Anaerobic Digester Gas to Energy

Using “Opportunity Fuel” to Benefit Society

Scott Yappen
Veolia Energy North America
Trenton | Philadelphia
syappen@veoliaenergyna.com

About Veolia Energy

- 150+ years. Founded in 1860
- 53,000+ employees in 42 countries
- 120,000+ energy systems managed
- 5,000+ MW CHP: 800+ gas turbines and engines
- 880+ district heating /cooling networks
- $10+ billion/yr global revenue

Veolia Water Biosolids Experience – Large Plants

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<td>Milwaukee, WI – 300 MGD</td>
<td>Berlin, Germany – 175 MGD</td>
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<td>Wilmington, DE – 134 MGD</td>
<td>Prague, Czech Republic – 150 MGD</td>
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<td>Incineration</td>
<td>Naugatuck, CT – 75 DT</td>
<td>Berlin, Germany – 250 DT</td>
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<td>Cranston, RI – 66 DT</td>
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<td>Dewatering and Thermal Drying</td>
<td>Chicago, IL – 200 DT</td>
<td>Berlin, Germany – 260 DT</td>
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<td></td>
<td>Milwaukee, WI – 200 DT</td>
<td>Zaragoza, Spain – 48 DT</td>
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<td>Berlin, Germany – 260 DT</td>
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<td>Composting</td>
<td>Baltimore, MD – 45 DT</td>
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<td>Hickory, NC – 20 DT</td>
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<td>Lime Stabilization</td>
<td>Oklahoma City, OK – 64 DT</td>
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Benefits of Digester Gas Utilization

- Economic
  - Reduce energy cost
- Environmental
  - Create energy from an otherwise wasted “renewable” fuel source
  - Reduce harmful GHG emissions like methane (CH₄)
    + CH₄ is 20x more potent than CO₂ in trapping sun’s heat in atmosphere
- Societal
  - Reduce stress on electric grid/gas
  - Good for community morale and PR
- Utilize a domestic source of energy
- Security
  - Enhance power reliability for the facility
- Regulatory
  - Satisfy “emergency power” mandate for WWTP to maintain operational continuity during utility outages

Opportunity Fuels

aka Alternative Fuels

- Fuels used in place of fossil fuels to generate energy
- Contains methane (CH₄)
- Derived from natural sources deep in the earth, or from natural processes that break down waste material
  - Coal mines
  - Landfill
  - Agricultural biogas
  - Anaerobic Digester Gas (ADG)
- Years ago, these gases were simply allowed to escape into the air. Now, they are recognized as valuable and in many cases renewable energy resources.

Basics of Digester Gas Process

- Micro-organisms break down biodegradable material in the absence of O₂
- Biogas is produced
  - Typically = 55-65% methane, 35-45% CO₂
- Sludge is heated to accelerate the process
  - Mesophilic bacteria live optimally =95°F
- Biogas can be utilized
  - to generate heat & power(CHP)
**Combined Heat & Power**

- **Definition:** simultaneous generation of multiple forms of thermal and electrical energy from a single fuel source
  - Power, hot water, steam, cooling, drying, etc.
  - AKA co-generation or tri-generation
- **High total energy efficiency:** 65-90%
  - Electric grid efficiency has been 30% since the 1950s

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**Serving Plant Thermal Loads**

**WWTP Plant thermal loads: digesters & building HVAC**
- For digesters, heat is needed to:
  - Raise incoming sludge temperature
  - Compensate for thermal losses

**Digester Thermal Load Assumptions**
- 12,000 gal/day - sludge volume fed to digester
- 55°F - incoming sludge temperature
- 95°F - target temperature for Mesophillic digester sludge

**Calculation**

\[12,000 \text{ gal/day} \times 8.34 \text{ lb/gal} \times 1 \text{ BTU/lb-°F} \times (95°F - 55°F) = 4,003,200 \text{ BTU/Day} = 166,800 \text{ BTU/Hr}\]

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**Digester Gas Production Calculation**

**Assumptions**
- 12,000 lb/day sludge - 7,500 primary sludge, 4,500 waste activated sludge
- .8 cu ft volatile solid per pound sludge
- 55% volatile solids reduced by digester and generate biogas
- 15 cu ft/lb of volatile solids destroyed

**Gas Volume Calculation**

\[12,000 \text{ lb} \times 0.8 \text{ lbvss} \times 0.55 \times 15 \text{ cubic feet} = 79,200 \text{ cu ft/day gas (≈} 50 \text{ cfm})\]

**Biogas Low Heating Value (LHV)**

- 550-600 BTU/cu ft
- Natural gas = 1,000 BTU/cu ft
- Engines/Turbines "eat" BTUs (LHV)

79,200 cu ft/day x 600 BTU/cu ft = 47,520,000 BTU/day or 1,980,000 BTU/hr

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**Digester CHP Process Flow Diagram**

- Electric Energy – 137 kW
- Thermal Energy – 634,680 BTU/hr
- Total Efficiency (CHP) – 67.1%
- CFM Flow Rate – 50 CFM
EPA Statistics

- How much energy is available from ADG?
- EPA: 4.5 mgd WWTP with AD can produce:
  - 100 kW of electricity
  - 12.5 million BTU per day of thermal energy

Enhancing Digester Gas Production

- Low Hanging fruit
  - Clean digester
  - 30% of digester is filled with grit/sand/silicon
  - Make sure mixing system works
  - OpEx that is often not budgeted
  - Co-digestion
    - Supplement normal WWTP sludge feed with FOG
      - Higher available BTU content (90%+)

Enhanced Gas Production

Co-digestion

- Import High-Strength Organic Wastes with Sludge
  - Increases biogas quantity & quality (↑ BTU)
  - Improves Gas Quality
    (↑ BTU, ↓ Contaminants)
  - Increases Revenues
- Most Common Wastes – FOG, Food & Industrial

Milwaukee, WI – South Shore WRF

1/3 National Power Usage per MG

- Net Power Usage:
  - ~ 400 KWH/MG Treated vs. National Average of ~ 1,200 KWH/MG)
- Plant Flows:
  - 315 MGD/300 MGD Design with 12 Digesters
- Biogas Used to Fuel 5.1 MW Cogeneration Systems
  - 4 - 925 & a 1.5 KW Engine-Generators
  - 1 - 1.5 MW Engine-Generator
- Recovered Thermal Energy Used for Digester & Building Heat
- Digester Enhancements to Increase Gas Generation
  - Receive Imported Airport Deicing Fluids for Co-Digestion
  - Piloting Co-Digestion of Various High-Strength Organic Wastes

Enhanced Gas Production

Thermal Hydrolysis Technology

- Sludge energy = 7500 BTU/lb
  - Typical digester reduces 50% volatile solids
    - Yield 3500+ BTU/lb
Thermal Hydrolysis (300+°F, 100+ psi)

- Suspended solids liquefied
  - Volatile solids destruction, and biogas, increases 30-40%
  - Reduces sludge quantity and disposal costs
  - Higher ops cost
State of NJ

- NJ Energy Master Plan
  - 1500 MW CHP; 100 MW District Energy
- Energy Savings Improvement Program (ESIP)
  - Energy savings contracts for public sector
  - Third party financing
  - 20 year term for CHP
  - Advantageous for municipalities in this economy
- Pay for Performance Incentives
- State Bill A3339, A3439
  - Eliminates state sales and use tax on natural gas for CHP
  - Allows customers not immediately on the same site as a CHP plant serving them heating and cooling to also purchase electricity, steam and cooling as onsite customers. This enables district energy systems
  - Effective 2009

Project Finance Considerations

- Traditional Project Financing
  - Does authority have borrowing/credit capacity?
  - Financial risk transferred to investors
    - Good rates (sub-market tax exempt)
    - Not applicable for tax benefits
    - Financial/Operational risks
    - Can employees operate a CHP plant?
- Third Party BOOM/Finance
  - CHP Project expertise
    - Regulatory, financial, operational, design/build
    - Mitigates finance and O&M risks
    - Budgeting of unplanned equipment failures
  - Possible via ESIP program; 20 year energy service agreements
  - Project benefits from incentives applicable to taxable entities

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Questions

Scott Yappen
Business Development Director
Veolia Energy North America
Trenton | Philadelphia
syappen@veoliaenergyna.com
609-498-1180