Biogas Utilization Improvements at the West Bend WWTP

Dan Schaefer, PE
Outline:

• Project Background
• Biogas to Energy Opportunity
• Biogas Study
• Design
• Construction
• Operation (1st Year)
• Q & A
Project Background
Background

• Project drivers
  – Increased high-strength waste receiving in 2011
  – Excess digester gas production
  – Desire to utilize a renewable resource to offset WWTP O&M costs
Background

• Project goals
  1. Minimize staff operating requirements
  2. Provide a safe and reliable system
  3. Achieve utilization in the most cost-effective manner
  4. Optimize funding opportunities
  5. Maximize digester gas utilization
Biogas to Energy Opportunity
Biogas to Energy Opportunity

• Why Biogas to Energy?
  – Produce electrical power
    • We Energies will buy-back at $0.155/kWh on peak (9 AM-9PM)
    • Sewer Utility currently pays $0.069/kWh on peak
    • On-Peak Buyback of 2.25 times current purchase rate
  – Offset heating needs
  – Sustainable energy “Green Project”
  – Generate additional revenue
Biogas Utilization Study
Project Goals

1. Minimize staff operating requirements
2. Provide a safe and reliable system
3. Achieve utilization in the most cost-effective manner
4. Optimize funding opportunities
5. Maximize digester gas utilization
Microturbines vs Engines

• Microturbine Advantages Over Engines:
  – One Moving Part
  – No Oil Changes
  – Quiet Operation
  – Compact Footprint
  – Clean
  – 65 kW Capstone Microturbines have a proven installation track record
### Biogas Study – Alternatives

<table>
<thead>
<tr>
<th>Biogas Production and Utilization Alternatives for Detailed Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alternative No.</strong></td>
</tr>
<tr>
<td>Biogas Utilization Alternatives</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>Electrical Power Distribution/Production Alternatives</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>Biogas Storage Enhancement Alternatives</td>
</tr>
<tr>
<td>B1</td>
</tr>
<tr>
<td>C1</td>
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</table>
Project Goals

1. Minimize staff operating requirements
2. Provide a safe and reliable system
3. **Achieve utilization in the most cost-effective manner**
4. Optimize funding opportunities
5. Maximize digester gas utilization
<table>
<thead>
<tr>
<th>Project Costs</th>
<th>ALT 1A</th>
<th>ALT 1B</th>
<th>ALT 1B1</th>
<th>ALT 1C</th>
<th>ALT 1C1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Construction Costs</td>
<td>$2,188,700</td>
<td>$2,375,600</td>
<td>$3,835,500</td>
<td>$2,614,300</td>
<td>$4,074,200</td>
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<tr>
<td>Subtotal Annual Costs</td>
<td>-$107,100</td>
<td>-$177,900</td>
<td>-$392,600</td>
<td>-$345,600</td>
<td>-$483,400</td>
</tr>
<tr>
<td>Estimated Payback Period</td>
<td>20.4 yrs</td>
<td>13.4 yrs</td>
<td>9.8 yrs</td>
<td>7.6 yrs</td>
<td>8.4 yrs</td>
</tr>
<tr>
<td>Net Present Worth of Alternative</td>
<td>$618,800</td>
<td>-$145,700</td>
<td>-$1,571,300</td>
<td>-$2,161,300</td>
<td>-$2,554,000</td>
</tr>
</tbody>
</table>
Selected Alternative 1C

- Estimated Annual Cost Breakdown (at midpoint of 20 year design period – 2022)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual O&amp;M Cost</td>
<td>$ 60,500</td>
</tr>
<tr>
<td>Annual Natural Gas Cost Savings</td>
<td>-$ 44,500</td>
</tr>
<tr>
<td>Annual Electrical Power Cost Savings</td>
<td>-$ 244,600</td>
</tr>
<tr>
<td>Annual High Strength Waste Hauling Revenue</td>
<td>-$ 117,000</td>
</tr>
<tr>
<td><strong>Total Annual Cost</strong></td>
<td>-$ 345,600</td>
</tr>
</tbody>
</table>
Project Goals

1. Minimize staff operating requirements
2. Provide a safe and reliable system
3. Achieve utilization in the most cost-effective manner
4. **Optimize funding opportunities**
5. Maximize digester gas utilization
Biogas Study - Potential Funding Sources

• We Energies
  – Customer Biogas Generated Systems

• Focus On Energies
  – New Programs were announced on April 2, 2012

• WDNR Clean Water Fund Program
  – FY 2013 Principle Forgiveness – Followed Revised Formula
  – Project Preliminary Priority Evaluation Ranking Form (PERF) Score = 97.449
Design
## Design Criteria

<table>
<thead>
<tr>
<th>Unit Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Strength Waste Receiving Facility</td>
<td>1 – 125 gpm, Rotary Lobe Pump 30,000 gal HSW Receiving Tank (5 Tanker Capacity)</td>
</tr>
</tbody>
</table>
| Gas Conditioning                      | 230 scfm capacity  
Moisture Removal  
Biogas Compression to 90 psig  
3 – Siloxane Removal Vessels |
| Co-Generation                         | 4 – 65kW w/Integral Heat Recovery  
Total Heat Recovery Capacity:  
Approx. 220,000 – 270,000 btu/hr per turbine @ full load (880,000 – 1,080,000 btu/hr total) |
| Digester Boiler/HX Replacement        | Replace existing 1,000,000 btu/hr combination boiler/HX |
| Digester and Building Heating Modifications | Connect Microturbine heat recovery into existing Digester Heating loop, and revise Service Building Heating Loop to incorporate Microturbine heat recovery |
Design – Unique Aspects

• High Strength Waste Receiving:
  – PVC Sheet Liner Utilized
  – Utilization of Existing Tunnel for HSW Pump
  – HSW Feed Options
    • Gravity Thickener
    • Digesters
    • Recycle/Tank Mixing
  – Incorporation into existing Digester Feed Operation

• Microturbine Combined Heat & Power (CHP):
  – Grid Connection w/Buyback Agreement
  – Utilization of Existing Spaces
  – Intake Plenum Room
  – Heat Recovery
    • Building Heating
    • Digester Heating
    • Relieve Burden on Digester Boilers
Construction
Construction – Key Elements

• High Strength Waste Receiving Facility
• Replacement of original Digester Boiler/HX (1966)
• New Gas Conditioning Building Housing Gas Conditioning Skid
• Modifications to 1960s Service Building to House:
  – 4 – 65kW Capstone Microturbines
  – Hot Water Recirculation Pumps
  – Electrical Room
  – Microturbine Intake Plenum Room
Construction Challenges

- Underground Utilities
Construction Challenges

• Winter Work
  – Concrete
Construction Challenges

- Winter Work
  - Temporary Heat
  - Enclosures

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Construction Challenges

• Project Schedule
  – Grid Connection
  – Shutdown Coordination
Operation (1st Year)
Operation – 1st Year Timeline

June 2013 - Substantial Completion of CHP System

December 2013 - Boilers Re-Fired

October 2013 - Max HSW Received

March 2014 – Boilers Shutdown

June 2014 – Peak kW-Hr/Day Produced (4,137 kW-Hr/Day)

August 1, 2014 – Cargill Milwaukee Shutdown
Power Production & High Strength Waste Received
June 2013 - July 2014

- kWh/day
- HSW

MONTHLY KWh PRODUCED vs MONTHLY HSW GALLONS RECEIVED

Jun-13 to Jul-14

June 2013 to July 2014
Natural Gas Usage

Microturbine Start-Up
### Annual Cost (1st Year)

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual O&amp;M Cost</td>
<td>$17,130</td>
</tr>
<tr>
<td>Annual Natural Gas Cost Savings</td>
<td>-$5,500</td>
</tr>
<tr>
<td>Annual Electrical Power Cost Savings</td>
<td>-$110,800</td>
</tr>
<tr>
<td>Annual High Strength Waste Hauling Revenue</td>
<td>-$81,100</td>
</tr>
<tr>
<td><strong>Total Annual Cost</strong></td>
<td><strong>-$180,270</strong></td>
</tr>
</tbody>
</table>
Operation & Maintenance

- **Energy Content of Biogas:**
  - 12/7/11 – 639 btu/scf
  - 6/26/12 – 661 btu/scf

- **Siloxane Media Life:**
  - Media replaced 3 times during 1st Year of operation (Approx. $1,700 per replacement)
  - Average 15,000,000 scf between media replacement
  - Average Si concentration downstream of vessels between 0.18 and 0.32 mg/m³
Operation & Maintenance

• Unison Maintenance Trips:
  – CHP System Fault – Flow Setter Adjustment
  – Chiller Fault – Debris
  – Owner Requested HMI/PLC modifications
  – Annual Conditioning Skid & Microturbine inspection and maintenance
Project Goals

1. Minimize staff operating requirements – Microturbines and Gas Conditioning
2. Provide a safe and reliable system – Microturbines and Gas Conditioning
3. Achieve utilization in the most cost-effective manner – HSW Hauling Fees, NG Offset, Power Buyback
4. Optimize funding opportunities – We Energies Interconnection Agreement
5. Maximize digester gas utilization – HSW Receiving
Acknowledgements

• Scott Tutas, Sewer Utility Manager, West Bend Sewer Utility
• Tony Schilling & Kim Murdock-Timmerman, Unison Solutions
• Bryan Lewis, Project Manager, AECOM
Questions?
Thank you!