



Digesting Urban Organics Residuals

A Forum on Technology, Economics and Permitting

Biogas Use Alternatives: Economic and Technical Considerations

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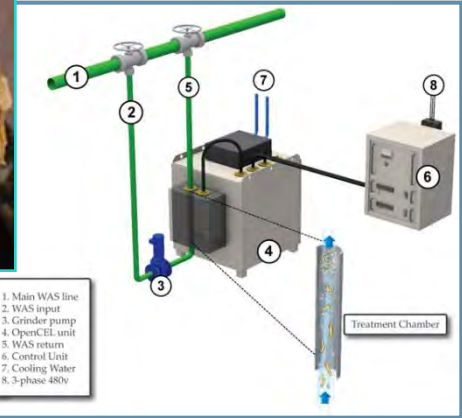
Why is Renewable Energy (Biogas) Use Essential to Your Operation?

- Best use of available resources
- Sustainable
- Cost effective
- Offers security/reliability
- Supports regulatory compliance



Technologies that are Associated with Biogas Use?

- Biogas Generation Enhancements
 - FOG/Foodwaste/Organics
 - Cell lysis
- New cogeneration technologies
 - Fuel Cells
- Biogas supply/wholesaling
- Renewable motor vehicle fueling





Biogas Utilization



Comparison of Various Cogeneration Technologies Using Digester Gas

Comparison Criteria	IC Engines	Micro-turbines	Gas Turbines	Fuel Cells
Size Range (kW)	60 to 3,000	30 to 250	3,000 to 10,000+	300 to 2,800
Electricity Conversion Efficiency (%)	25 to 40	25 to 30	30 to 40	35 to 50
Emissions	High	Low	Medium	Negligible
Experience on DG	Most	Limited	Significant	Limited

Reciprocating Engines

- Proven technology for using digester gas (Caterpillar-MWM, Cummins, GE-Jenbacher, Waukesha)
- Strict (and getting stricter) air permit regulations
- BACT requires oxidation catalysts and SCR
- Installation now requires extensive fuel conditioning to remove contaminants – no longer optional
- Efficiency 30-40%



**335-kW Digester Gas Fueled
Cogeneration System, Chico, CA
WWTP**

Micro Turbines

- Easy to permit - CARB-07 compliant
- Only two manufacturer's with DG experience (Capstone, FlexEnergy- Ingersoll Rand)
- Lower efficiency than engines; approximately 25%
- Requires >50 psi fuel pressure



**250-kW Landfill Gas Fueled microturbine
Cogeneration System, Lancaster, CA**

Gas Turbines

- Strict air permit regulations
- **Limited manufacturer's with experience on DG** (Solar Turbines, Rolls Royce-Allison)
- Effective fuel conditioning is required
- Competitive only for larger installations; greater than 3MW
- Efficiency typically 25-38%
- Requires >200 psi pressure



3.5 MW gas turbine Cogeneration System

Fuel Cells

- Ultra low emissions
- Expensive
 - Operational issues have significantly increased capital and O&M costs
- SGIP grant no longer favors fuel cells
- Only one manufacturer with digester gas experience
 - Fuel Cell Energy
- Very high efficiency 47%



250-kW Digester Gas Fueled Fuel Cells, EMWD-Moreno Valley, CA

General Cogeneration Considerations

General Design Considerations

- Fuel availability and type(s)
 - Landfill gas nearby
 - Natural Gas on site/available
- WWTP Digester gas can normally generate 40%-**70% of WWTP's average power requirement**
 - 40-50% is typical of CA plants with engines
 - 60% or more with Fuel Cells or with FOG/foodwaste addition
- Recovered heat is normally adequate to heat digesters

Reliable Fuel Treatment is Key



Gas Conditioning Basics

- Typical Gas Conditioning System
 - H₂S Removal
 - Moisture removal
 - Siloxane Removal
- Robust Gas conditioning system is key to the success of all options



**Digester Gas Treatment System,
EMWD-Moreno Valley, CA**

Fuel Treatment Design Issues

- Redundancy in media
 - Dual vessel trains for both H₂S and Siloxane removal in parallel
 - Switchable lead/lag operation
- Redundant or spare long lead components
- Flow control to prevent channeling
- Maintainability
- Flexibility to adapt to digester gas changes

Emission Regulations for Biogas Engines

SCAQMD Rule 1110.2

- Rule adopted on February 1, 2008

(Adopted August 3, 1990)(Amended September 7, 1990)(Amended August 12, 1994)
(Amended December 9, 1994)(Amended November 14, 1997)
(Amended June 3, 2005)(Amended February 1, 2008)

RULE 1110.2 EMISSIONS FROM GASEOUS- AND LIQUID-FUELED ENGINES

(a) Purpose

The purpose of Rule 1110.2 is to reduce Oxides of Nitrogen (NO_x), Volatile Organic Compounds (VOCs), and Carbon Monoxide (CO) from engines.

(b) Applicability

All stationary and portable engines over 50 rated brake horsepower (bhp) are subject to this rule.

SCAQMD Rule 1110.2 excerpts

- Emission Requirements Effective July 1, 2012

TABLE III CONCENTRATION LIMITS FOR LANDFILL AND DIGESTOR GAS-FIRED ENGINES		
NO_x (ppmvd)¹	VOC (ppmvd)²	CO (ppmvd)¹
bhp ≥ 500: 36 x ECF ³	Landfill Gas: 40	2000
bhp < 500: 45 x ECF ³	Digester Gas: 250 x ECF ³	
CONCENTRATION LIMITS EFFECTIVE JULY 1, 2012		
NO_x (ppmvd)¹	VOC (ppmvd)²	CO (ppmvd)¹
11	30	250

* Install and report CEMs by January 1, 2011

Criteria Pollutant Emission's Comparison

	Engines (SJVAPCD current)	Future Engines (SCAQMD rule 1110.2)	Fuel Cells	Micro- turbine
VOC's	750 ppmv	30 ppmv	ND	<5 ppmv
NOx	65 ppmv	11 ppmv	0.3 ppmv	<5 ppmv
CO	2000 ppmv	250 ppmv	10 ppmv	<5 ppmv

BACT for Engines is now
stricter than SCAQMD rule!

Example Economics - South Orange County Wastewater Authority (SOCWA)

Economic Evaluation Summary

SOCWA - JBLTP

Alternative (Costs in Million \$)	No Cogeneration	Power Purchase Agreement	633 kW Engine Generator Cogen System	500 kW Microturbine Cogen System	600 kW Fuel Cell Cogen System
Estimated Cogeneration System Project Cost	\$0	\$0	\$4.1	\$4.8	\$9.3
Estimated SGIP Grant Funding	\$0	\$0	(\$1.4)	(\$1.1)	(\$3.1)
Estimated Net Project Cost	\$0	\$0	\$2.7	\$3.7	\$6.2
Present Worth of Energy Costs	\$12.7	\$11.6	\$6.9	\$8.4	\$8.1
Total 20-Year Present Worth Costs	\$12.7	\$11.6	\$9.6	\$12.1	\$14.3
Present Worth of Net Benefit Compared to No Cogeneration System		\$1.1	\$3.2	\$0.7	(\$1.6)
Payback Period of Cogeneration System, years		N/A	8	16	20+

Biogas Sale

Current Biogas Sale Options in California

- Southern California Gas is only NG utility allowing digester gas into pipeline
 - Point Loma WWTP, San Diego
- SRCSD sells gas to SMUD
 - SMUD transmits digester gas in a dedicated SMUD pipeline to Consumnas Power Plant
- DG to vehicles
 - City of Modesto & Phoenix had systems in 1980's
 - Storage and compression are costly



Funding Opportunities

What Funding Is Available?



Grants:

- DOE Energy Efficiency Block Grants
- USDA Rural Energy Program
- Self Generation Incentive Program
- SRF Green Project Reserve Funds



Loans:

- CEC SMART Loans
- SRF Programs
- Clean Renewable Energy Bonds (CREB's)



Externally Financed:

- Power Purchase Agreements (PPA's)
- Leasing Options



Questions?