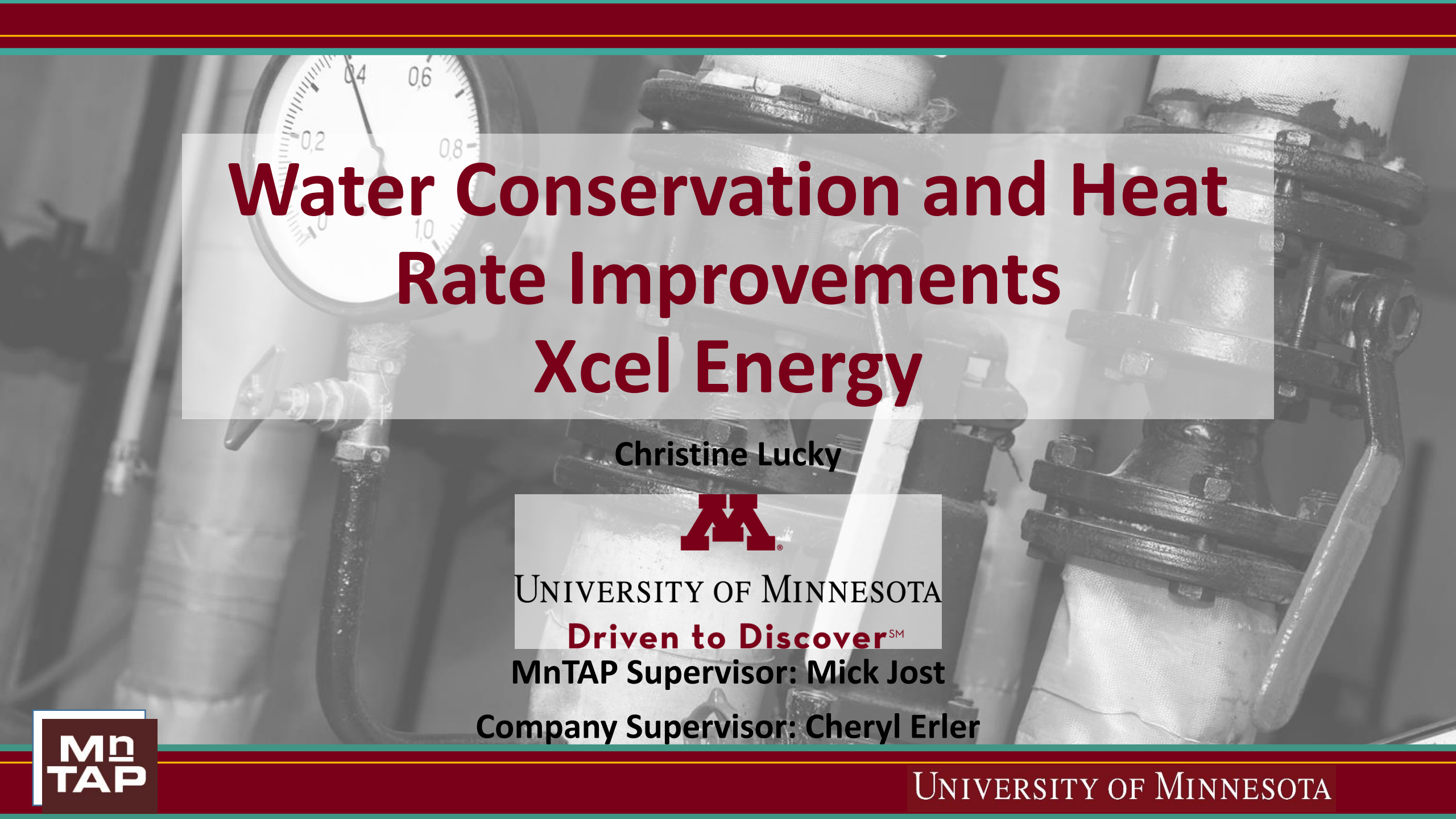




Water Conservation and Heat Rate Improvements Xcel Energy

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Driven to DiscoverSM

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Company Supervisor: Cheryl Erler



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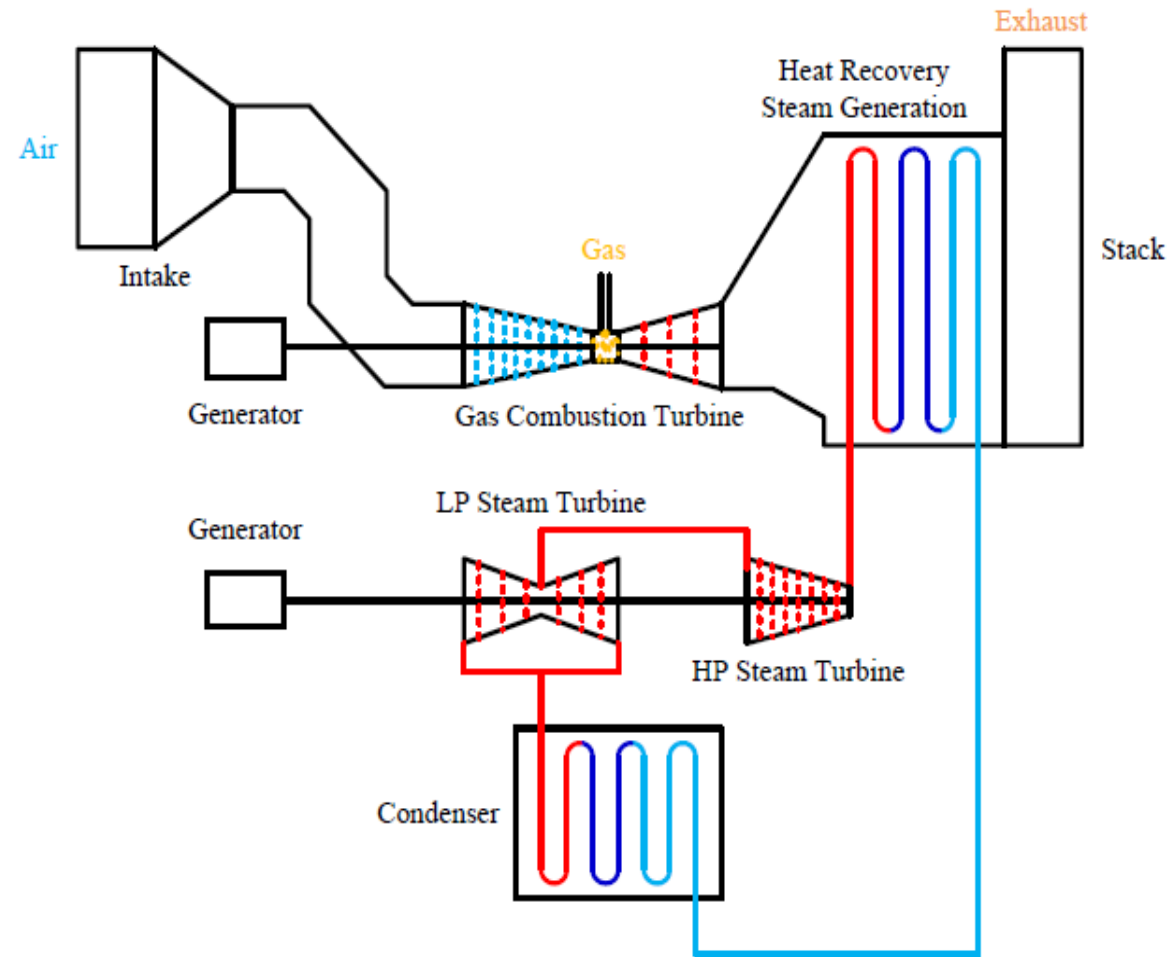
Company Background



- 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**

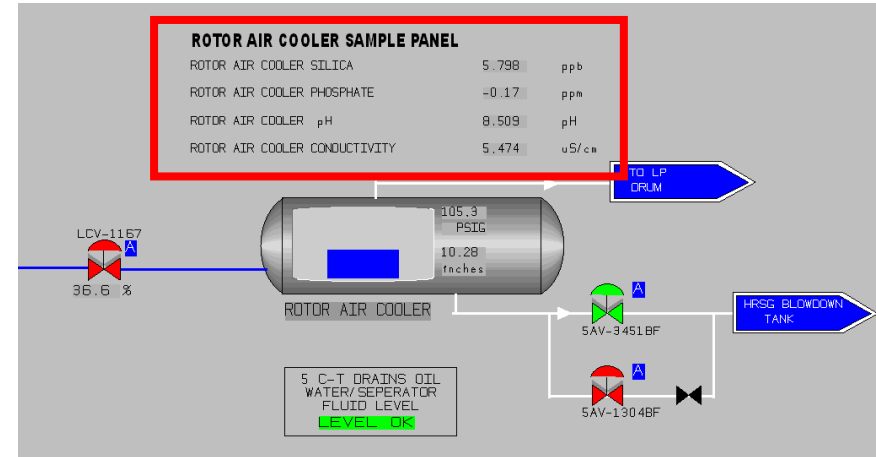
Water Balance Improvements

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

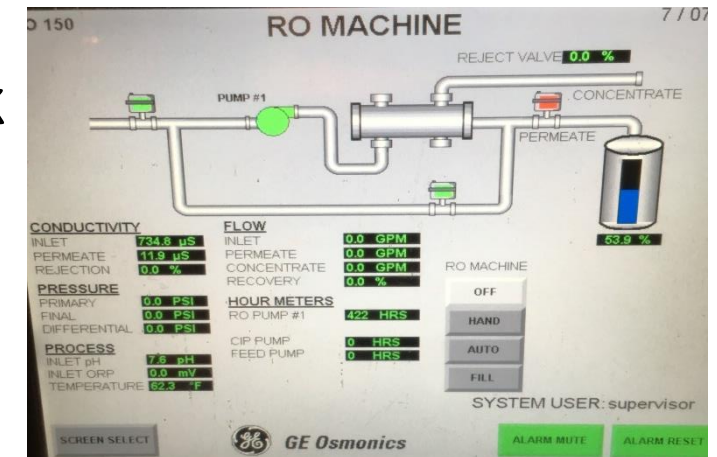


Recommendation	Annual Reduction	Implementation Cost	Annual Savings	Payback Period	Project Status
Isolate Unused Systems	4,032,000 gal	\$0	\$9,720	Immediate	Complete
Repair Leaking Valves	756,000 gal 93,000 therms	\$18,600	\$29,100	8 months	In Planning
Optimize Rotor Air Cooler Blowdown	Needs Further Analysis	\$0	To Be Determined	Immediate	In Progress
Total	4,810,000 gal 93,000 therms	\$18,600	\$38,900	6 months	--

Prevent RO Drainage

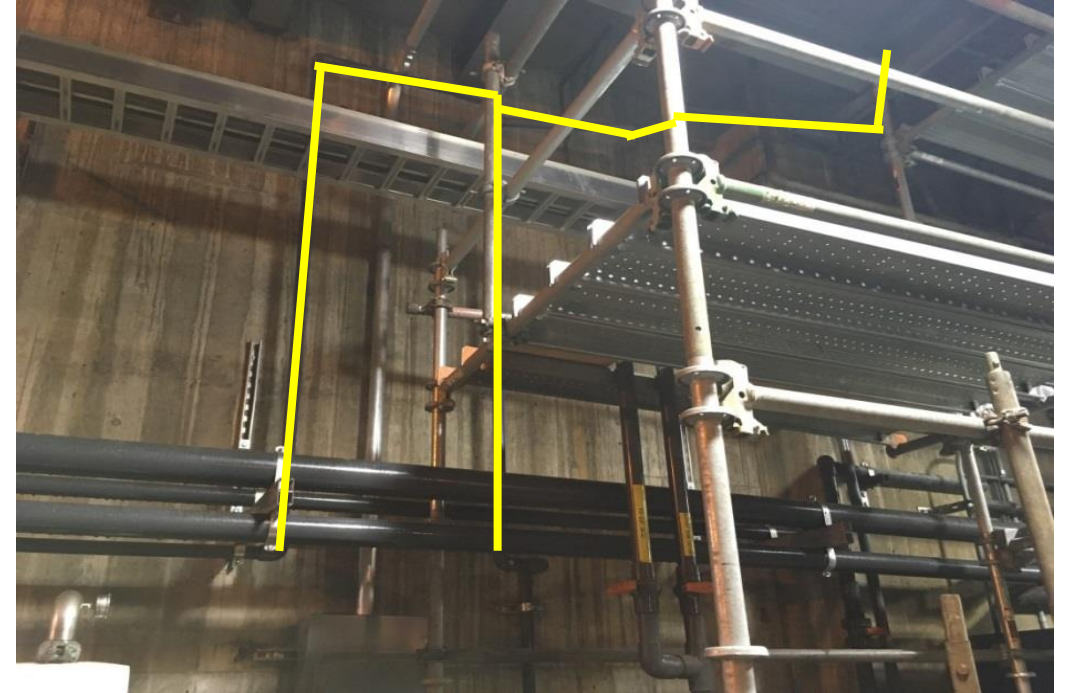
Opportunity – Riverside:

- 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



Recommendation	Annual Reduction	Implementation Cost	Annual Savings	Payback Period	Project Status
Elevated Vacuum Break (RO 1)	528,000 gal	\$100	\$340	3 months	Complete
Close Redundant Drain Valve (RO 2)	202,500 gal	\$0	\$180	Immediate	Complete
Total	730,500 gal	\$100	\$520	2 months	Complete

Improve Mixed Bed Tank Operation

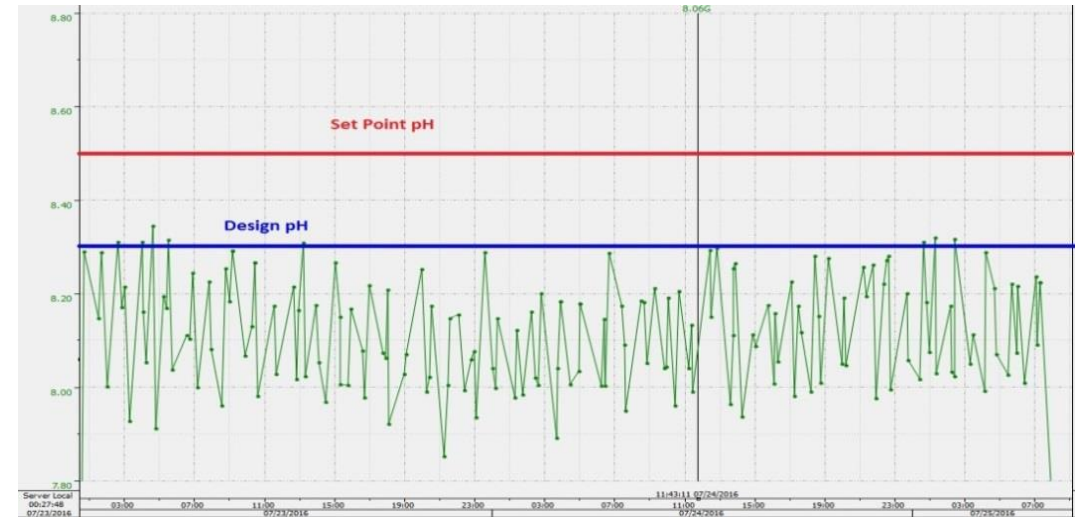
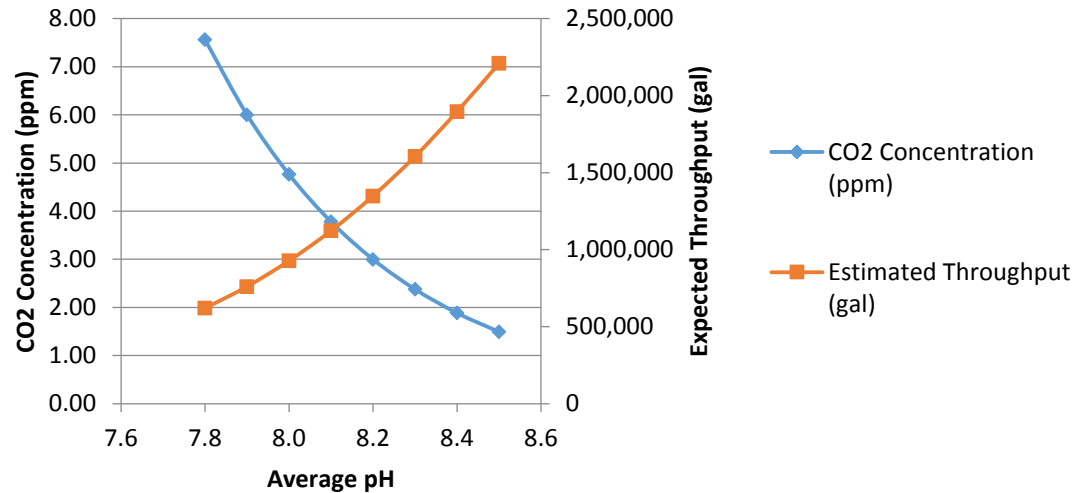
Opportunity – Riverside:

- **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



Recommendation	Annual Reduction	Implementation Cost	Annual Savings	Payback Period	Project Status
Tune pH Control Loop	4 regenerations	\$730	\$10,860	1 month	In Progress
Bypass Unneeded Piping		\$110			Complete
Begin Caustic Injection Immediately	2 regenerations	\$245	\$5,140	3 weeks	In Planning
Total	6 regenerations	\$1,085	\$16,000	1 month	--

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

Recommendation	Annual Reduction	Implementation Cost	Annual Savings	Payback Period	Project Status
Repair Leaking Drain Valve	425,100 gal 4,935 lbs salt	\$800	\$1,090	9 months	In Progress
Improve Procedure Adherence	58,300 gal 9,870 lbs salt	\$0	\$1,100	Immediate	In Progress
Increase Throughput Between Regenerations	33,300 gal 5,640 lbs salt	\$0	\$650	Immediate	Complete
Add Hardness Monitor	62,400 gal 10,575 lbs salt	\$2,300	\$1,150	2 years	In Progress
Total	545,800 gal 25,400 lbs salt	\$3,100	\$3,340	11 months	--



Heat Rate Calculations

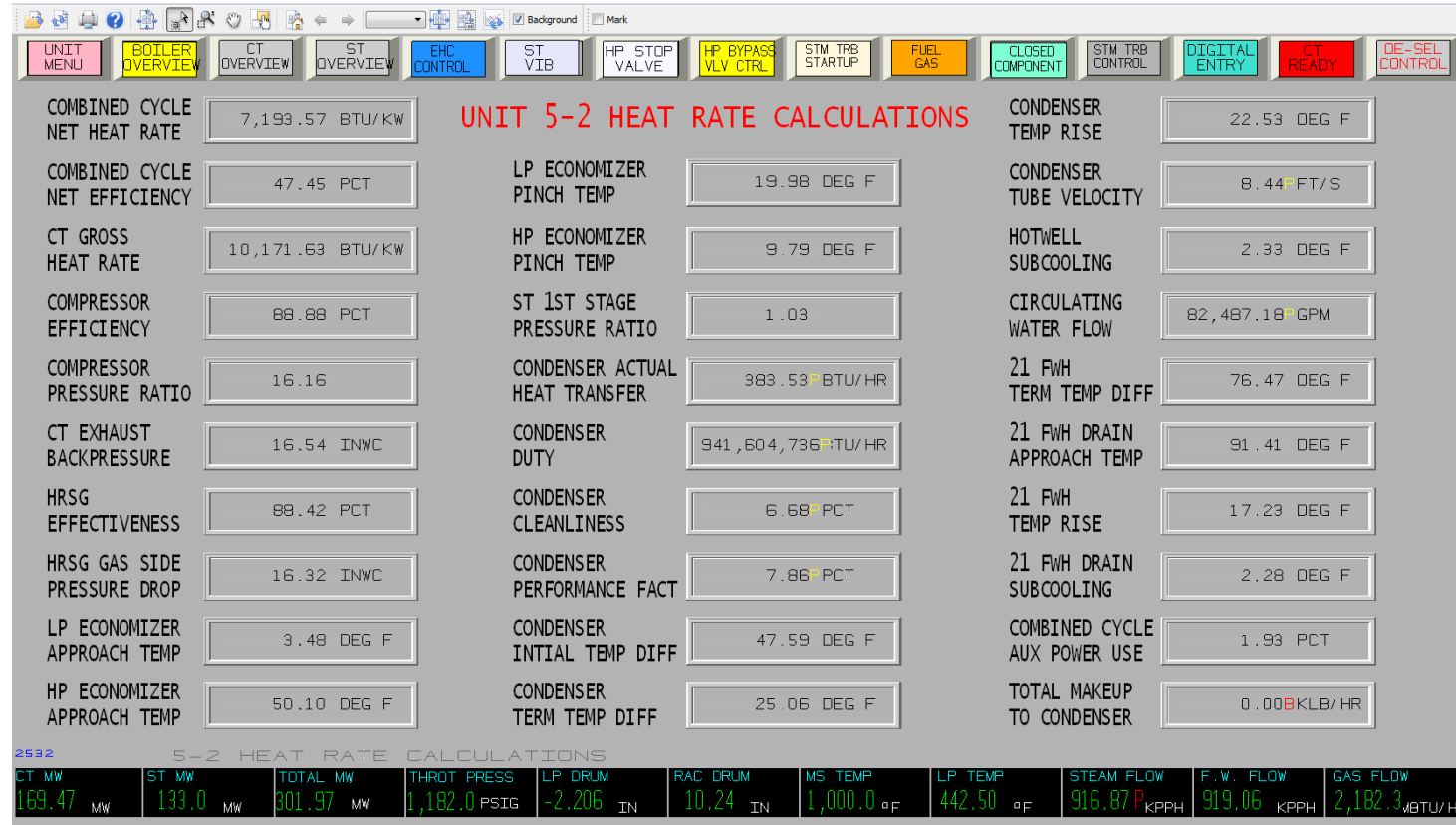
Opportunity – Black Dog:

- 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

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

Heat Rate Calculations

- **Monitor efficiency online**
 - 27 new points
 - Quarterly review recommended
- **Informs decisions**
 - Future projects
 - Maintenance
 - Cleanings



Recommendation Summary

Recommendation	Annual Reduction	Implementation Cost	Annual Savings	Payback Period	Project Status
Reduce Auxiliary Water Use	4,810,000 gal 93,000 therms	\$18,600	\$38,900	6 months	In Progress
Prevent Permeate Tank Drainage	730,500 gal	\$100	\$520	2 months	Complete
Increase Mixed Bed Throughput	6 regenerations	\$1,085	\$16,000	1 month	In Progress
Optimize Water Softeners	545,800 gal 25,400 lbs salt	\$3,100	\$3,340	11 months	In Progress
Heat Rate Calculations	Further Analysis Needed	\$0	Variable	Immediate	Implemented
Totals	6,086,000 gal 93,000 therms 25,400 lbs salt	\$22,900	\$58,700	4.5 months	--

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