DIGESTER GAS
ENERGY RECOVERY
ALTERNATIVES

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Presentation Overview

- Digester Gas Production and Characterization
- Gas Production Rates at JPWWTP & SWWTP
- Project-Specific Goals at JPWWTP & SWWTP
- Digester Gas Cleaning & Energy Recovery Alternatives
Digester Gas Production

- Anaerobic digestion: 50 to 65% of VSS destroyed

<table>
<thead>
<tr>
<th>SRT (days)</th>
<th>% Reduced</th>
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<tbody>
<tr>
<td>30</td>
<td>65.5</td>
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<tr>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>56</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
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- 12 to 18 ft³ digester gas produced per pound of VSS destroyed

- Rule of thumb: 9,000 to 12,000 ft³ per day of digester gas per million gallons of plant capacity
JPWWTP Digester Gas Production

Avg. Gas Production & Usage (Jan ‘07 – Dec ‘07)

- Total Gas: Monthly average range of 800,000 to 1,200,000 CFD
- “Waste Gas”: Monthly average range of 57,000 to 790,000 CFD
At time of study, there was no anaerobic digestion at Southerly

- S66 improvements incorporate two-stage acid-phase digestion

Estimated average gas production & usage:

<table>
<thead>
<tr>
<th>Gas Usage</th>
<th>Gas Flow Rate (CFD)</th>
<th>Gas Flow Rate (CFM)</th>
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<tbody>
<tr>
<td>Boilers</td>
<td>509,000</td>
<td>353</td>
</tr>
<tr>
<td>Incinerators</td>
<td>158,000</td>
<td>109</td>
</tr>
<tr>
<td>“Waste” Gas</td>
<td>380,000</td>
<td>264</td>
</tr>
<tr>
<td>Total</td>
<td>1,046,000</td>
<td>726</td>
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Digester Gas Composition

- Methane, CH$_4$ (55 to 70%)
- Carbon Dioxide, CO$_2$ (30 to 45%)
- Trace Amounts of the following:
  - Hydrogen Sulfide H$_2$S
  - Siloxanes,

Heating value of 530 to 675 BTU / ft$^3$
Digester Gas Trace Constituents

- **Hydrogen Sulfide**
  - Up to 10,000 ppm H$_2$S (typically 40 to 1,000 ppm)
  - Combustion in presence of water vapor results in H$_2$SO$_4$
  - “Pipeline quality” requires < 4 ppm H$_2$S

- **Siloxanes**
  - By-product of cosmetics and toiletries
  - Typically 2 to 4 ppm siloxanes
  - Damage to equipment can occur at levels approaching 50 ppb
Digester Gas Cleaning Technologies
Hydrogen Sulfide Removal

- **Sorption techniques**
  - Activated Carbon, Iron Sponge
- **Chemical addition**
  - Iron Salts (Ferric chloride)
- **Scrubbing with liquid media**
  - Packaged Systems

Sorption media columns

Liquid Scrubbers
Siloxane Removal

- Sorption Systems
  - Siloxane-specific media
- Liquid Scrubbing
- Condensation
- Packaged Systems
Carbon Dioxide Removal

- Generally not harmful for engine operation
- “Pipeline Gas” requires 2% maximum CO$_2$
- Removed with:
  - Liquid scrubbers
  - Membrane separation technologies
- Packaged Systems available
Cleaning System Costs

Hydrogen Sulfide
- Cleaning system: ~ $100,000 per 100 CFM
- Operation ~ $7,000 per year per 100 CFM

Siloxanes
- Cleaning system ~ $190,000 per 100 CFM
- Operation ~ $15,000 per year per 100 CFM

Carbon Dioxide / Nitrogen Removal
- Cleaning System: ~ $220,000 per 100 CFM
- Operation: ~ $30,000 per 100 CFM
Levels of Treatment

**Pipeline Quality Gas**

Treatment A
- Carbon dioxide (< 2%)
- Water Vapor (< 7 lb/MMSCF)
- Hydrogen Sulfide (< 4 ppm)
- Siloxanes (< 30 ppb)

~ 98% Methane
Trace inert gases

**On-Site Energy Generation**

Treatment B
- Hydrogen Sulfide (< 10 ppm)
- Siloxanes (< 50 ppb)

~ 55 to 65% Methane
~ 35 to 45% Carbon Dioxide
Reduced Constituents Other Inert Gases
Alternatives - Cogeneration

- Typical electrical efficiency: 28 to 33% efficient

  - Per 1 MGD of plant capacity*:
    - 500 to 600 kWh per day generated
    - $15,000 + per year in electricity savings

- Typical thermal efficiency: 45 to 60% efficient

  - Per 1 MGD of plant capacity*:
    - 3 to 3.5 MMBTU per day in recoverable heat
    - $7,000 + per year in natural gas savings

* Assuming no other usage of digester gas
Possible Implementation of Electricity Generating Engine at JPWWTP & SWWTP

<table>
<thead>
<tr>
<th>Plant</th>
<th>Average Gas Flow</th>
<th>Engine Size</th>
<th>kWh per Month Generated</th>
<th>Plant Monthly Power Usage</th>
<th>Percent of Plant Power Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackson Pike</td>
<td>240,000 CFD</td>
<td>570 kW</td>
<td>411,000 kWh</td>
<td>4.51 MM kWh</td>
<td>9%</td>
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<tr>
<td>Southerly</td>
<td>380,000 CFD</td>
<td>900 kW</td>
<td>651,000 kWh</td>
<td>5.03 MM kWh</td>
<td>13%</td>
</tr>
</tbody>
</table>

- JPWWTP: $390,000 per year in electrical savings
- SWWTP: $625,000 per year in electrical savings

- GE Jenbacher Engine
  - Approx $100,000 per 100 kW
Possible Implementation of Direct Drive Engine at JPWWTP & SWWTP

- **JPWWTP**: Operation of 400 HP fluidized bed incinerator blower
  - Electrical savings of ~ $210,000 / year
- **SWWTP**: Operation of 700 HP center aeration blower
  - Electrical savings of ~ $365,000 / year

**Brake Horsepower vs Digester Gas Flow**

- Cost of approximately $30,000 per 100 HP capacity
Alternatives – Clean Natural Gas Sale

- Option 1: Public / Private Partnership
  - Gas cleaning system ($1.5 million) provided by private company
  - City pays electrical costs
  - City and private company split revenue of gas sale

JPWWTP (2007 data) net revenue of $95,000
- $170,000 in gas sale (after 50 / 50 split)
- $75,000 in annual electric cost
Option 2: Gas cleaning system owned by City

JPWWTP (2007 data) net revenue of $125,000
- $340,000 in gas sale
- $75,000 in annual electric cost
- $115,000 in amortized annual payment
- $25,000 in miscellaneous operation and maintenance
Alternatives – CNG Vehicles

**Installation at SWACO (Green Energy Center)**
- Phase 1 ($4.5 Million) can process 430,000 CFD landfill gas
- Cleaning system and microturbine in pre-engineered metal building
- Compressor and storage (3,000 and 3,600 psi tanks) located outside
- Filling stations

![CNG storage tanks](image1)

![CNG filling station](image2)

![Compressor](image3)

![Facility Building](image4)
Alternatives – CNG Vehicles

Cost analysis for implementation at SWWTP, based on:

- Sell gas not used for CNG to pipeline at $7.00 per MMBTU
- Capital cost of $4,000,000 amortized at 4.5% interest
- Electrical costs of 8 cents per kWh
- Additional O&M expense of $25,000 per year
- CNG demand of 100 GGE per day

CNG cost of approximately $1.60 per GGE for “break even”
Summary and Conclusions

- Electrical and thermal energy savings
  - Electrical: $15,000 + per year per MGD of plant capacity
  - Heating: $7,000 + per year per MGD of plant capacity

- Electrical and thermal recovery system costs
  - Return on investments ~ 3 to 7 years

- Clean natural gas and CNG
  - Public / private partnerships or facility-owned
  - Not profitable for smaller plants

- Varying energy costs can have substantial impact on the return on investment
Questions