LAWPCA Open House and Workshop: Biogas

- Introduction
  - What is Biogas?
  - What can you do with it?
  - Is it dangerous, explosive or cause odors?
  - How can it be handled safely?
  - Air Quality Regulations

Biogas: Definition

- Microorganism bacteria called methanogens
- Methanogenesis
- Microbiological overall reaction:
  - Bacteria + Organics $\rightarrow$ **CH_4** + CO_2 + H_2 + NH_3 +H_2S
- Strict and facultative bacteria:
  - Bacterioides, Bifidobacterium, Clostridium, Lactobacillus, Streptococcus

Reference: Bitton, Gabriel, Wastewater Microbiology, second edition, Wiley–Liss 1999.

Biogas: Definition

- **Aerobic** bacteria produce about *800-1,200* lb. of bacterial cell material per ton of organic material.
- **Anaerobic** bacteria produce about *40-300* lb. of bacterial cell material per ton of organic material.
- Aerobic microorganisms convert carbon to sludge.
- Anaerobic microorganisms converts carbon to biogas.

Biogas: Definition

- Biogas is mostly methane, CH_4.
- Methane
  - naturally occurring hydrocarbon gas
  - A common phenomenon in diverse natural environments
    - Glacier ice, sediments, marshes, termites, rumen and oil fields
  - the primary component of Natural Gas Fuel

Biogas: Definition

Biogas

- Renewable Energy Source
- Produced by Anaerobic Digesters for municipal WW sludge and manure.
- Also produced in landfills

Biogas: Characteristics

Biogas

- Landfill gas ~ 50% methane
- Digester gas ~ 55-75% methane
- Digester gas energy content ~ 500-700 btu/cf
- Natural Gas ~ 1,000 btu/cf

Biogas: Production Rate

Conventional mesophillic anaerobic digester gas production rate:

12-18 CF biogas /
lb. Volatile Solids Destroyed

Two phase thermophillic – mesophillic anaerobic digester gas production rate:

15 - 25% greater biogas production

Reference: Wastewater Engineering Treatment and Reuse, Metcalf & Eddy, McGraw Hill, 2003.

Biogas: What can you do with it?

Combined Heat & Power (CHP) uses:

- Internal Combustion Engines
- Combustion Gas Turbines
- Microturbines
- Fuel Cells

Biogas: What can you do with it?

Non-CHP Uses:

- Injection of biogas into natural gas pipelines
- Sale of biogas to an industrial user or power company
- Use of biogas as a vehicle fuel

Biogas: CHP Uses

Internal Combustion Engine

- Biogas fuel is combusted in an engine resulting in shaft work
- Shaft work turns an electric generator to generate electric power.
- High T exhaust gas flows through a Heat Recovery Unit (HRU) to capture heat energy.
- HRU typically includes a digester gas to water heat exchanger.
- Heated water is circulated to heat the anaerobic sludge or as building heat.

Biogas: CHP Uses

Combustion Gas Turbines & Microturbines

- A compressor compresses combustion air to bring it to a high pressure
- Biogas fuel is sprayed into the compressed combustion air and ignited.
- The combusted high pressure fuel/air flow enters a turbine where it expands down to exhaust pressure resulting in shaft work output.
- The shaft work turns an electric generator .
- Exhaust gas flows through an HRU.

Biogas: CHP Uses

65 KW Microturbine

3.3 MGD Airport Parkway WWTF

City of South Burlington, Vermont

Biogas: CHP Uses

Digester Gas
Treatment Skid
- Boosts pressure
- Removes moisture
- Removes siloxane

Airport Parkway WWTF
City of South
Burlington, Vermont

Biogas: CHP Uses

Fuel Cells

- Utilize electrochemical reactions to convert chemical energy into electricity.
- Converts clean, pressurized biogas to produce hydrogen gas to power the fuel cell unit.
- Hydrogen rich fuel reacts electrochemically to produce electric current, heat and water.
- No combustion, no NO_x, SO_x or PM emitted.

Biogas: Non-CHP Uses

Biogas addition to NG pipeline

Biogas is treated to remove:

water, carbon dioxide and hydrogen sulfide

Then pressurized &

Pumped into NG pipeline

Biogas: Non-CHP Uses

Vehicle fuel

Biogas is treated to remove most CO_2

Compressed

Typically used in fleet vehicles

May be cost effective for existing NG fleets

Is Biogas dangerous/explosive/odorous?

Biogas is essentially methane.

- Methane is non toxic odorless gas.
- Asphyxiant as it may displace oxygen in an enclosed space.
- Biogas non methane parts can cause odor
- Extremely flammable and may form explosive mixtures with air.
- A methane gas explosion was the cause of the Upper Big Branch coal mine disaster in WV on April 5, 2010, killing 25.

How can biogas be used safely?

- Digester Gas Safety System includes
  - Digester Covers to contain digester gas
  - Waste Gas Burner
  - Condensate and Sediment Traps
  - Drips traps control condensate drainage
  - Flame arresters
  - Pressure regulator and relief valves
  - Designed and constructed to NFPA 820.

How can biogas be used safely?

Waste Gas Burner

- Reliably incinerate waste digester gas of varied or low BTU value
- Used when other biogas utilization equipment is shutdown.
- Automatically controls air to fuel mixture
- Minimizes odor, VOC and smoke emissions
- Operates in high wind conditions

Digester gas safety equipment

Waste Gas Burner

Digester gas supply piping

Pilot gas piping

Burner assembly

Waste Gas Burner, Airport Parkway Wastewater Treatment Facility
City of South Burlington, Vermont.

Hoyle, Tanner & Associates, Inc.

Digester gas safety equipment photos

Condensate and Sediment Trap

Airport Parkway Wastewater Treatment Facility City of South Burlington, VT

Biogas: Air Regulations

Check with State Regulatory Agency

Typical contaminants of concern

- Particulate Matter
- Sulfur dioxides
- Nitrogen dioxides
- Carbon monoxide
- Volatile Organic Compounds

Biogas: Summary

Biogas is predominantly a methane gas byproduct of anaerobic digestion.

Biogas piping systems are designed with gas safety equipment in accordance with NFPA820 to reduce the risk for fire, explosion and odors.

Biogas is typically used at WWTF's to produce electrical power, process and building heat to reduce operational costs.

Biogas:

- Thank you
- Any questions or comments?

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