Water Conservation and Heat Rate Improvements Xcel Energy

Christine Lucky

UNIVERSITY OF MINNESOTA Driven to Discoversm MnTAP Supervisor: Mick Jost

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





| 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





M<u>n</u> TAP

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



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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





| 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

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|----------------------------------|-------------------|--------------------------------------------------|----------------------------|-------------------------------------|----------------------------|
| UNIT BOILER MENU OVERVIEW | OVERVIEW OVERVIEW | EHC ST HP STOP | HP BYPASS STM TRB FUEL GAS | CLOSED STM TRB COMPONENT CONTROL | DIGITAL CT DE-SEL CONTROL |
| COMBINED CYCLE NET HEAT RATE | 7,193.57 BTU/KW | UNIT 5-2 HEAT | RATE CALCULATIONS | CONDENSER TEMP RISE | 22.53 DEG F |
| COMBINED CYCLE NET EFFICIENCY | 47.45 PCT | LP ECONOMIZER PINCH TEMP | 19.98 DEG F | CONDENSER TUBE VELOCITY | 8.44 FT/S |
| CT GROSS HEAT RATE | 10,171.63 BTU/KW | HP ECONOMIZER PINCH TEMP | 9.79 DEG F | HOTWELL SUBCOOLING | 2.33 DEG F |
| COMPRESSOR EFFICIENCY | 88.88 PCT | ST 1ST STAGE PRESSURE RATIO | 1.03 | CIRCULATING WATER FLOW | 82,487.18 GPM |
| COMPRESSOR PRESSURE RATIO | 16.16 | CONDENSER ACTUAL HEAT TRANSFER | 383.53 BTU/HR | 21 FWH TERM TEMP DIFF | 76.47 DEG F |
| CT EXHAUST BACKPRESSURE | 16.54 INWC | CONDENS ER DUTY | 941,604,736 :TU/HR | 21 FWH DRAIN APPROACH TEMP | 91.41 DEG F |
| HRSG EFFECTIVENESS | 88.42 PCT | CONDENSER CLEANLINESS | 6.68 PCT | 21 FWH TEMP RISE | 17.23 DEG F |
| HRSG GAS SIDE PRESSURE DROP | 16.32 INWC | CONDENSER PERFORMANCE FACT | 7.86 PCT | 21 FWH DRAIN SUBCOOLING | 2.28 DEG F |
| LP ECONOMIZER APPROACH TEMP | 3.48 DEG F | CONDENSER INTIAL TEMP DIFF | 47.59 DEG F | COMBINED CYCLE AUX POWER USE | 1.93 PCT |
| HP ECONOMIZER APPROACH TEMP | 50.10 DEG F | CONDENSER TERM TEMP DIFF | 25.06 DEG F | TOTAL MAKEUP TO CONDENSER | 0.00 <mark>8</mark> KLB/HR |
| 2592 5-2 | 2 HEAT RATE C/ | ALCULATIONS | | | |
| 169.47 MW | COTAL MW TH | RUI PRESS LP DRUM RA 182 A PSTG 1-2 206 tri 1 | 10,24 TN 11,000,0 ar 1442 | 50 ar 1916 87 Proc | 919.06 KDBU 2.182.3 OTUVU |

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

