 GW)

Opportunity Fuel Capacity (12 GW)

- Agricultural Byproducts
- Anaerobic Digester Gas
- Black Liquor
- Blast Furnace Gas
- Landfill Gas
- Municipal Solid Waste
- Other Biomass Solids
- Tire-Derived Fuel
- Wood Waste Liquids
- Wood/Wood Waste

Source: EIA 860, 2006, units over 1 MW

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Anaerobic Digesters at WWTPs

- Primary benefits are waste treatment and odor control, with other value streams including reduction in disposal costs by reducing volume.
- Gas is typically 50-70 percent methane and 30-50 percent carbon dioxide, and is usually flared, utilized as a secondary boiler fuel, or used to heat digester.
- The cost of anaerobic digesters vary, typically ranging from $2,000-3,000 per kW.
- The wastewater treatment benefits of installing a digester can reduce the effective cost, and many plants already have them installed.
CHP Units for ADG

- CHP units range from $1,500-6,000/kW installed, depending on size, technology, and installation complexity
- Fuel treatment equipment is one of the major cost drivers (siloxane, H₂S and other particulates must be removed from the gas)
- Equipment modifications are likely required for NG units, though microturbines and smaller reciprocating engines have “off-the-shelf” models that will operate with low-Btu fuels like digester gas
- Negative past experience with ADG fuel use can be a barrier, but CHP equipment is more reliable now, and issues with contaminants and pretreatment are better understood
ADG Applications

- Wastewater treatment plants, with wastewater flows of at least 1 million gallons per day (MGD)
  - Municipal treatment plants*
    - At least 4,290 plants with 1 MGD or greater
    - Over 1,700 of these have anaerobic digesters, and over 1,500 are not currently utilizing digester gas
    - Paybacks in the 2-4 year range can be attained when investing in CHP and already possessing a digester
  - Industrial plants vary, depending on characteristics of effluent (food processing and pulp and paper mills are two of the most prevalent industries). At least 2,500 plants could potentially benefit from ADG.

- Manure farms, generally over 200 cows or 1,000 pigs

*Data taken from EPA 2000 Clean Water Needs Survey
Example ADG Installations - Wastewater Treatment Plants

- Metro Wastewater Reclamation District in Denver, Colorado
  - 7 MW of electricity produced from ADG-powered CHP turbines, waste heat used to heat several nearby buildings
- 75th Street Wastewater Treatment Plant in Boulder, Colorado
  - Two CHP engines were recently installed – heat used by plant, electricity sold to PSC
- Littleton-Englewood Wastewater Treatment Plant in Englewood, Colorado
  - Two CHP engines have been producing 900 kW of electricity and waste heat at this plant since 1999
- North Davis County Sewer Improvement District in Syracuse, Utah
  - A 1.4 MW reciprocating engine system was installed in 1998
Landfill Gas

- Methane gas produced in landfills through anaerobic digestion can be collected and used for power generation applications.
- LFG is typically just over 50 percent methane and just under 50 percent carbon dioxide - the energy content varies, but the average is around 500 Btu/ft³.
- There are numerous projects nationwide that use LFG for heat or power:
  - Approximately 425 LFG to energy projects are currently operating.
  - EPA estimates 560 more landfills are strong project candidates.
  - Most projects generate wholesale electricity, not utilizing CHP.
  - When gas is piped to a nearby facility, it is typically used as a secondary boiler fuel, but sometimes CHP is utilized.
LFG Economics

- LFG is essentially a free fuel – but the capital costs of gas collection, pipeline and treatment systems can be significant.
- Landfills with over 2.5 million metric tons of waste in place are required by federal law to collect and flare or utilize their gas, and regional laws may have similar requirements for smaller landfills.
- Landfills can expect to pay about $600,000 per million tons of waste to install gas collection equipment.
- Pipeline construction typically costs about $260,000 per mile - most projects fall within the 2-5 mile range.
- CHP systems cost $1,500-5,000/kW - fuel treatment is usually required, and the power output and efficiency of prime mover equipment is downgraded compared to natural gas.
LFG Applications

- LFG is rarely utilized by landfills themselves unless the majority of electricity is sold - site demand is usually too low to justify a project otherwise.

- Any facility with a suitable thermal and electric demand that is located close to a landfill can utilize LFG and potentially benefit - project financing is usually the largest hurdle.

- LFG has been used to power schools, homes, commercial and industrial buildings, and other facilities - only limited by demand, location, economics, and sometimes local authorities.

- Even with over 400 LFG-to-energy projects (over 300 of which produce electricity) already installed at many of the best-suited landfills, several locations still have large quantities of excess gas that can be used.
U. S. Landfill Gas Project Development Has Been Consistent

- About 30 units went in each of 2006 and 2007 for entire U. S.
- Mostly 1-3 MW IC engines
- WMI just announced new initiative to install 700 MW over 5 years at company landfills
LFG Capacity Primarily Concentrated in High Electricity Price, Highly Populated States

Source: EPA LMOP 2007

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### Status of Colorado Landfill Projects

<table>
<thead>
<tr>
<th>Landfill Name</th>
<th>Landfill City</th>
<th>Landfill County</th>
<th>Waste in Place (tons)</th>
<th>Landfill Closure Year</th>
<th>Project Status</th>
<th>Project Start Date</th>
<th>Project Shutdown Date</th>
<th>Project Developer Organization</th>
<th>LFGE Project Type</th>
<th>MW Capacity</th>
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<tr>
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<td>Aurora</td>
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<td>Pitkin County Resource Recovery LF</td>
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Most Intermountain CHP States Have Some Renewable Emphasis on ADG and LFG

<table>
<thead>
<tr>
<th>State</th>
<th>Renewable Portfolio Std</th>
<th>Digester Gas</th>
<th>Landfill Gas</th>
<th>Net Metering Standards</th>
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<tr>
<td>Arizona</td>
<td>Yes</td>
<td>X</td>
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<td>Statewide standards being developed*</td>
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<td>Utah</td>
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<td>Net metering standards do not include ADG/LFG</td>
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<td>Wyoming</td>
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<td>Net metering of Biomass** up to 25 kW</td>
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*It is uncertain whether or not ADG/LFG will make their way into the new net metering standards
**Biomass is a general category that often includes ADG and LFG
And the Market Opportunities Are …..

- Two of the top opportunity fuels that currently have the most potential for United States DER/CHP projects are:
  - Anaerobic Digester Gas - over 6,800 municipal/industrial WWTPs could potentially benefit, as well as over 7,000 dairy farms and 11,000 hog farms - well over 6 GW of electric capacity could be achieved.
  - Landfill Gas - currently about 425 landfills participate in LFG-to-energy projects, of which about 315 produce electricity (1.1 GW) - over 1,000 more landfills could have project potential, which could add 3-4 GW.

- Together, these fuels have the technical potential to add up to 10 GW of DER capacity
- RDC conducted a study to determine the nation-wide economic potential, and found that there is close to 1 GW of economically achievable potential for LFG, and about 600 MW for ADG (compared to over 20 GW from general biomass feedstocks)