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- HDR Inc
  - Jeremy Holland, PE
Columbia Blvd WTP
Anaerobic Digestion

- Treatment process for solids removed from wastewater
- Heated and mixed process
- Generates biosolids and anaerobic digester gas
“Traditional” Biogas Usage At CBWTP

- Boilers
  - Digester heat
  - Facility heat
- Malarkey Roofing
  - $180K to >300K per year!
- Flares....
Biogas Technologies Evaluated

- Fuel Cell
- Micro-Turbines
- Internal Combustion Engine-Generators
200 kW Phosphoric Acid Fuel Cell - 1999
Fuel Cell Cost Funding Pie Chart:

Total Cost: $1.3 Million
$6,500 /kW

Outside Funding

OR Bus. Energy
OR Office of Energy
PGE Renewable Energy
U.S. DOD/DOE

Tax Credit
$126K
$14K
$247K
$200K

Portland's Cost
$790K

Total Cost: $1.3 Million
$6,500 /kW
Design and Installation Issues

- Waste Heat (low temperature)
- Scrubber Carbon
  - Sulfur Content/Gas Contamination
- Moisture Trap
- Supply Pressure
- Water Treatment
- Fuel Piping Size
Estimated Annual Operation

- Produces 1.4 MWh/year
- Revenue $60,000/year
- Maintenance cost $10,000
- Annual Stack Replacement Cost
  - $22,000 x 6 years = $ 132,000
## Operational History

<table>
<thead>
<tr>
<th>Year</th>
<th>Operating Time (hrs)</th>
<th>Operational Uptime (%)</th>
<th>Grid MWh Delivered</th>
<th>Energy Savings ($)</th>
<th>Maintenance Cost ($)</th>
<th>Fuel Consumed (MSCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2000</td>
<td>6,166</td>
<td>70</td>
<td>901</td>
<td>58,565</td>
<td>18,069</td>
<td>16.2</td>
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<tr>
<td>2000-2001</td>
<td>6,858</td>
<td>97</td>
<td>872</td>
<td>56,654</td>
<td>34,575</td>
<td>16.1</td>
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<tr>
<td>2001-2002</td>
<td>6,474</td>
<td>74</td>
<td>824</td>
<td>53,586</td>
<td>40,861</td>
<td>15.3</td>
</tr>
<tr>
<td>2002-2004 (Avg)</td>
<td>6,031</td>
<td>69</td>
<td>737</td>
<td>47,873</td>
<td>37,066</td>
<td>13.8</td>
</tr>
</tbody>
</table>

**Fuel Stack Replacement after 5 years = $250K to $300K!**
Decommissioned January 2005
Fuel Cell Project Benefits

• Better understanding of Cogen technology
• Learned how to benefit from Oregon Business Energy Tax Credit
• Ratepayers and general public feel good about the project
• Made way for Micro-Turbine technology
Micro-Turbines - 2003

- Heat Recovery Heat Exchanger
- Carbon Vessels
- Refrigerated Dryer
- Desiccant
- Micro-Turbine
- Compressor
- Booster Compressor
Micro-Turbines Cost Data

- Purchased 4 units @ 30kW each = 120kW
- Purchase cost = $300,000
  - Turbines, compressors, heat recovery, gas processing, and electrical
- Estimated installation cost $46,000
- Total cost: $346,000 or $2,883 per kW
- Cost after BETC pass through = $309,000 or $2,575 per kW
Expected Performance

• Electric Output
  • 30 kW @ 480VAC, 60 Hz

• Efficiency
  • Electrical: 27%
  • Thermal: 53%
  • CHP: 80%

• Noise Levels
  • 65 dBA @ 33 feet
  • 83 dBA @ 2 feet
Operational History

• Installation and startup completed April 2003

• One month later, system shutdown due to excessive water, stayed down for 1-1/2 years

• Intermittent uptime – Dec 2004 to June 2007

• Decommissioned following startup of COGEN in 2009
## Pencil It

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Run Time Hours</td>
<td>21,900 (30 months)</td>
<td>16,000 (not all running)</td>
</tr>
<tr>
<td>Production</td>
<td>890 MWh</td>
<td>480 MWh</td>
</tr>
<tr>
<td>Electric Bill Reduction</td>
<td>$40,000</td>
<td>$22,000</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>$4,000</td>
<td>$17,000</td>
</tr>
<tr>
<td>5 yr rebuild costs</td>
<td>$10,000</td>
<td>??</td>
</tr>
</tbody>
</table>
Operational Lessons Learned

- Gas Treatment is Critically Important
  - Carbon Bed
  - Gas Drying
  - Siloxane Removal
- Equipment Requires Attention – not “Set and Forget”
  - Filter Cleaning
  - Carbon Media Replacement
- Design Issues
  - Hot Water Usage
  - Grid Independent Operation?
  - Integration into System; SCADA
Internal Combustion Engine-Generators
Engine Generators Cost Data

• Two Units @ 850kW Each = 1.7 MW
• Purchase Cost, Engines and Electrical: $1.4M
• 5 Yr Engine/Electrical Maintenance: $1.1M
• Total Cost: $ 7.9 Million or $ 4,650 per kW
• Cost After Oregon Energy Trust/BETC Pass-Through @ 25% (~$2.0 M):
  $ 6 Million or $ 3,500 per kW
Expected Performance

- Electric: 850 kW Each @ 4160 VAC, 60 Hz
- Thermal: 3.6 MBTU /hr/ Unit
- Efficiency
  - Electrical: 37%
  - Thermal: 47%
  - CHP: 84%
- Noise Levels
  - 117 dBA @ 3 feet
- Emissions – Lean-Burn Combustion
**Digester Gas Treatment**

- Skid Mounted, Vendor Design and Fabricate
- $\text{H}_2\text{S}$ Scrubber
  - Iron Sponge
- Pressure Boost
  - 2.5 PSIG
- Moisture Removal
  - 40 degree F Dew Point
- Siloxane Scrubber
  - Activated Carbon
CBWTP Electrical Power FY13-17 Average

% PGE, 59.6%

% Co-GEN, 40.4%
COGEN Performance History FY15-17

• Uptime: 90%
• Power Generation: 15,300,000 kWh/yr
• Approximately $1M/year utility bill reduction
• $211K/year O&M Costs
Lessons Learned

• Biogas Treatment
• Heat Balance – Use and Waste
• Power Company Coordination (PGE)
  • Grid Synchronization
  • Grid Independent Operation (no, in our case)
  • Buy Back Power or Trip?
• Engine
  • Housing
  • Load Follow, Fuel Follow?
  • Auxiliary Motor Control and Interlocks
• Communications and Monitoring
Operational Lessons Learned

- Performance is not NPDES permit related
- Waste heat system inadequate
- Iron Sponge Media life shorter than expected
Current Biogas Utilization

- **24%** Waste Gas Burner
- **19%** Malarkey Roofing Products
- **21%** Boilers
- **36%** Engine Generators

- **24%** Heat Reservoir System
- **19%** Gas Clean Up
- **36%** Power
- **21%** Plant Heating

- Wastewater Solids
- Biogas
- Thermal Energy
- Electrical Energy
Biogas Utilization (Encore)

Find the most beneficial use for the digester gas that is being flared.
Project Goals

• 100% methane recovery and most beneficial use for remaining biogas
• Maximize value to ratepayers
• Optimize return on investment with best balance of risk and reward
• Align with City’s goals, policies, and Climate Action Plan
### Future CBWTP Gas Utilization Technology

#### Alternatives Analyzed

<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cogeneration Expansion without Biogas Storage</td>
</tr>
<tr>
<td>2</td>
<td>Cogeneration Expansion with Biogas Storage</td>
</tr>
<tr>
<td>3</td>
<td>Biogas Treatment for Vehicle Use</td>
</tr>
<tr>
<td>4</td>
<td>Biogas Treatment for Sale to Industry/Pipeline Injection</td>
</tr>
<tr>
<td>5</td>
<td>Biogas Used in Biosolids Drying</td>
</tr>
</tbody>
</table>
Pipeline Injection for Transporting RNG

Biogas (methane) forms in digesters → Biogas (methane) sent to processing → Renewable natural gas produced → Distributed through NW Natural → And on-site fueling station built for City vehicles
Map of CNG Fueling Stations in the U.S.

Legend:
- CNG and LNG Stations
  - CNG, Existing
  - CNG, Planned
  - CNG, Temporarily Unavailable
  - LNG, Existing
  - LNG, Proposed
  - LNG, Temporarily Unavailable

Source: NGVAmerica
Biogas (Methane) to Renewable Natural Gas Facilities
RNG Production Technology (Water Wash)

Source: Greenlane Biogas
On-Site RCNG Fueling Station

- Consists of compressor, storage tanks and fuel dispensers
- Use for City Fleet or contractor vehicles with operation on site
- Enter Schedule H agreement with NWN to design, build and maintain
- ODOE AVFI Tax credit available

Source: GE CNG-IN-A-BOX
NWN Monitoring Facility

- Located on CBWTP site for monitoring RNG quality before the pipeline injection
- NW Natural to design, build, operate and maintain during the term of the agreement, with BES to pay the costs over time

Source: Fortis BC
Triple Win Solution

City of Portland Environmental Services
Columbia Boulevard Wastewater Treatment Plant

100% Waste Methane Recovery

CUT
21,000 tons
OF CLIMATE-CHANGING EMISSIONS/YEAR

ADD
$3 million
IN ANNUAL REVENUE

REPLACE ENOUGH DIESEL TO POWER
154 garbage trucks
FOR A YEAR

@BESPortland
Questions?

Presenter eMail Addresses: James.Brown@portlandoregon.gov
End of Presentation