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Biogas From Municipal WWTPs Fuel Cells Viewed as a Value Proposition

Biogas and Fuel Cells Workshop

National Renewable Energy Laboratory

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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

Technology	Heat Rate (Btu/kWh)
Reciprocating Engine	9,500 to 10,500
Microturbine	11,500 to 13,000
Combustion Turbine	11,000 to 12,300
Fuel Cell	7,850

Typical Air Emissions of Power Generation Technologies

Technology	Air Pollutant (lb/MWh)	
	NO_x	CO
Reciprocating Engine	1.51	2.52
Combustion Turbine	0.83	3.45
Microturbine	0.17	0.29
Fuel Cell	0.0001	0.0015

Disadvantages

- Fuel cells require advanced fuel cleanup
- High capital cost (though grants or other incentives may be available)

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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

Gas Constituent	Percent
Methane	62
Carbon Dioxide	37.5
Nitrogen	0.4
Oxygen	0.1

Point Loma Project

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

Inlet Gas Quality

Gas Constituent	Percent
Methane	99.4
Carbon Dioxide	0.5
Nitrogen	0.1
Oxygen	Nil

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