Anaerobic Digester Gas to Energy

Using "Opportunity Fuel" to Benefit Society

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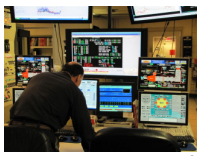
About Veolia Energy

- 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



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Veolia Water Biosolids Experience – Large Plants

Technology	U.S. Experience	Global Experience
Anaerobic Digestion	Milwaukee, WI – 300 MGD Wilmington, DE – 134 MGD	Berlin, Germany – 173 MGD Prague, Czech Republic – 150 MGD
Incineration	Naugatuck, CT – 75 DT Cranston, RI – 66 DT	Berlin, Germany – 250 DT Bali, Taiwan – 80 DT
Dewatering and Thermal Drying	Chicago, IL – 200 DT Milwaukee, WI – 200 DT	Berlin, Germany – 260 DT Zaragoza, Spain – 48 DT Berlin, Germany - 260 DT
Composting	Baltimore, MD – 45 DT Hickory, NC – 20 DT	Riyadh, Saudia Arabia – 125 DT Prague, Czech Republic – 118 DT
Lime Stabilization	Oklahoma City, OK – 64 DT	Brussels, Belgium – 55 DT

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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 (CH_4)
    - CH_4 is 20x more potent than CO_2 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

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Opportunity Fuels

aka Alternative Fuels

- Fuels used in place of fossil fuels to generate energy
- Contains methane (CH_4)
- 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.

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Basics of Digester Gas Process

- Micro-organisms break down biodegradable material in the absence of O_2
- Biogas is produced
  - Typically ≈ 55-65% methane, 35-45% CO_2
- Sludge is heated to accelerate the process
  - Mesophilic bacteria live optimally ≈95°F
- Biogas can be utilized
  - to generate heat & power(CHP)

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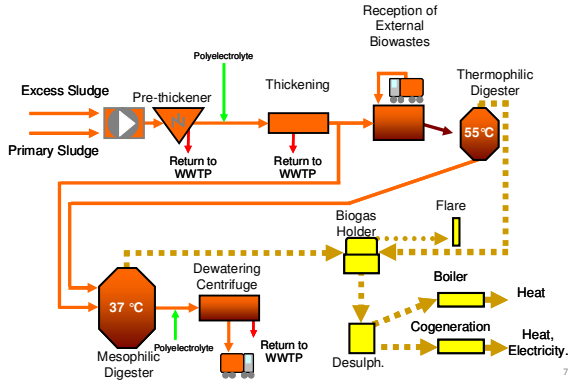
Digester Process



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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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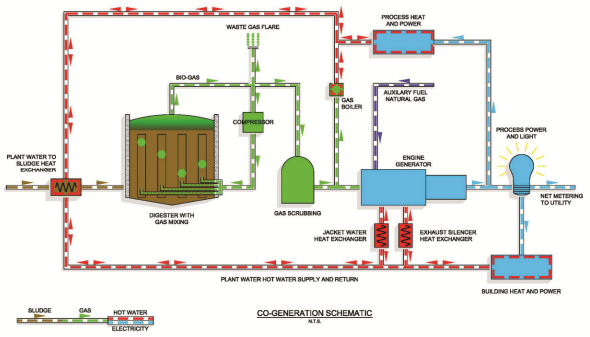
CHP Process



CME Associates
Joint Meeting Essex & Union Counties

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 gal/day x 8.34 lb/gal x 1 BTU/lb- °F x (95°F - 55°F)

= 4,003,200 BTU/Day = 166,800 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 lb/day x 0.8 lbvss/lbss x 0.55 x 15 cubic feet/lb/vss destroyed = 79,200 cu ft/day gas (≈**50 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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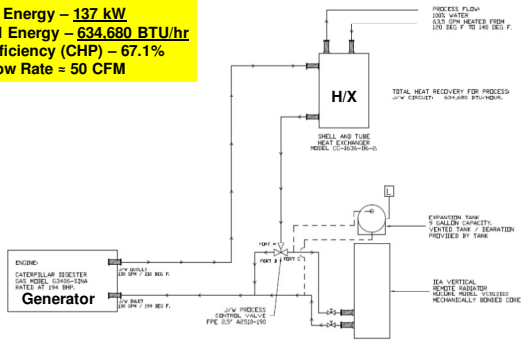
Digester CHP Process Flow Diagram

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



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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*

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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+%)

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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

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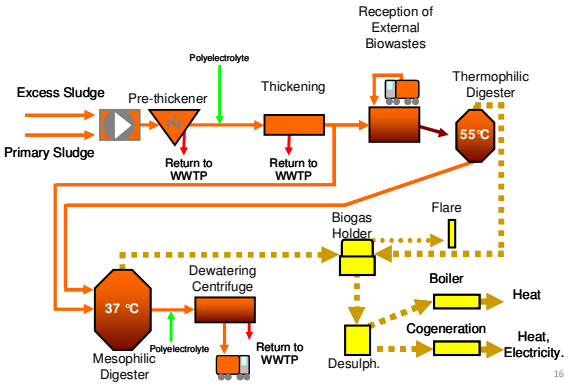
Digester Process



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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:
  - 115 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

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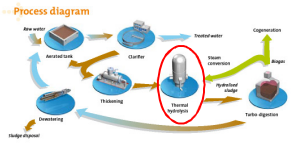
Enhanced Gas Production

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



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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

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Project Finance Considerations

- Traditional Project Financing
  - Does authority have borrowing/credit capacity?
  - Financial risk transferred to investors
    - Good rates (sub-market tax exempt debt)
  - Not applicable for tax benefits
  - Financial/Operational risks
    - Can employees operate a CHP plant?
- Third Party DBOOM/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

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