UNU-INWEH - Another Drop Lecture Series
Water-Energy Nexus

City of Hamilton
Biogas Enhancement at the Woodward Avenue Wastewater Treatment Plant

March 18, 2014
Agenda

- Background
- Project Objectives
- Project Overview
- Revenue Potential
- Questions
Background
WOODWARD WWTP

- 520,000 services area population
- Conventional activated sludge secondary treatment facility with seasonal disinfection.
- Capacity - 409 MLD average, 614 MLD peak
- Solids Train – anaerobic digestion, dewatering, land application
Background
Cogeneration Facility

- Renewable energy supply contract signed with the Ontario Electricity Financial Corp December 2004 to supply Green Energy for a 20 year term
- 1.6 MW Cogeneration Facility (CHP) was installed in 2006 at a cost of $4.4M
- Heat recovery used for digester heating, offsets purchase of natural gas
- Capacity - 15,300 m3/d Raw Biogas
Cogeneration Facility – Benefits

- Production of 1.6 of 1.6MW of renewable energy that will displace energy that is produced from coal
- Reduction of over 1.5 million cubic meters of natural gas annually
- Reduction of 6,500 tonnes of carbon dioxide emissions annually
- Local production of energy make Hamilton more self sustainable for the future
- Employment opportunities for operation and maintenance staff in Hamilton
- A model for other municipalities to utilize in the quest for new innovative solutions
- Annual revenue
Background

Woodward 1.6 MW Cogen & Biogas Storage Sphere
Figure 1 Anticipated daily biogas production rate and CHP demand.
Figure 2 Predicted biogas generation rate increases from Woodward Avenue WWTP enhancements 2010 to 2031.
PROJECT OBJECTIVES
Biogas Enhancement & Digester Upgrades

PROJECT OBJECTIVES:

- Stabilized biosolids
- Less biosolids requiring disposal
- Increase biogas generation
- To produce natural gas via gas purification
- Increase revenue

PROJECT OBJECTIVES THROUGH:

- Construction of a new Sludge Thickening Facility
- Upgrading the Digester Complex
- Installation of a biogas purification system
PROJECT OVERVIEW
Biogas Enhancement & Digester Upgrades Project

Project Overview

• ISF funded project
• Sludge Thickening Facility
• Biogas Purification
• $40 Million Capital Investment
• $20M funded by Federal/Provincial Government
• Fast track project to meet funding timeline
• EPCM (Engineering Procurement Construction Management) Delivery Model
Biogas Enhancement & Digester Upgrades Project

Sludge Thickening Building

• Primary Sludge Thickening
  ➢ Up to 7% solids

• Waste Activated Sludge Thickening
  ➢ Up to 7% solids

• Provide better sludge blending and consistent digester feed

• Sized for immediate and future flows
Biogas Enhancement & Digester Upgrades Project

Sludge Thickening Building (con’t)

• Decreases volume to digesters
• Increase solids retention time (SRT) in digesters to 21 days which:
  ➢ produces a stabilized biosolid
  ➢ maximum biogas generation
Biogas Purification – upgrade biogas (digester gas) to biomethane (natural gas)

**Raw Biogas**
- 65% methane
- 35% carbon dioxide
- Hydrogen sulphide
- Siloxanes
- Saturated with moisture

**Biomethane**
- 98% methane
- 2% carbon dioxide
- Trace other
- Acceptable quality for use in natural gas vehicles or injection into the local gas grid
# Raw Biogas Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical</th>
<th>Range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Biogas Pressure</td>
<td>103.8</td>
<td>99.0 - 105.0</td>
<td>kPa</td>
</tr>
<tr>
<td>Raw Biogas Temperature</td>
<td>37</td>
<td>20 - 60</td>
<td>Deg C</td>
</tr>
<tr>
<td>Methane</td>
<td>63</td>
<td>55 – 70</td>
<td>%</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>37</td>
<td>30 – 45</td>
<td>%</td>
</tr>
<tr>
<td>Water</td>
<td>Saturated</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.0</td>
<td>0 – 0.5</td>
<td>%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0</td>
<td>0 – 2</td>
<td>%</td>
</tr>
<tr>
<td>Hydrogen Sulphide</td>
<td>13</td>
<td>0 – 300</td>
<td>ppm</td>
</tr>
<tr>
<td>Total Sulphur as H₂S</td>
<td>25</td>
<td>0 – 300</td>
<td>ppm</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>3</td>
<td>0 – 15</td>
<td>ppm</td>
</tr>
<tr>
<td>Silicon</td>
<td>16</td>
<td>0 – 100</td>
<td>mgSi/m³</td>
</tr>
<tr>
<td>Non-Methane Hydrocarbons</td>
<td>250</td>
<td>0 – 800</td>
<td>ppm</td>
</tr>
</tbody>
</table>
### Biogas Enhancement & Digester Upgrades Project

#### Biomethane (RNG) Quality Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>2%</td>
</tr>
<tr>
<td>CO</td>
<td>&lt;=0.5%</td>
</tr>
<tr>
<td>Heating Value</td>
<td>36.0 to 40.2 MJ/Nm³</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>&lt;=trace</td>
</tr>
<tr>
<td>H₂S</td>
<td>7 mg/Nm³</td>
</tr>
<tr>
<td>Mercaptans</td>
<td>5 mg/Nm³</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>No liquefiable hydrocarbons (&gt; -10°C and &lt; 5,500 kPa)</td>
</tr>
<tr>
<td>Overall Quality</td>
<td>Merchantable and commercially free from objectionable substance (sand, dust, gums, crude oils, lubricating oils, liquids, chemicals, etc.)</td>
</tr>
<tr>
<td>Oxygen</td>
<td>&lt;=0.4 %</td>
</tr>
<tr>
<td>Pressure</td>
<td>550 to 1035 kPa</td>
</tr>
<tr>
<td>Temperature</td>
<td>&lt;=43 Deg C</td>
</tr>
<tr>
<td>Total Sulphur</td>
<td>100 mg/Nm³</td>
</tr>
<tr>
<td>Water Vapour</td>
<td>&lt;80 mg/Nm³</td>
</tr>
</tbody>
</table>
Biogas Enhancement & Digester Upgrades Project

Biogas Purification

- Five purification processes evaluated
- Water Scrubbing Technology selected
- Ability to process up to 10,000 cubic meters RNG/day (equivalent of heating 1200 homes)
- Inject to Union Gas distribution grid
- Gas quality monitored at the Biogas Purification Unit (BPU) and Union Gas
Process Flow Diagram

- Primary Clarifiers
- Primary Equalization
- Secondary Clarifiers
- Secondary Equalization
- Filtrate
- Thickener Building
  - GBTs
  - Thickened Sludge
  - Blending Tank
    - GBTs
    - Blended Sludge
- Anaerobic Digesters
  - Biogas
  - Flares
  - Digested Sludge
- Dewatering
  - 1.6 MW Cogeneration
    - Purification
      - Biomethane
      - Union Gas
Revenue Potential
Cogeneration (15,300 m³/day)

Figure 3 Net annual revenue from a CHP consuming 15,300 Nm³/day biogas for a range of natural gas and electricity values.
REVENUE POTENTIAL

Purification (15,300 m³/day)

Figure 4 Net annual revenue from a BPU processing 15,300 Nm³/day biogas for a range of natural gas and electricity values.
Biogas Enhancement & Digester Upgrades Project

Revenue Potential \((15,300 \text{ m}^3/\text{day})\)

![Graph showing the relationship between Natural Gas Unit Rate and Electricity Unit Rate. The graph indicates that BPU FAVOURED has a lower Natural Gas Unit Rate compared to CHP FAVOURED.]
Biogas Enhancement & Digester Upgrades Project

Revenue Potential

![Graph showing revenue potential over time with biogas generation and related costs.]