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

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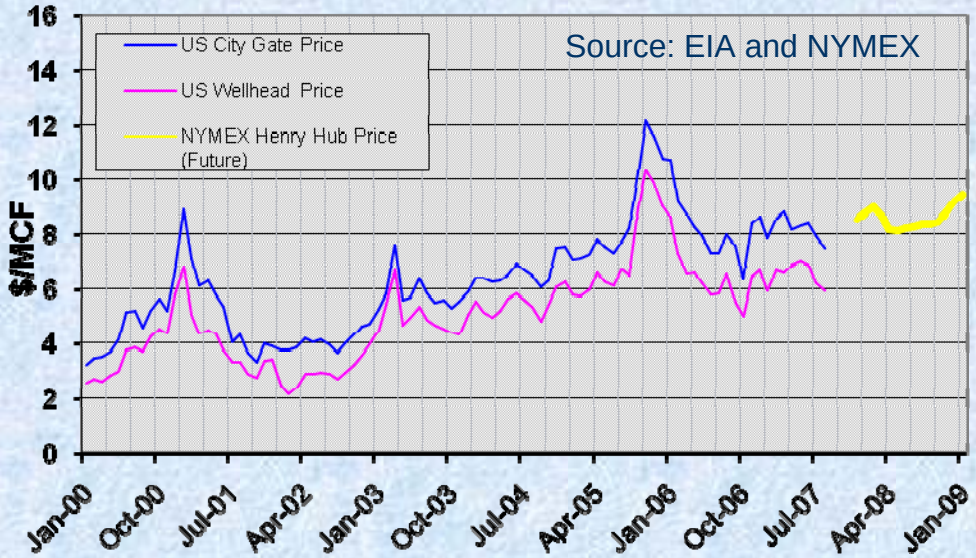
Denver, Colorado

Paul Lemar Jr., President
pll@rdcnet.com

www.rdcnet.com
www.distributed-generation.com

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

Alternative Solution: Develop Other, Cost-Effective Fuels

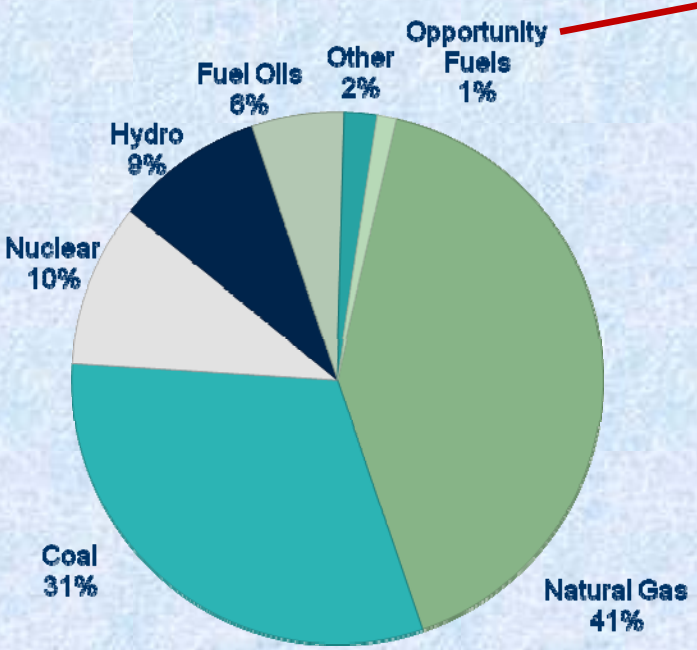
- Opportunity Fuel: any fuel that has the potential to be used for economically-viable power generation, but is not traditionally used for this purpose
- Opportunity fuels include:
  - Anaerobic Digester Gas
  - Biomass (General)
  - Biomass Gas
  - Black Liquor
  - Blast Furnace Gas
  - Coalbed Methane
  - 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?

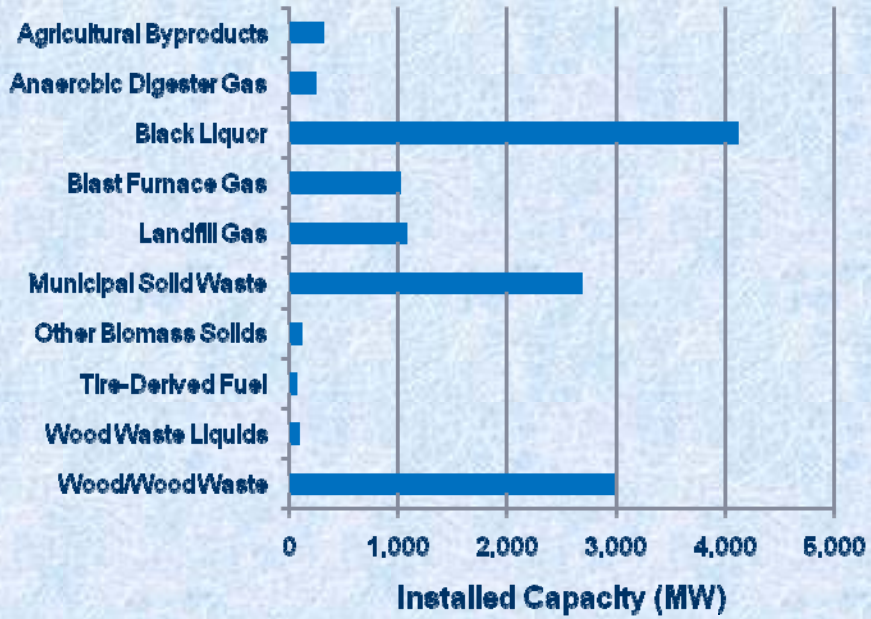
- Availability of fuel source often inconsistent in volume and in quality, resulting in variations in fuel volume, BTU content, and contaminants
- Often requires investment in power generating equipment and/or processing equipment (digester, filtration, gasifier)
- Site where fuel is located has little 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)



Source: EIA 860, 2006, units over 1 MW

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, H_2S 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/ft^3
- 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

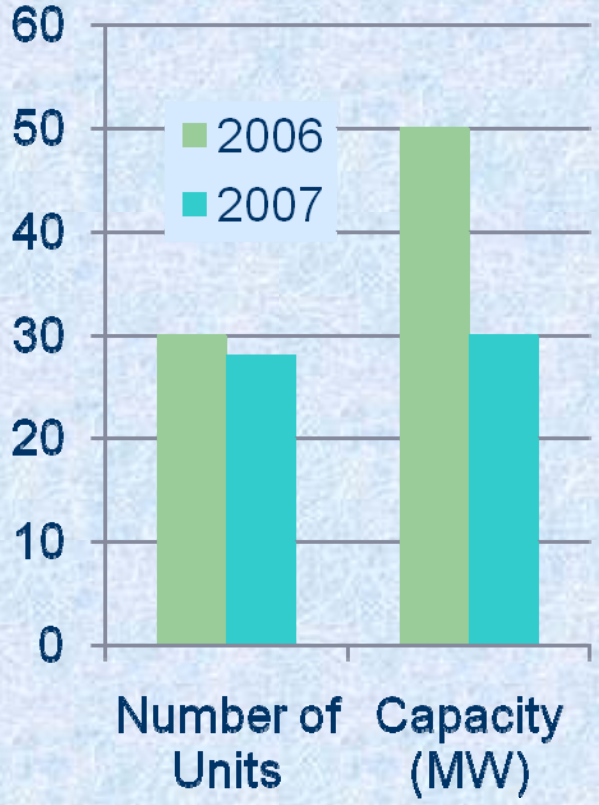
- LFG is essentially a free fuel – but the capital costs of gas collection, pipeline and treatment systems can be significant
- Landfills with over 2.5 million metric tons of waste in place are required by federal law to collect and flare or utilize their gas, and regional laws may have similar requirements 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

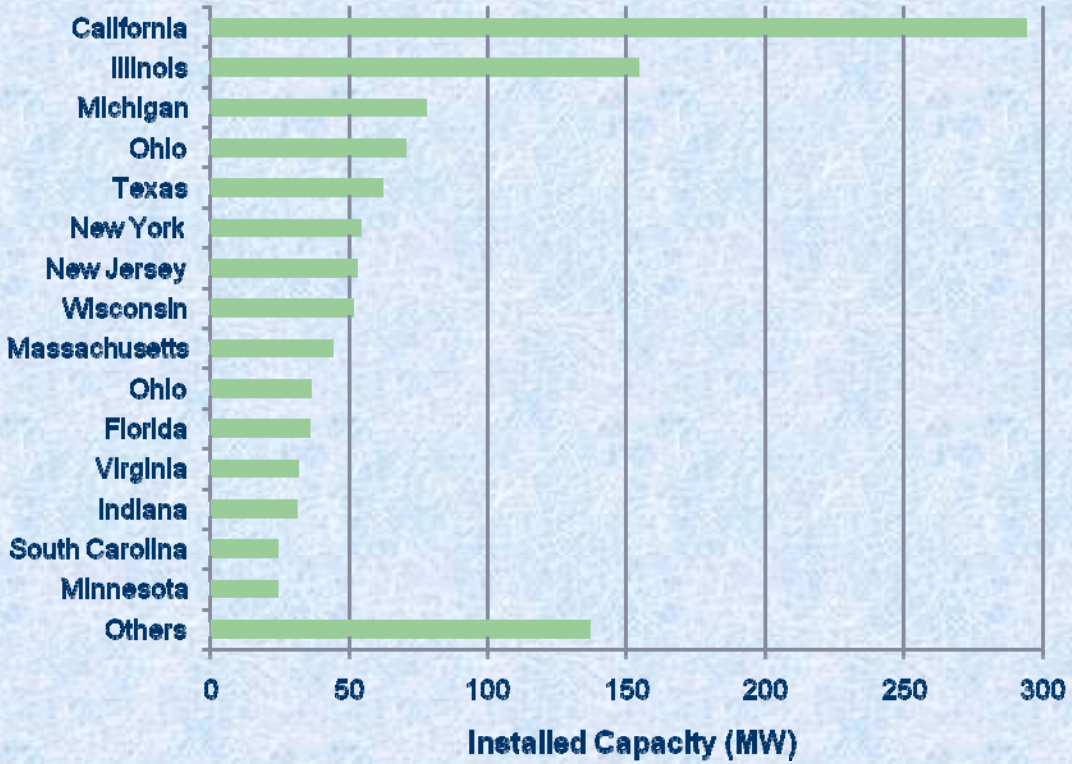
- LFG is rarely utilized by landfills themselves unless the majority of electricity is sold - site demand is usually too low to justify a project otherwise
- Any facility with a suitable thermal and electric demand that is located close to a landfill can utilize LFG and potentially benefit - project 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

Status of Colorado Landfill Projects

Landfill Name	Landfill City	Landfill County	Waste In Place (tons)	Landfill Closure Year	Project Status	Project Start Date	Project Shutdown Date	Project Developer Organization	LFGE Project Type	MW Capacity
Denver Arapahoe Disposal Site-DADs	Aurora	Arapahoe	11,499,652	2050	Construction	12/1/2007		Waste Management, Inc.	Reciprocating Engine	3.2
County Line LF	Littleton	Douglas	30,000,000	1987	Shutdown	1/1/1986	1/19/2000	Bio Energy Partners	Reciprocating Engine	0.8
Denver Regional Landfill (North)	Erie	Weld	6,319,775	1992	Shutdown	1/1/2000	6/1/2002		Reciprocating Engine	11.7
Tower Landfill	Commerce City	Adams	18,052,817	2037	Shutdown	1/1/2000		Energy Developments	Reciprocating Engine	2.7
Denver Regional Landfill (South)	Erie	Weld	7,600,000	2010	Candidate					
Foothills Landfill	Golden	Jefferson	3,394,539	2022	Candidate					
Fountain Landfill	Fountain	El Paso	5,218,297	2002	Candidate					
Larimer County Landfill	Fort Collins	Larimer	12,558,321	2008	Candidate					
Midway Landfill	Fountain	El Paso	1,059,137	2025	Candidate					
Milner Landfill	Milner	Routt	1,125,701		Candidate					
Montrose East End SWDS	Montrose	Montrose	2,054,466		Candidate					
Orchard Mesa SWDS	Grand Junction	Mesa	8,688,255	2007	Candidate					
Pitkin County Resource Recovery LF	Aspen	Pitkin	2,465,911	2015	Candidate					
South Canyon Landfill	Glenwood Springs	Garfield	1,798,154	2002	Candidate					
Summit County Solid Waste Disposal Site	Dilon	Summit	2,680,410	2030	Candidate					
WMI/Colorado Springs SWDS	Colorado Springs	El Paso	15,562,598	2002	Candidate					

Most Intermountain CHP States Have Some Renewable Emphasis on ADG and LFG

State	Renewable Portfolio Std	Digester Gas	Landfill Gas	Net Metering Standards
Arizona	Yes	X	X	Statewide standards being developed*
Colorado	Yes	X	X	Net metering for LFG/ADG up to 2 MW
New Mexico	Yes	X	X	Net metering of LFG/Biomass** up to 80 MW
Utah	No			Net metering standards do not include ADG/LFG
Wyoming	No			Net metering of Biomass** up to 25 kW

*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)