The Solutions Network

Rochester, New York

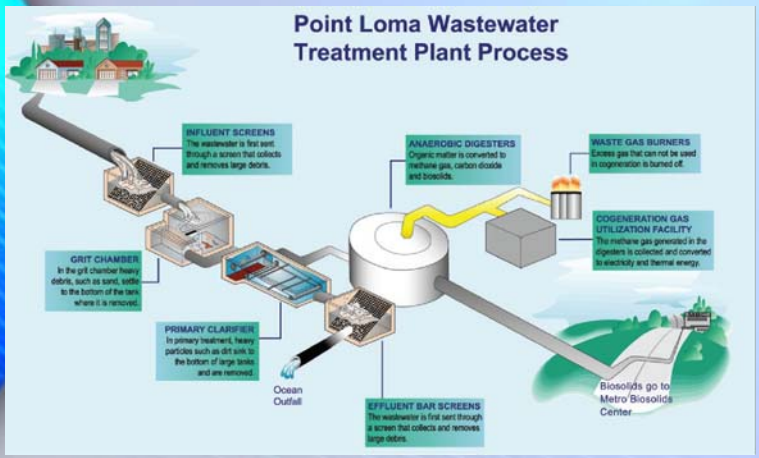
Use of WWTP Digester Gas to Generate Power

Craig Hustwit
Edd Bills
Chuck White
National Energy Technology Laboratory

Overview

- What is WWTP Digester Gas?
- Applications
- Process Issues
- WWTP Gas to Power

Wastewater Treatment Plant



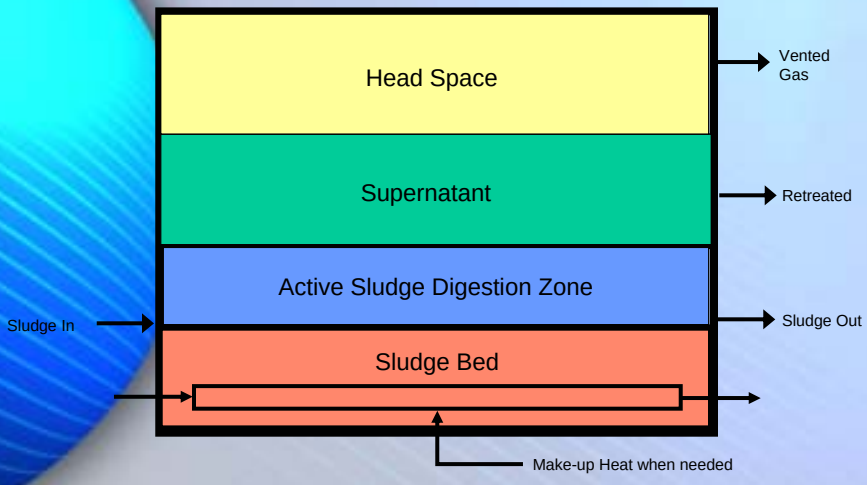
Wastewater Treatment Process

- Preliminary Treatment
- Primary Treatment
- Secondary Treatment
- Tertiary Treatment
- Sludge Thickening
- Sludge Dewatering
- Digestion and Stabilization

Anaerobic Digestion

- Sludge & resident anaerobic bacteria pumped into large covered tank, anaerobic conditions
- Temperature 90 - 95 °F, pH circum-neutral
- Supernatant and scum periodically returned to beginning of the treatment process
- Sludge allowed to sit for 1 – 3 months

Anaerobic Digester



Anaerobic Digestion

- Bacteria (methanogens, SRB) metabolize complex hydrocarbons in the sludge

  $(CH_2O)_x \rightarrow (CH_2O)_y + H_2O + CO_2 + H_2S + CH_4$

- Gas collects in head space, periodically drawn off (Typical production = 1 scf / capita / day)
- Even small concentration of H_2S problematic
  - Odor
  - Corrosive properties

Anaerobic Digestion

Optimum Temperature	95 - 98 °F
Optimum pH	6.7 - 7.8
Gas production	7-10 ft^3/lb volatile solids
Gas composition	64% CH_4, 35% CO_2, trace H_2S
Gas heating value	600 Btu/ft^3
Retention time	30 – 90 days
Typical tank diameter	20 – 115 ft

Digester Gas to Power

- Substitute for natural gas
- Internal combustion (IC) engines
- Small gas turbines & Microturbines
- Sterling engines
- Fuel cells

Reciprocating Engines

- Most common choice for DG applications
- Wide capacity range (1kw – 6 MW)
- Wide range of fuels (liquid and gaseous)
- Feed rates from under 5,000 scf/day
- Can utilize low BTU gas – some models as low as 300 Btu/scf

Reciprocating Engines

- Proven and reliable technology
- Tolerate H_2S in the 200 ppm range
- Generally more emissions problems than other types of equipment but cleanup is understood
- Heat from exhaust can be used to heat digester
- Lowest capital cost at 300 – 500 $/kW

Microturbines

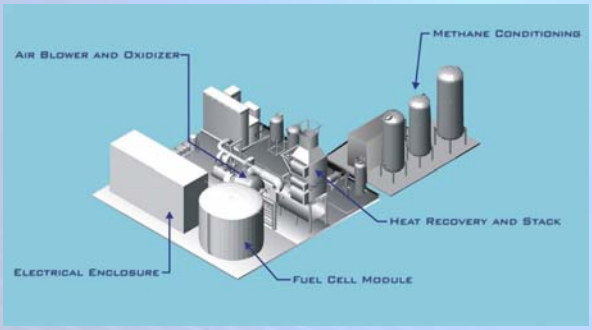
- Better for smaller operations – "plug and play" for pipeline quality gas
- Small "modular" units available: 30 – 100 kW
- Inlet pressures from 0.2 to 55 psi
- Inlet temperatures from – 20 to 50 °C
- Feed rates from 10,000 – 40,000 scf/day
- Some models tolerate high levels (7%) H_2S

Microturbines

- Heat from exhaust can be used to heat digester
- Low NOx (< 9 ppm – most models)
- Most run on air bearings having only one moving part (the central shaft with turbine) → less maintenance than reciprocating engines
- Cost is 1,000 -1,500 $/kW
- For large plants good strategy to use recips for bulk of power and use microturbines for peaking power

Fuel Cells

- Low Emissions
  - H_2O
  - Heat
- Heat used for digesters



- Low O&M costs – no moving parts
- High capital cost > 2,000 $/kW

Success Story 1

- Point Loma, San Diego Metropolitan WWT Dept.

Point Loma

- Treats up to 240 MGD
- Two reciprocating engine generators – 4.5 MWe
- Exhaust heat – heats digesters
- Dual fuel recip. engine generator – 1.2 MWe
- In 2000:
  - saved $3 million energy costs
  - sold $1.4 million to grid

Success Story 2

- South Treatment Plant – King County (Seattle) Washington

South Treatment Plant

- Uses a Binax scrubber to remove CO_2, H_2S and Siloxanes
- Scrubber produces pipeline quality gas, sold to Puget Sound Energy
- Can use two 3.5 MWe Solar turbine/generators (under construction)
- Lessons learned: removing the CO_2 from digester gas is expensive
  - Better to utilize lower Btu gas
  - Occasionally has been cheaper to flare than to run the scrubber

South Treatment Plant

- Alternative Usage of Unscrubbed Gas
  - Can use in 1 MWe molten carbonate FuelCell Energy fuel cell
  - Fuel with CO_2 is preferred
  - H_2S removed with SulfaTreat

Success Story 3

- West Point Treatment Plant King County (Seattle) Washington

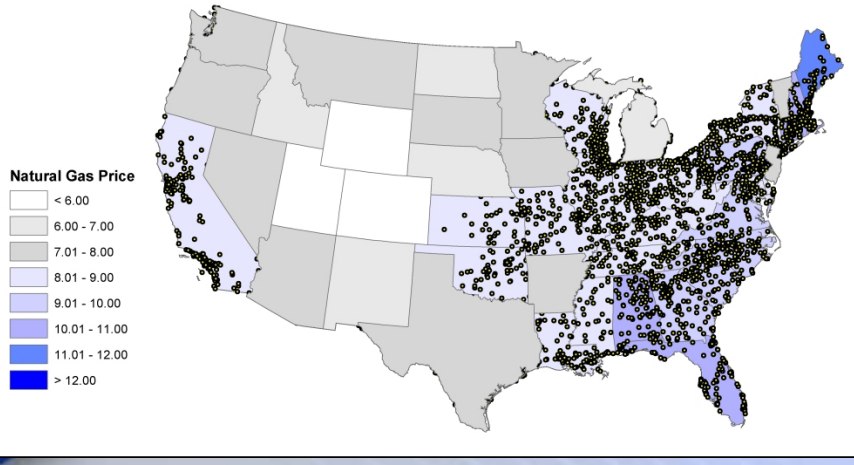
West Point Treatment Plant

- 133 MGD, 1.4 mmscfd digester gas
- Two 1.3 MWe recip. engine generators
- Exhaust heats LP boilers producing steam for digesters
- Engines have modified carburetors to use lower Btu gas

Digester Gas to Power

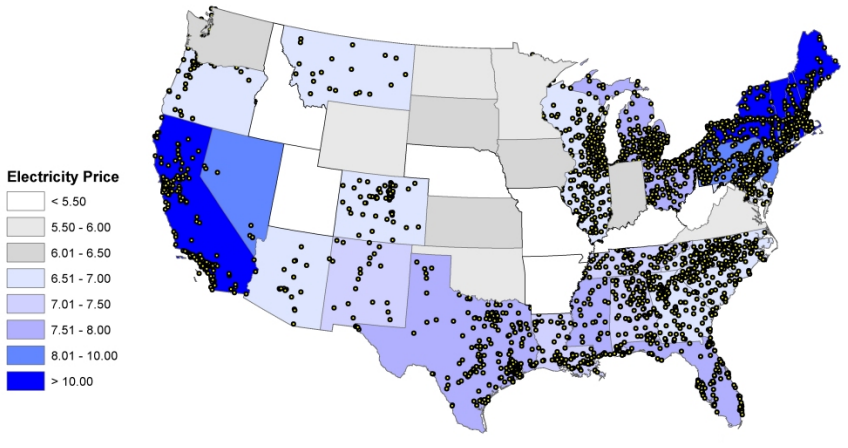
- Other Issues to Consider:
  - Availability
  - Economics
  - Energy Security
  - Regulations & Environment
  - Contracts

Natural Gas Prices



August 8-11, 2004 www.energy2004.ee.doe.gov

Electricity Prices



August 8-11, 2004 www.energy2004.ee.doe.gov

Economic Evaluation

- Digester gas cost includes base price plus:
  - Cost of H_2S and H_2O removal
  - Cost of transportation
    - pipeline construction
    - land right of ways, etc.
  - Cost of gas conditioning (i.e. compressing, etc.)
  - Special adaptation to combustors or engines

Economic Evaluation

- Can be a long-term, low cost renewable fuel source for generating electricity and heat
- Requires in-depth economic comparison to competing fuel and/or energy sources
- Issue is further complicated when digester gas availability fluctuates during the year
- Mitigating factor: digester gas can be burned in combination with natural gas, landfill gas, and other organic waste materials

Economic Evaluation

- Issues to Take into Account
  - Use of certain renewable and alternative fuel sources to generate electricity qualifies for green tax credits
  - The tax credits can be used to improve the financial viability of a project either directly or through their sale

Economic Evaluation

- Issues to Take into Account
  - Explore state incentives for use of green and/or renewable fuel sources to generate power
  - Explore utility company incentives for use of green and/or renewable fuel sources to generate power

Economic Evaluation

- Issues to Take into Account
  - Include avoided costs when performing financial evaluation
  - Consider value to customer of protection from grid outages and volatility of competing fuel costs
  - Consider any potential O&M Savings

Successful Approaches

- Use digester gas in combination with other locally available renewable resources
- Generate as much electricity (or heat) as you can, use what you can at the facility, sell the rest
- When using digester gas and other renewables to generate electricity, capture and use process heat, i.e. CHP

Digester Gas to Power

- Resources are Available:
  - DOE's Office of Energy Efficiency and Renewable Energy
  - Federal Energy Management Program
  - FEMP's Biomass and Alternative Methane Fuels (BAMF) Super ESPC group
  - EPA Office of Wastewater Management (OWM) for general information, laws and regulations, permitting and location data for WWTPs
    - http://www.epa.gov/owm
  - Water Environment Federation (WEF), the national WWTP trade association
    - http://www.wef.org

Digester Gas to Power

- BAMF
  - Streamlined contracting vehicle for federal facilities to utilize digester gas (and other fuels)
  - Financing alternative to Congressional appropriations
  - Trained and experienced technical core team
  - More information available from:
    - NETL booth
    - FEMP booth
    - Workshop "BAMF Baseball"

Conclusion

- Use of digester gas in generating electricity and/or steam can be an attractive approach especially when used in combination with conventional or other renewable fuels

- For more information contact:

Christopher Abbuehl
National Program Representative
215-656-6995
christopher.abbuehl@ee.doe.gov