Water Conservation and Heat Rate Improvements
Xcel Energy

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Company Supervisor: Cheryl Erler
Company Background

- Major natural gas and electricity provider in 8 Midwestern and Western States

- Black Dog and Riverside sites for project
  - Combined cycle generating plants
Combined Cycle
Incentives for Change

• **Reduce water usage**
  • Reduce waste water discharge to environment
  • Decrease operation loads on equipment
  • Lower operating costs

• **Improve heat rate**
  • Reduce amount of natural gas burned
    • $3,000-$12,000 reduction per 1 Btu/kWh reduction
  • Reduce catalyst and chemical use
Reasons for MnTAP Assistance

• Explore opportunities for water savings
• Identify systems with largest potential savings
• Find energy efficiency improvements
• Make recommendations to reduce water use
• Initiate implementation of reduction projects
Approach Taken

• Tracked water use and discharge data over last 4 years
• Performed water balance on systems
• Gathered information from engineers, I&C, operators
• Identified systems and variables for optimization
• Developed recommendations and planned implementation
Water Balance Improvements

Opportunity – Both Plants:

- Significant difference in water reporting data and process flow estimates
- Closed valves going to common discharge
  - Internally leaking valves to blowdown
- Water use not accounted for in control system instrumentation
  - Ex. Building heating system still using water
# Water Balance Improvements

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Annual Reduction</th>
<th>Implementation Cost</th>
<th>Annual Savings</th>
<th>Payback Period</th>
<th>Project Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolate Unused Systems</td>
<td>4,032,000 gal</td>
<td>$0</td>
<td>$9,720</td>
<td>Immediate</td>
<td>Complete</td>
</tr>
<tr>
<td>Repair Leaking Valves</td>
<td>756,000 gal</td>
<td>$18,600</td>
<td>$29,100</td>
<td>8 months</td>
<td>In Planning</td>
</tr>
<tr>
<td>Optimize Rotor Air Cooler Blowdown</td>
<td>Needs Further Analysis</td>
<td>$0</td>
<td>To Be Determined</td>
<td>Immediate</td>
<td>In Progress</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,810,000 gal</td>
<td>$18,600</td>
<td>$38,900</td>
<td>6 months</td>
<td>--</td>
</tr>
</tbody>
</table>
Prevent RO Drainage

Opportunity – Riverside:

• RO 1 permeate tank level dropped in standby
  • Water coming out of drain line
  • Should be no flow

• RO 2 had open drain with elevated vacuum break
  • Sent water to drain at normal tank levels
Prevent RO Drainage

- Saves 75 equipment hours
- Prevents equipment damage

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<tbody>
<tr>
<td>Elevated Vacuum Break (RO 1)</td>
<td>528,000 gal</td>
<td>$100</td>
<td>$340</td>
<td>3 months</td>
<td>Complete</td>
</tr>
<tr>
<td>Close Redundant Drain Valve (RO 2)</td>
<td>202,500 gal</td>
<td>$0</td>
<td>$180</td>
<td>Immediate</td>
<td>Complete</td>
</tr>
<tr>
<td>Total</td>
<td>730,500 gal</td>
<td>$100</td>
<td>$520</td>
<td>2 months</td>
<td>Complete</td>
</tr>
</tbody>
</table>
Improve Mixed Bed Tank Operation

Opportunity – Riverside:

• Mixed bed throughput is lower than expected
  • Design throughput: 1,890,000 gallons
    approx. 22 days of service

  • Average 2016 usage: approx. 1,087,000 gallons (60% of design)
    15.5 days of service

• Likely the result of low pH to mixed beds
  • Results in higher CO₂ levels
Improve Mixed Bed Tank Operation

**Effects of pH Control**

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<tr>
<td>Tune pH Control Loop</td>
<td>4 regenerations</td>
<td>$730</td>
<td>$10,860</td>
<td>1 month</td>
<td>In Progress</td>
</tr>
<tr>
<td>Bypass Unneeded Piping</td>
<td></td>
<td>$110</td>
<td>$5,140</td>
<td>3 weeks</td>
<td>Complete</td>
</tr>
<tr>
<td>Begin Caustic Injection</td>
<td>2 regenerations</td>
<td>$245</td>
<td>$5,140</td>
<td></td>
<td>In Planning</td>
</tr>
<tr>
<td>Immediately</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6 regenerations</td>
<td>$1,085</td>
<td>$16,000</td>
<td>1 month</td>
<td></td>
</tr>
</tbody>
</table>

**Expected Throughput (gal)**

- 0.00
- 1.00
- 2.00
- 3.00
- 4.00
- 5.00
- 6.00
- 7.00
- 8.00

**CO2 Concentration (ppm)**

- 7.6
- 7.8
- 8.0
- 8.2
- 8.4
- 8.6

**Average pH**

- 0
- 500,000
- 1,000,000
- 1,500,000
- 2,000,000
- 2,500,000

**Expected Throughput (gal)**

**CO2 Concentration (ppm)**

**Set Point pH**

**Design pH**
Optimize Water Softeners

Opportunity – Black Dog:

- Water softeners regenerated before any decrease in water quality
- Damaged valve leaking softened water
- Regenerations completed before set point reached
# Optimize Water Softeners

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<tbody>
<tr>
<td>Repair Leaking Drain Valve</td>
<td>425,100 gal 4,935 lbs salt</td>
<td>$800</td>
<td>$1,090</td>
<td>9 months</td>
<td>In Progress</td>
</tr>
<tr>
<td>Improve Procedure Adherence</td>
<td>58,300 gal 9,870 lbs salt</td>
<td>$0</td>
<td>$1,100</td>
<td>Immediate</td>
<td>In Progress</td>
</tr>
<tr>
<td>Increase Throughput Between Regenerations</td>
<td>33,300 gal 5,640 lbs salt</td>
<td>$0</td>
<td>$650</td>
<td>Immediate</td>
<td>Complete</td>
</tr>
<tr>
<td>Add Hardness Monitor</td>
<td>62,400 gal 10,575 lbs salt</td>
<td>$2,300</td>
<td>$1,150</td>
<td>2 years</td>
<td>In Progress</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>545,800 gal 25,400 lbs salt</strong></td>
<td><strong>$3,100</strong></td>
<td><strong>$3,340</strong></td>
<td><strong>11 months</strong></td>
<td>--</td>
</tr>
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</table>
Heat Rate Calculations

Opportunity – Black Dog:

• Many important heat rate parameters only calculated yearly
• Have needed instrumentation
  • Can put logic into control system
• Give information for performance and areas of improvement
  • 1 Btu/kWh improvement saves $3,000 to $12,000 annually

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effect on Net Heat Rate</th>
<th>Added Fuel Cost per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Steam Spray Flow</td>
<td>+2 Btu/kWh / 1% Throttle Flow</td>
<td>$10,100</td>
</tr>
<tr>
<td>Condenser Backpressure</td>
<td>12 Btu/kWh / 0.1 in Hg</td>
<td>$60,600</td>
</tr>
<tr>
<td>Final Feedwater TTD</td>
<td>21 Btu/kWh / 10°F</td>
<td>$106,200</td>
</tr>
<tr>
<td>HP Turbine Efficiency</td>
<td>20 Btu/kWh / % efficiency</td>
<td>$83,700</td>
</tr>
<tr>
<td>Cycle Water Loss</td>
<td>2 Btu/kWh / 1000 lb/hr</td>
<td>$10,100</td>
</tr>
</tbody>
</table>
Heat Rate Calculations

- Monitor efficiency online
  - 27 new points
  - Quarterly review recommended

- Informs decisions
  - Future projects
  - Maintenance
  - Cleanings
## Recommendation Summary

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</thead>
<tbody>
<tr>
<td>Reduce Auxiliary Water Use</td>
<td>4,810,000 gal 93,000 therms</td>
<td>$18,600</td>
<td>$38,900</td>
<td>6 months</td>
<td>In Progress</td>
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<tr>
<td>Prevent Permeate Tank Drainage</td>
<td>730,500 gal</td>
<td>$100</td>
<td>$520</td>
<td>2 months</td>
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<tr>
<td>Increase Mixed Bed Throughput</td>
<td>6 regenerations</td>
<td>$1,085</td>
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<td>1 month</td>
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<tr>
<td>Optimize Water Softeners</td>
<td>545,800 gal 25,400 lbs salt</td>
<td>$3,100</td>
<td>$3,340</td>
<td>11 months</td>
<td>In Progress</td>
</tr>
<tr>
<td>Heat Rate Calculations</td>
<td>Further Analysis Needed</td>
<td>$0</td>
<td>Variable</td>
<td>Immediate</td>
<td>Implemented</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>6,086,000 gal 93,000 therms 25,400 lbs salt</td>
<td>$22,900</td>
<td>$58,700</td>
<td>4.5 months</td>
<td>--</td>
</tr>
</tbody>
</table>
Personal Benefits

• Hands on engineering work
• Experience in power generation
• Problem solving
• Project planning and management
Questions?

This project was sponsored in part by Metropolitan Council Environmental Services