Prioritizing Energy Conservation & Minimization of Greenhouse Gas Emissions at the Arlington WWTP

Tom Giese, P.E.
26 October 2010
Outline

- Project Overview
- Opportunities for Energy Savings
- Determination of Energy Savings
- Estimating Avoided Greenhouse Gas (GHG) Emissions
- GHG Equivalencies
- ARRA Green Project Reserve Funding
Project Overview

- Project Drivers: Growth and DO TMDL
- Use of Best Available Technology (High Quality Effluent)
- Maximize Use of Existing Structures/Equipment
- Environmental Stewardship
**Project Overview**

- Intentional Focus on Energy Conservation/Reduction
  - New Technology
  - Equipment Upgrades
  - Process Efficiency
Opportunities for Energy Savings

- Gravity Flow of Permeate
- Recycle Oxygenated RAS After Anaerobic/Anoxic Zones
- Strip Diffusers
- Tapered Aeration in Aeration Basins
- Cyclic Aeration in Digesters
- Retrofit Existing Blowers with VFDs
- Other Considerations
  - VFDs for New Equipment
  - Denitrification
  - Turbo Blowers
  - Backup Power Generation
Gravity Flow of Permeate

- Achievable with Hydraulics & Selected Flat Plate Membranes
- Pumps Triggered by High Flow and/or River Stage
- Historical Flow & River Stage and Hydraulic Model Used to Estimate Pump Use
- Expected Pump Runtime = 1.4%
- Est. Savings = 70,000 kWh/yr
Recycling Oxygenated RAS

- RAS Oxygenated from Membrane Air Scour
- Oxygen in RAS Reduces Aeration Requirement and Improves Nutrient Removal
- Estimated DO in RAS from Process Model
- Determined Equivalent Air Supply from RAS
- Determined Blower HP Saved
- Est. Savings = 115,000 kWh/yr
Strip Diffusers

- 5-10% Higher SOTE
- Conservatively Used 5%
- Examined Life-Cycle Cost vs. Disc and Tube Diffusers
  - Higher Capital Cost
  - Lower O&M Cost
  - Favorable 20-yr NPV
- Determined Blower HP Saved from Increased SOTE
- Est. Savings = 130,000 kWh/yr (Based on 5% Increase SOTE)
Tapered Aeration

- Improved Performance at Lower DO
  - Aerobic A Zone ~ 1.5 vs. 2.0 mg/L
  - Aerobic B Zone < 1.0 vs. 2.0 mg/L
  - ~10% Lower Effluent TP
  - NH₃ Remains < 0.5 mg/L
  - Slight Reduction in Effluent TN
- ~20% Reduction in Aeration Air
- Determined Blower HP Saved from Decreased Aeration Air
- Est. Savings = 210,000 kWh/yr
Cyclic Digester Aeration

- Digesters Mixing Limited
- Benefits of Cycling Air
  - Provide Sufficient Mixing Energy
  - Avoid Over-Aerating
  - Reduce Blower HP
- Determined Blower HP Saved from Decreased Aeration Air
- Reduces Blower HP by ~1/2
- Est. Savings = 400,000 kWh/yr
- Non-Cyclic Aeration Available Too
VFDs for Existing Blowers

- Existing Blowers Run On/Off
- VFDs Incorporated into New MCC Allowing Operation at Reduced Speed
- > 20% Reduction in Blower HP
- Est. Savings = 285,000 kWh/yr
## Summary of Energy Savings

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Estimated Savings Energy (kWh/yr)</th>
<th>Estimated Improvement Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity Flow of Permeate</td>
<td>70,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>Recycling Oxygenated RAS</td>
<td>115,000</td>
<td>$200,000</td>
</tr>
<tr>
<td>Strip Diffusers</td>
<td>130,000</td>
<td>Diff. ~ $130,000 (Total ~ $395,000)</td>
</tr>
<tr>
<td>Tapered Aeration</td>
<td>210,000</td>
<td>$120,000</td>
</tr>
<tr>
<td>Cyclic Digester Aeration</td>
<td>400,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>VFDs for Existing Blowers</td>
<td>285,000</td>
<td>$65,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,210,000</strong></td>
<td><strong>$715,000</strong></td>
</tr>
</tbody>
</table>

- Cost of Savings ~$0.59 per kWh
- Payback ~8.5 years at $0.07 per kWh

---

**PNCWA 2010**
Building Professional Excellence in Water Quality™
**Kennedy/Jenks Consultants**
Other Considerations

- **VFDs for New Equipment**
  - Standard for Design, Not Considered In Energy Comparison Calculations
  - Applies to all Significant Pumps and Blowers
  - Estimated Savings = 1,800,000 kWh/yr
  - Project Cost ~ $270,000

- **Denitrification**
  - Standard for Design, Not Considered In Energy Comparison Calculations
  - Reduces Aeration Requirements and Effluent TN
  - Reduces Aeration Air by > 20%
  - Estimated Savings = 230,000 kWh/yr
Other Considerations

- Turbo Blowers
  - Compared with PD Blowers During Design
  - Higher Efficiency
  - Neuros Blowers
    - Highest Efficiency
    - Reduced O&M Did Not Offset High Capital Cost
  - K-Turbo
    - Slightly Higher Efficiency,
    - Favorable Life-Cycle and Capital Cost
    - At That Time: No U.S. Installations, Controls Not City Std., Flat Curve, UL Listing, and Potentially Undersized Selection
  - Selected PD Blowers
Other Considerations

- Backup Power Generation
  - 1.5 MW Generator
  - Sized for Class 1 Reliability
  - Explored Cost Sharing with Power Utility
    - Share Capital Cost
    - Utilize for Peak Demands
    - Issues Pertaining to Access
Estimating Avoided GHGs

- Primary GHGs Emitted
  - Carbon Dioxide
  - Methane
  - Nitrous Oxide

- Global Warming Potential (GWP) of GHGs
  - As Determined by UN Panel on Climate Change
  - GWP Methane 25 Times Carbon Dioxide
  - GWP Nitrous Oxide 298 Times Carbon Dioxide

- Emissions Based on Power Generation Mix

- Currently Unavailable from PUD or CTED
### Power Generation Mix

#### Clean Energy

You are here: EPA Home  Climate Change  Clean Energy  Clean Energy Resources  eGRID  eGRIDweb

---

**eGRID Subregion Level Data**

**eGRID Subregion: NWPP -- WECC Northwest**

<table>
<thead>
<tr>
<th>NERC: WECC</th>
<th>Capacity (MW): 61,126.6000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Net Generation (MWh): 251,609,925.8000</td>
</tr>
</tbody>
</table>

#### Emissions Profile  |  Generation Resource Mix

<table>
<thead>
<tr>
<th>Nonrenewable Resource</th>
<th>Fuel Mix %</th>
<th>MWh</th>
<th>Renewable Resource</th>
<th>Fuel Mix %</th>
<th>MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>34.3589</td>
<td>86,450,337.6</td>
<td>Wind</td>
<td>0.7129</td>
<td>1,793,803.8</td>
</tr>
<tr>
<td>Oil</td>
<td>0.2676</td>
<td>673,211.9</td>
<td>Solar</td>
<td>0.0000</td>
<td>0.0</td>
</tr>
<tr>
<td>Gas</td>
<td>10.8421</td>
<td>27,279,823.6</td>
<td>Geothermal</td>
<td>0.3334</td>
<td>838,906.4</td>
</tr>
<tr>
<td>Other Fossil</td>
<td>0.2773</td>
<td>697,651.7</td>
<td>Biomass</td>
<td>1.2886</td>
<td>3,191,674.3</td>
</tr>
<tr>
<td>Nuclear</td>
<td>3.2758</td>
<td>8,242,273.0</td>
<td>Hydro</td>
<td>48.6135</td>
<td>122,316,454.9</td>
</tr>
<tr>
<td>Other Unknown / Purchased Fuel</td>
<td>0.0499</td>
<td>125,588.7</td>
<td><strong>Nonrenewable Total</strong></td>
<td>49.0715</td>
<td>123,468,886.4</td>
</tr>
</tbody>
</table>

#### Fuel Mix %  |  MWh

| Combustion Total     | 47.0643     | 118,418,487.7 |
| Noncombustion Total  | 52.9357     | 133,191,438.1 |
### Emissions Profile

#### Clean Energy

You are here: [EPA Home](#)  [Climate Change](#)  [Clean Energy](#)  [Clean Energy Resources](#)  [eGRID](#)  [eGRIDweb](#)

---

#### eGRIDweb

[Home](#)  [Data](#)  [GHG Emission Factors](#)  [Reports](#)  [Notes](#)  [Help](#)

[Reset](#)  [1 Select Data](#)  [View Data](#)  [3 Export Data](#)

---

#### eGRID Subregion Level Data

**eGRID Subregion: NWPP -- WECC Northwest**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NERC</td>
<td>WECC</td>
</tr>
<tr>
<td>Capacity (MW)</td>
<td>61,126.6000</td>
</tr>
<tr>
<td>Net Generation (MWh)</td>
<td>251,609,925.8000</td>
</tr>
<tr>
<td>Heat input (MMBtu)</td>
<td>1,232,657,879.2000</td>
</tr>
</tbody>
</table>

---

#### Emissions Profile

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Emissions</th>
<th>Units</th>
<th>Output Emission Rates</th>
<th>Units</th>
<th>Input Emission Rates</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual CO₂</td>
<td>113,506,309.000</td>
<td>tons</td>
<td>902.2400</td>
<td>lb/MWh</td>
<td>184.1700</td>
<td>lb/MMBtu</td>
</tr>
<tr>
<td>Annual SO₂</td>
<td>155,639.7400</td>
<td>tons</td>
<td>1.2372</td>
<td>lb/MWh</td>
<td>0.2525</td>
<td>lb/MMBtu</td>
</tr>
<tr>
<td>Annual NOₓ</td>
<td>199,886.3700</td>
<td>tons</td>
<td>1.5899</td>
<td>lb/MWh</td>
<td>0.3243</td>
<td>lb/MMBtu</td>
</tr>
<tr>
<td>Ozone Season NOₓ</td>
<td>84,719.0200</td>
<td>tons</td>
<td>1.5664</td>
<td>lb/MWh</td>
<td>0.3332</td>
<td>lb/MMBtu</td>
</tr>
<tr>
<td>Annual Hg</td>
<td>3,388.0400</td>
<td>lbs</td>
<td>0.0135</td>
<td>lb/GWh</td>
<td>0.0027</td>
<td>lb/BBtu</td>
</tr>
<tr>
<td>Annual CH₄</td>
<td>4,813,277.9000</td>
<td>lbs</td>
<td>19.1300</td>
<td>lb/GWh</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Annual N₂O</td>
<td>3,748,935.0000</td>
<td>lbs</td>
<td>14.9000</td>
<td>lb/GWh</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

---

[Additional Emissions Rates](#)
## GHG Emission Factors

<table>
<thead>
<tr>
<th>eGRID subregion acronym</th>
<th>eGRID subregion name</th>
<th>Annual output emission rates</th>
<th>Annual non-base-load output emission rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGRID subregion acronym</td>
<td>Carbon dioxide (CO2) (lb/MWh)</td>
<td>Methane (CH4) (lb/GWh)</td>
<td>Nitrous oxide (N2O) (lb/GWh)</td>
</tr>
<tr>
<td>AKGD</td>
<td>ASCC Alaska Grid</td>
<td>1,232.36</td>
<td>25.60</td>
</tr>
<tr>
<td>AKMS</td>
<td>ASCC Miscellaneous</td>
<td>498.86</td>
<td>20.75</td>
</tr>
<tr>
<td>AZNM</td>
<td>WECC Southwest</td>
<td>1,311.05</td>
<td>17.45</td>
</tr>
<tr>
<td>CAMX</td>
<td>WECC California</td>
<td>724.12</td>
<td>30.24</td>
</tr>
<tr>
<td>ERCT</td>
<td>ERCOT All</td>
<td>1,324.35</td>
<td>18.65</td>
</tr>
<tr>
<td>FRCC</td>
<td>FRCC All</td>
<td>1,318.57</td>
<td>45.92</td>
</tr>
<tr>
<td>HIMS</td>
<td>HICC Miscellaneous</td>
<td>1,514.92</td>
<td>314.68</td>
</tr>
<tr>
<td>HIOA</td>
<td>HICC Oahu</td>
<td>1,811.98</td>
<td>109.47</td>
</tr>
<tr>
<td>MROE</td>
<td>MRO East</td>
<td>1,834.72</td>
<td>27.59</td>
</tr>
<tr>
<td>MROW</td>
<td>MRO West</td>
<td>1,821.84</td>
<td>28.00</td>
</tr>
<tr>
<td>NEWE</td>
<td>NPCC New England</td>
<td>927.68</td>
<td>86.49</td>
</tr>
<tr>
<td>NWPP</td>
<td>WECC Northwest</td>
<td>902.24</td>
<td>19.13</td>
</tr>
<tr>
<td>NYCW</td>
<td>NPCC NYC/Westchester</td>
<td>815.45</td>
<td>36.02</td>
</tr>
<tr>
<td>NYLI</td>
<td>NPCC Long Island</td>
<td>1,536.80</td>
<td>115.41</td>
</tr>
<tr>
<td>NYUP</td>
<td>NPCC Upstate NY</td>
<td>720.80</td>
<td>24.82</td>
</tr>
<tr>
<td>RFCE</td>
<td>RFC East</td>
<td>1,139.07</td>
<td>30.27</td>
</tr>
<tr>
<td>RFCM</td>
<td>RFC Michigan</td>
<td>1,563.28</td>
<td>33.93</td>
</tr>
<tr>
<td>RFCW</td>
<td>RFC West</td>
<td>1,537.82</td>
<td>18.23</td>
</tr>
<tr>
<td>RMPA</td>
<td>WECC Rockies</td>
<td>1,883.08</td>
<td>22.88</td>
</tr>
<tr>
<td>SPNO</td>
<td>SPP North</td>
<td>1,960.94</td>
<td>23.82</td>
</tr>
<tr>
<td>SPSO</td>
<td>SPP South</td>
<td>1,658.14</td>
<td>24.98</td>
</tr>
<tr>
<td>SRMV</td>
<td>SERC Mississippi Valley</td>
<td>1,019.74</td>
<td>24.31</td>
</tr>
<tr>
<td>SRMW</td>
<td>SERC Midwest</td>
<td>1,830.51</td>
<td>21.15</td>
</tr>
<tr>
<td>SRSO</td>
<td>SERC South</td>
<td>1,489.54</td>
<td>26.27</td>
</tr>
<tr>
<td>SRTV</td>
<td>SERC Tennessee Valley</td>
<td>1,510.44</td>
<td>20.05</td>
</tr>
<tr>
<td>SRVC</td>
<td>SERC Virginia/Carolina</td>
<td>1,134.88</td>
<td>23.77</td>
</tr>
</tbody>
</table>
Determining CO₂ Equivalents

Annual Non-Baseload Output Emission Rates (considering combustion plants only) are typically used when calculating reduction in GHGs due to energy savings. The lower Total Annual Output Emission Rates (considers all plants) are used for GHG inventory and determination of carbon footprint.

- **Non-Baseload**
  - 1,333.64 lbs CO₂ per MWh = 0.0006048 MT CO₂/kWh
  - 49.28 lbs CH₄ per GWh = 0.0000006 MT CO₂/kWh
  - 18.73 lbs N₂O per GWh = 0.0000025 MT CO₂/kWh
  - Total Emissions = 0.0006079 MT CO₂/kWh
  - 1,210,000 kWh/yr = 735 MT CO₂/yr (Non-Baseload)

- **Baseload**
  - Total Emissions = 0.0004114 MT CO₂/kWh
  - 1,210,000 kWh/yr = 498 MT CO₂/yr
GHG Equivalencies

- US EPA GHG Equivalency Calculator
  - http://www.epa.gov/cleanenergy/energy-resources/calculator.html
  - More Accurate to Input Known Quantities of Emissions

- 735 Metric Tons of CO$_2$ Equivalent
  - Annual Emissions from 127 Passenger Vehicles
  - 75,000 Gallons of Gasoline
  - Electricity Used by 81 Homes Annually
  - Carbon Sequestered Annually by 142 Acres of Pine or Fir Forest
ARRA Green Project Reserve (GRP)

- 20% ARRA Funds Dedicated to GRP ($13.6 Million FY 2010 WA)
- 50% Forgivable Principal
- Applicants Were Actively Sought
- Requirements:
  - “Shovel Ready”
  - Energy Savings Not Incidental
  - 20% Energy Savings, or Business Case Showing Substantial Savings
  - VFDs Categorically Accepted
  - Good Faith Effort to Find Green Projects
### GRP Funding

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Eligibility</th>
<th>Eligible Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity Flow of Permeate</td>
<td>Incidental (Least Cost Alt.)</td>
<td>$0</td>
</tr>
<tr>
<td>Recycling Oxygenated RAS</td>
<td>Incidental (Process Need)</td>
<td>$0</td>
</tr>
<tr>
<td>Strip Diffusers</td>
<td>Yes (with Business Case)</td>
<td>$395,000</td>
</tr>
<tr>
<td>Tapered Aeration</td>
<td>Yes (&gt;20% Savings)</td>
<td>$120,000</td>
</tr>
<tr>
<td>Cyclic Digester Aeration</td>
<td>Yes (&gt;20% Savings)</td>
<td>$50,000</td>
</tr>
<tr>
<td>VFDs for Existing Blowers</td>
<td>Yes (Categorically Accepted)</td>
<td>$65,000</td>
</tr>
<tr>
<td>VFDs for New Equipment</td>
<td>Yes (Categorically Accepted)</td>
<td>$270,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>$900,000</strong></td>
</tr>
</tbody>
</table>

- Forgivable Principal on SRF Loan ~$450,000
$1.2 Billion ARRA Allocation for GRP is 80% of Total 2008 FY SRF Appropriation

Office of Inspector General Conducted Review of GRP Procedures and Suggested Modifications
  - Improved Solicitation
  - Improved Guidance on Eligibility
  - More Definitive Criteria

GPR Here to Stay?
  - Continued for FY 2011 Applications
  - Shown to Continue for FY 2012 Applications
Questions and Answers