Using Optimization Software to Improve Efficiency & Reduce GHG Emissions

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NeuCo
The Optimization Standard™

ProcessLink®

Recent Developments

- EPA Endangerment Finding
  - Murkowski Procedural Challenge
  - Industry Lawsuits
  - Current Status
- Kerry-Lieberman-Graham
- Other Legislative Proposals
  - Collins-Cantwell (Cap and Dividend)
  - Voinovich-Carper (Power Plant Only)

Addressing GHGs With Optimization

- No commercial emissions control systems for CO_2
  - Improving efficiency is the only proven option
- Real-time Optimization can improve efficiency & reduce CO_2 by 1.5% to 2%
- Co-benefits
  - Improved competitive position via lower variable costs
  - Reduced NOx and/or reagent costs
  - Improved control over CO and opacity
  - Increased reliability and commercial availability

Optimization: Integrate Formerly Separate Emissions & Efficiency Silos

- In past, emissions and efficiency addressed by different “silos” within power generation organizations
- Efficiency efforts often took back seat to emissions
  - Regulatory “pass-through” clauses
- Fuel costs often handled fleet-wide
- CO_2 has brought efficiency and emissions together
- Reagent costs for NOx create large new “non-fuel” O&M cost
- Optimization integrates management of emissions, fuel, reagent costs and tradeoffs between them

Potential CO_2 Impacts
(500 MW Coal Unit)

Product	% Change	Tons CO2/yr	Svgs ($/yr) @ 7.50/Ton
CombustionOpt	-0.375%	18,278	$137,082
SootOpt	-0.350%	17,059	$127,943
MaintenanceOpt	-0.375%	18,278	$137,082
PerformanceOpt	-0.400%	19,496	$146,221
Total	-1.500%	73,110	$548,328

CO_2 Reduction Adds to Currently Monetized Benefits

- Optimization alone can't solve GHG issues, but is the most cost-effective means to reduce CO_2
- Currently monetized efficiency, emissions, and availability benefits already have compelling payback
- Optimization suite can reduce CO_2 by 1.5-2%

•Annual Benefits for 500 MW Coal-Fired Unit: Currently Monetized and w/CO2 at $7.50/ton

Product	NOx-Related	Fuel Savings	Availability	Total $/Yr	CO2 $/yr	Total w/CO2
CombustionOpt	$302,348	$322,576	$0	$624,924	$137,082	$762,006
SootOpt	$75,587	$301,071	$360,939	$737,597	$127,943	$865,540
MaintenanceOpt	$0	$322,576	$892,785	$1,215,361	$137,082	$1,352,443
PerformanceOpt	$0	$705,020	$851,241	$1,556,262	$146,221	$1,702,482
Total	$377,935	$1,651,243	$2,104,966	$4,134,144	$548,328	$4,682,472

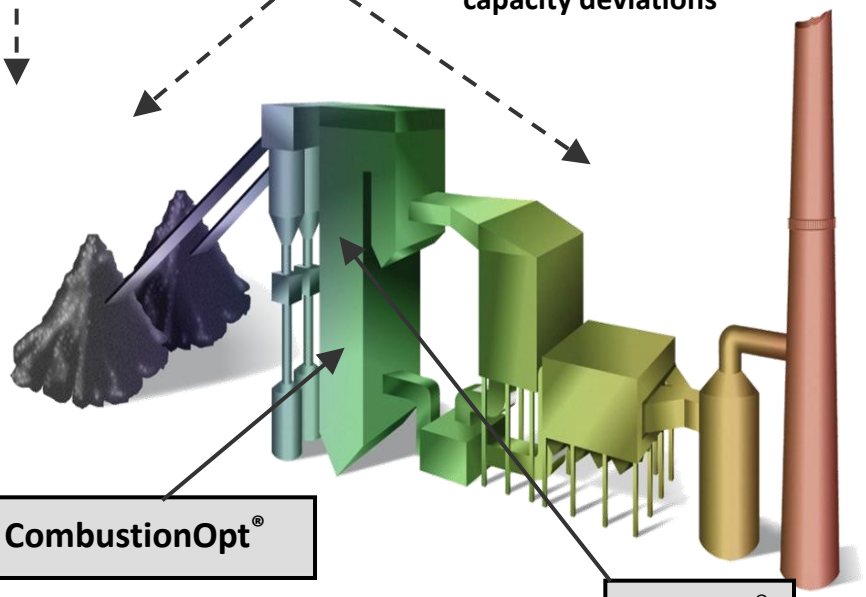
NeuCo Optimization Suite

Alerts user to potential equipment health issues and expedites problem diagnosis

MaintenanceOpt®

PerformanceOpt®

Monitors unit performance and alerts user to efficiency and capacity deviations



CombustionOpt®

Optimizes fuel & air mixing to reduce emissions and improve efficiency

SootOpt®

Dynamically directs boiler cleaning actions toward achieving unit reliability, efficiency & emissions goals

ProcessLink® Platform

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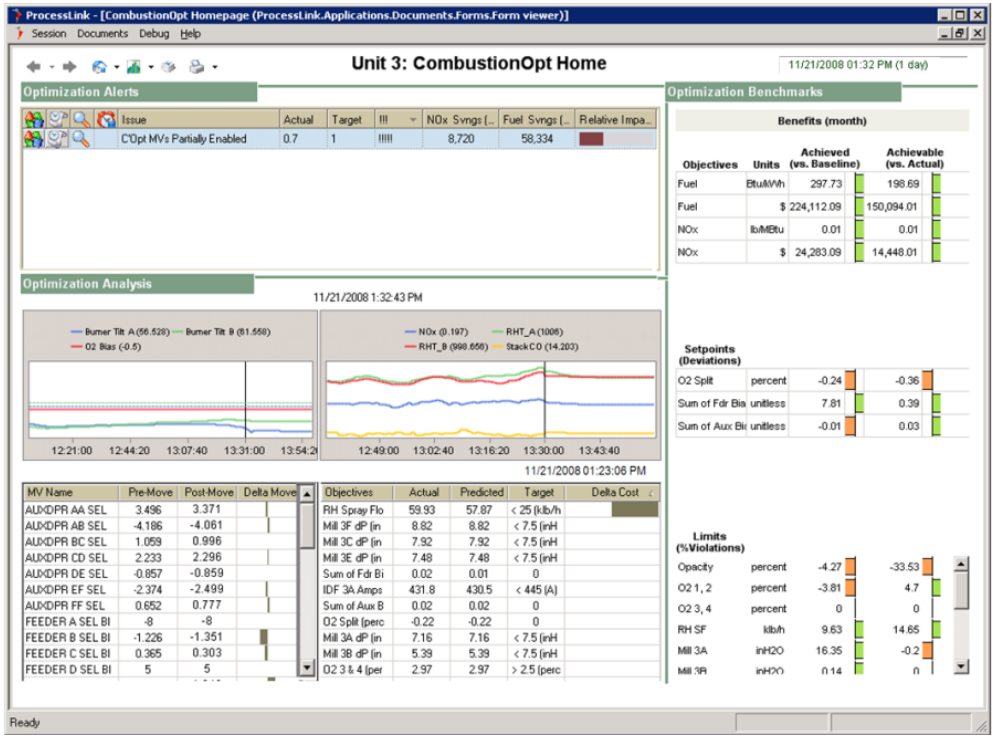
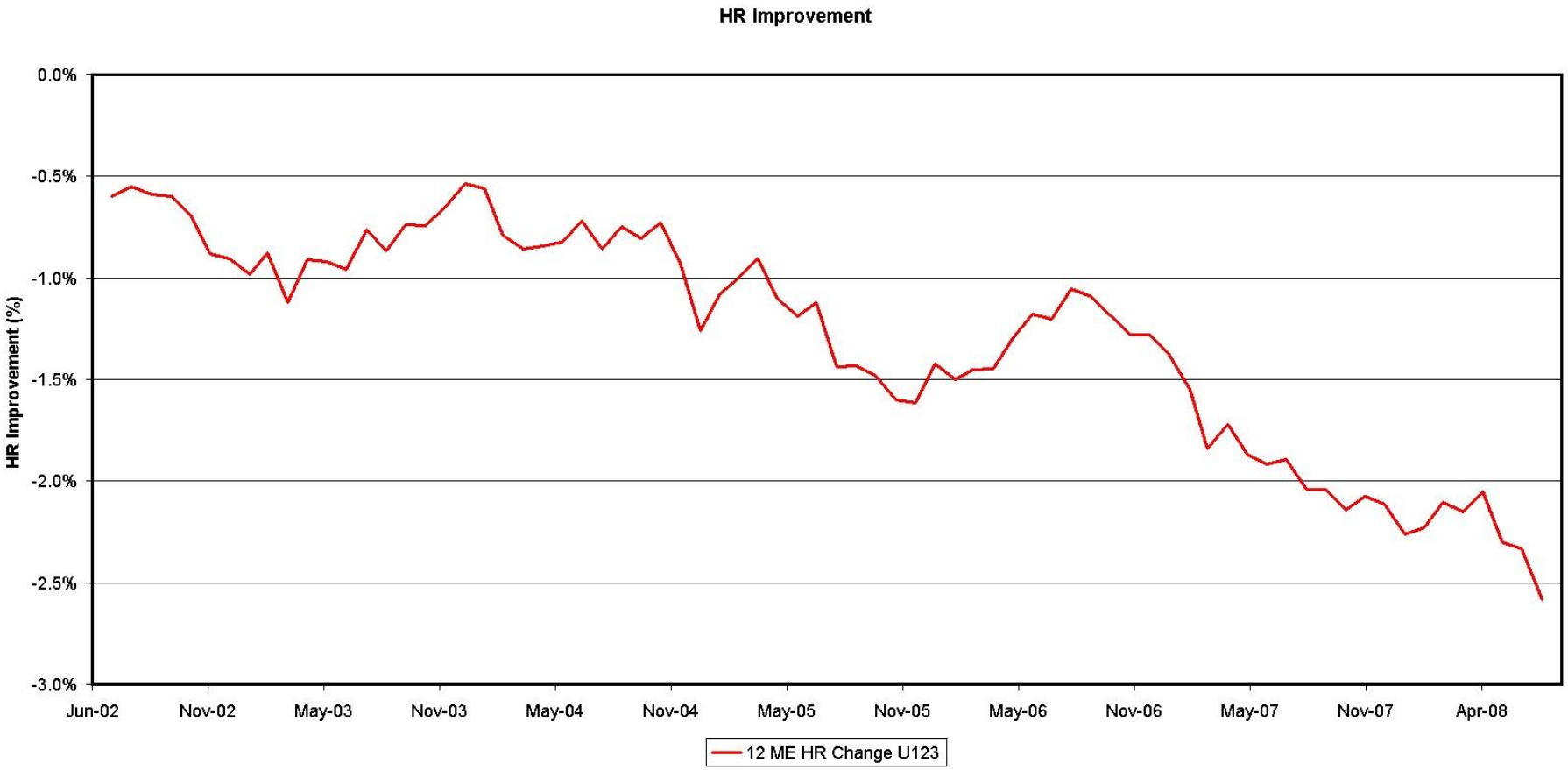
CombustionOpt®

- Provides real-time closed-loop optimization of fuel and air biases
- Using:
  - Model Predictive Control (MPC)
  - Neural Networks
  - Design of Experiments (direct search)
  - Expert Rules
- To Improve:
  - NOx
  - CO
  - Heat rate
  - Steam temps
  - Opacity
  - Constraint performance
    (Mill Dp's, Fan Amps, O2 split)



APS Analysis of C'Opt HR Impact at Units 1-3



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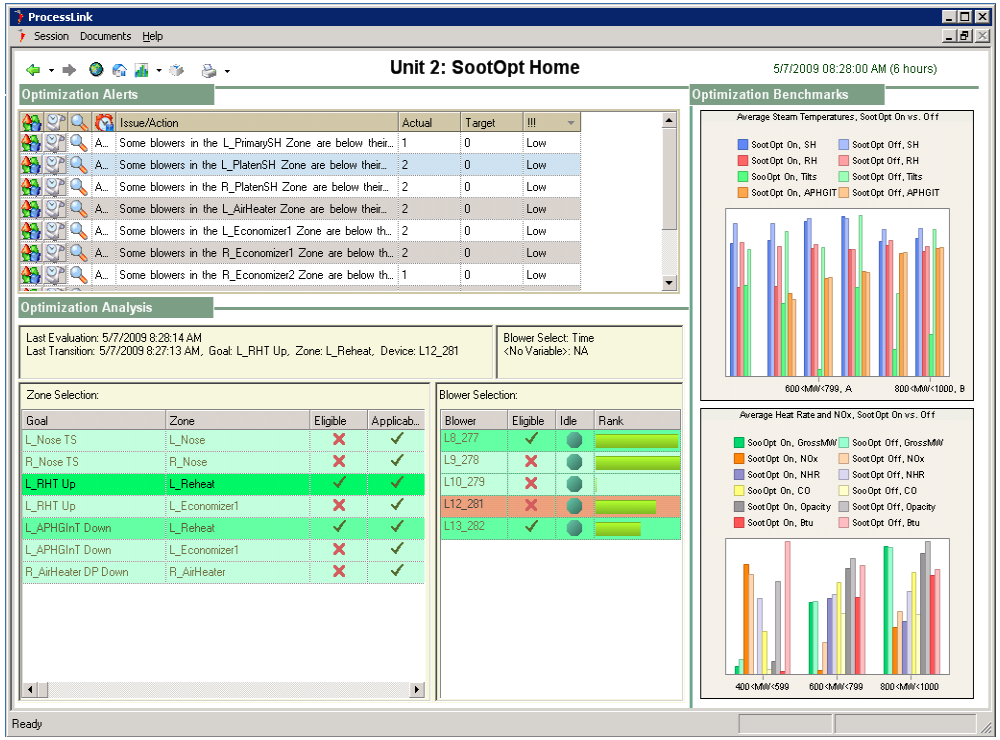
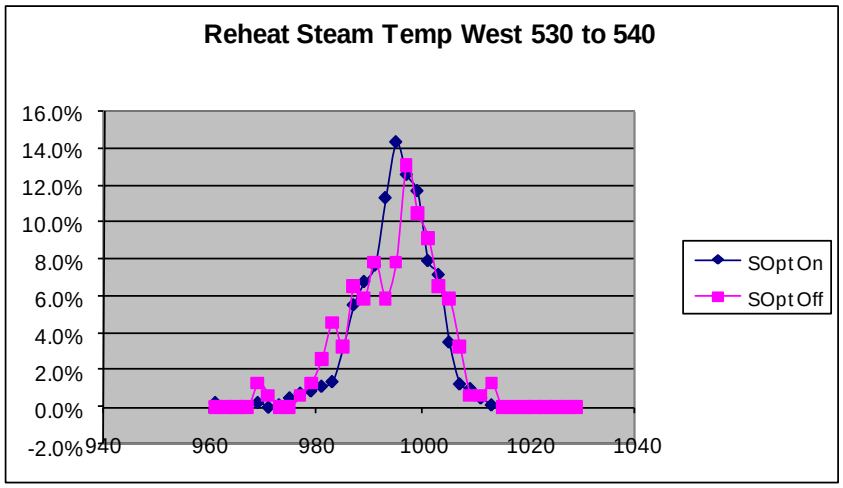
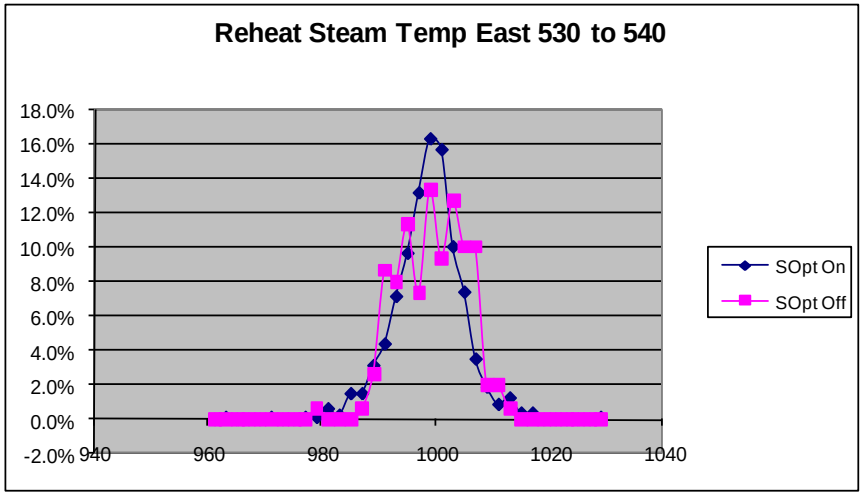
SootOpt ®

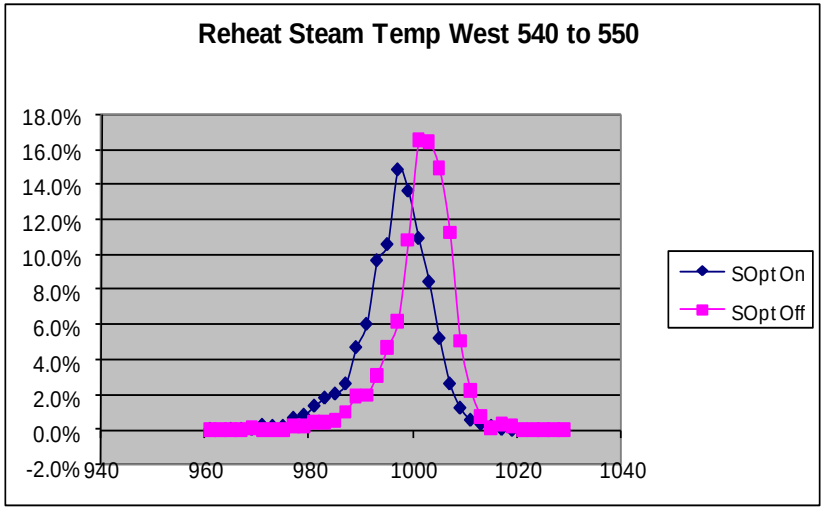
- Provides real-time closed-loop optimization of soot cleaning equipment
- Using:
  - Expert Rules
  - Neural Networks
- To Improve:
  - Sootblowing consistency
  - Unnecessary sootblowing
  - Steam temps
  - Sprays
  - Leverage on heat rate

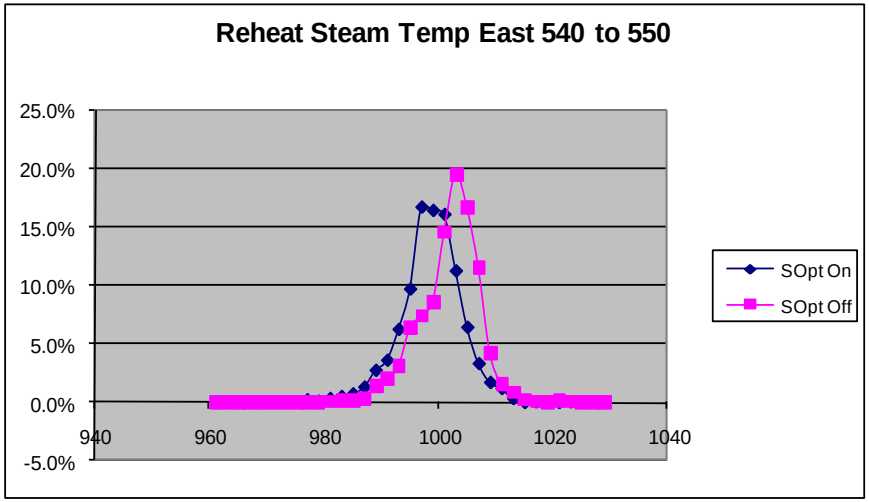


Reheat Steam Temperatures Tolk U2









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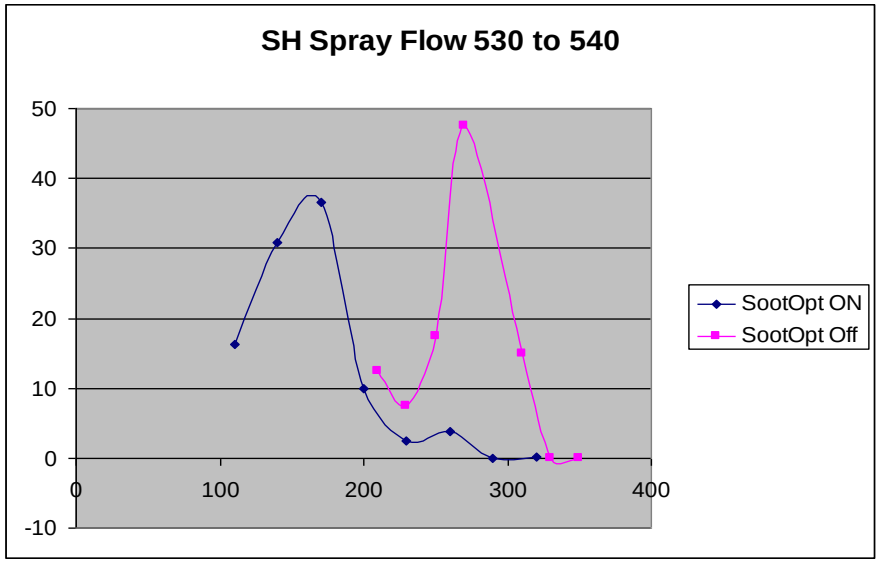
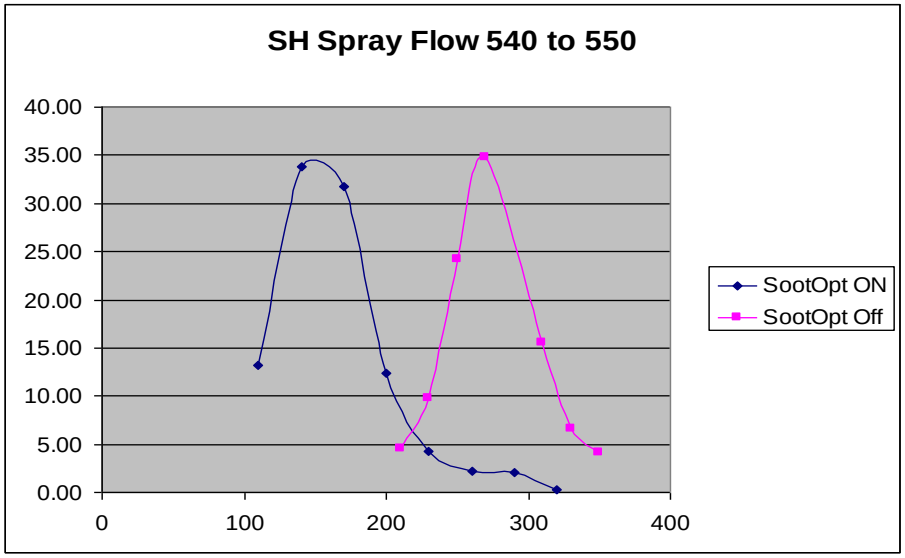
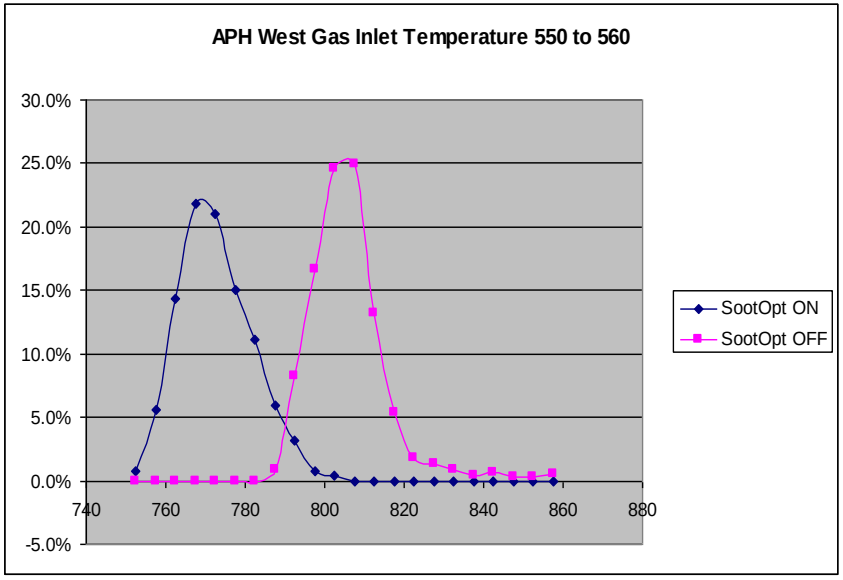
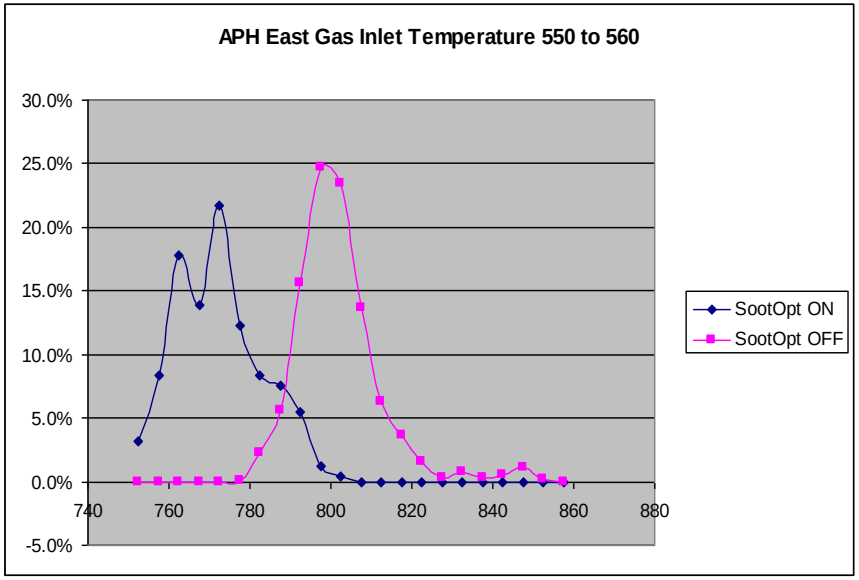
Tolk Unit 2 Superheat Spray Flows





APH Gas Inlet Temperatures Tolk U2

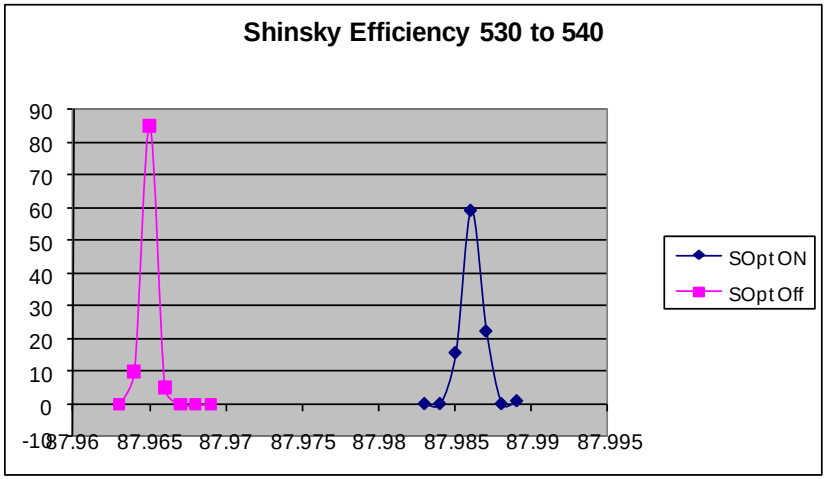


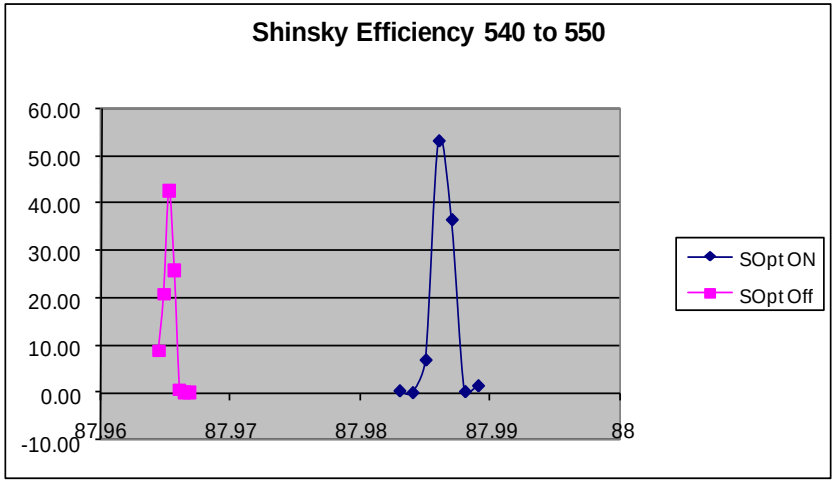


~ 30° F Reduction in Average Temperatures

Improved Boiler Efficiency at Tolk

- Boiler Efficiency with SootOpt off and on





Comprehensive Boiler Optimization

- Interrelated boiler variables must be continually managed
  - Combustion quality, fuel & air mixing, gas & steam temps, fouling, tube erosion, & emissions
  - Fluctuating constraints & changing objectives add complexity
- Independently optimizing combustion & sootblowing delivers value, but leaves benefits on the table

ProcessLink

Session Documents Memory Help

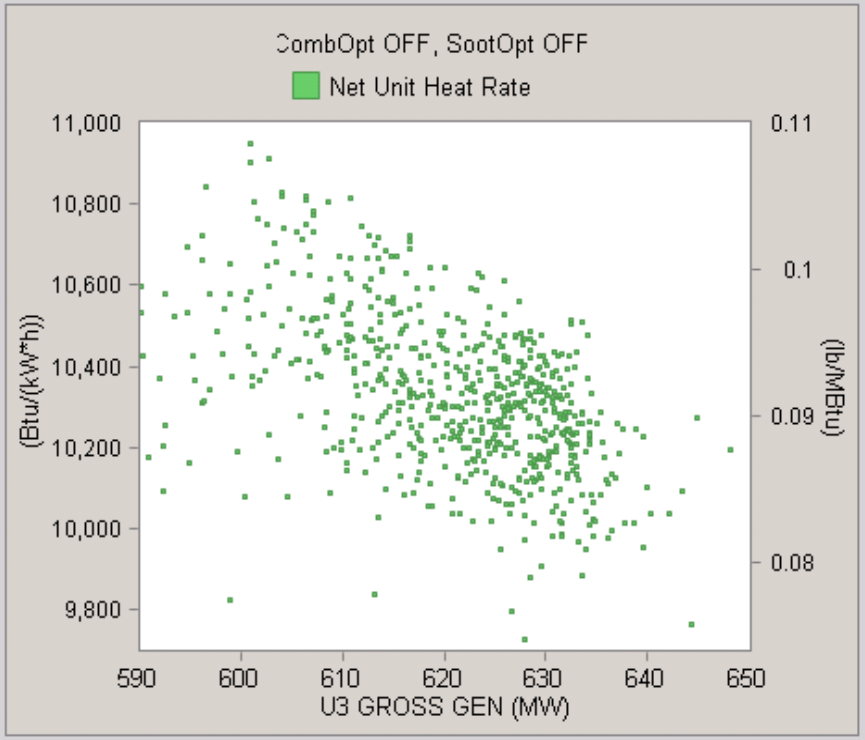
Boiler Optimization (Combustion & Soot) Combined Impact on Unit Heat Rate at Dynegy site

Standard ON/OFF

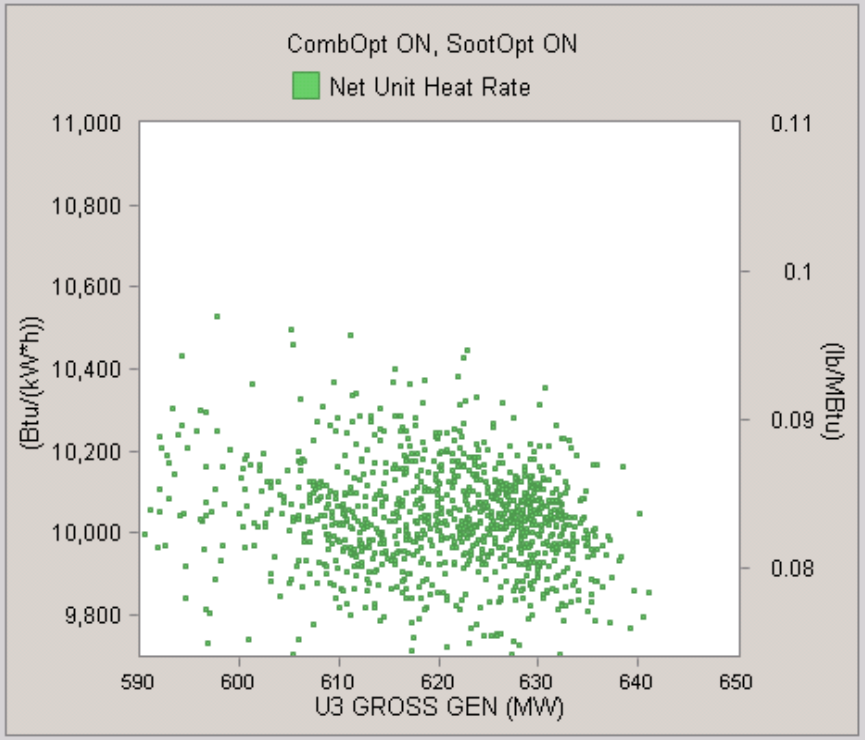
Scatter Plots (30days)

Comb OFF,Soot OFF | Comb ON, Soot ON | Comb OFF,Soot ON | Comb ON,Soot OFF

X-Axis: U3 GROSS GEN



X-Axis: U3 GROSS GEN

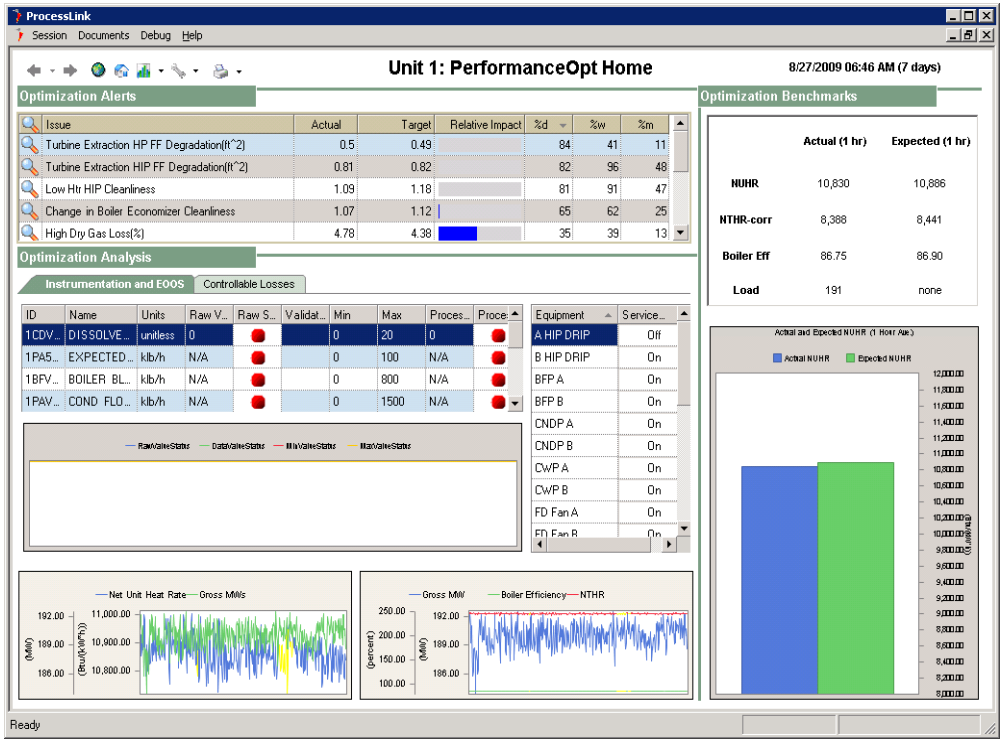


Combined CombustionOpt & SootOpt solution provided HR benefit while also lowering NOx

Ready

PerformanceOpt

- Provides deep understanding of unit subsystem performance and alerts users to performance deviations
- Using:
  - 1st Principles Models (full mass & energy balance)
  - Neural Networks
- To Improve:
  - Heat rate
  - Capacity
  - Reliability
  - Operational awareness



PerformanceOpt: FWH Venting Problem

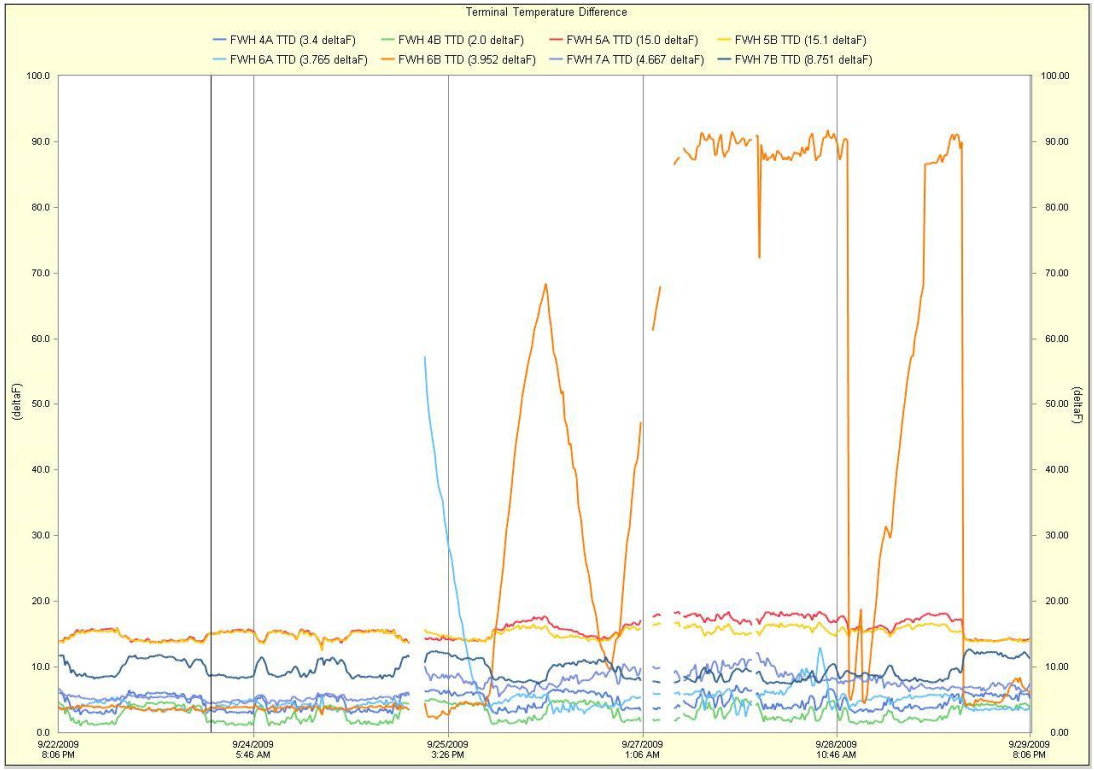
- **Unit:** Ameren's Sioux Unit #2, 450 MW
- **Usage:** The following problem was identified during the close-out meeting for PerformanceOpt. Customer asked NeuCo to explain one of the triggers on the home page.
- **Incident:** Air had entered the heater during low load and gotten trapped thus adversely affecting heater performance at higher loads.
- **Fix:** The heater was manually vented during a break in the meeting. The performance immediately returned back to normal.

Diagnosing the Problem

- An experienced operation supervisor noted that this heater had experienced venting problems in the past
- The heater shell pressure drops below atmospheric pressure during low load operation, sucks air in to the shell, and the air was not being removed properly
- The air in the heater restricts the extraction steam flow from the turbine, reducing the heater performance
- Using the context data available in PerformanceOpt, it was possible to confirm this diagnosis

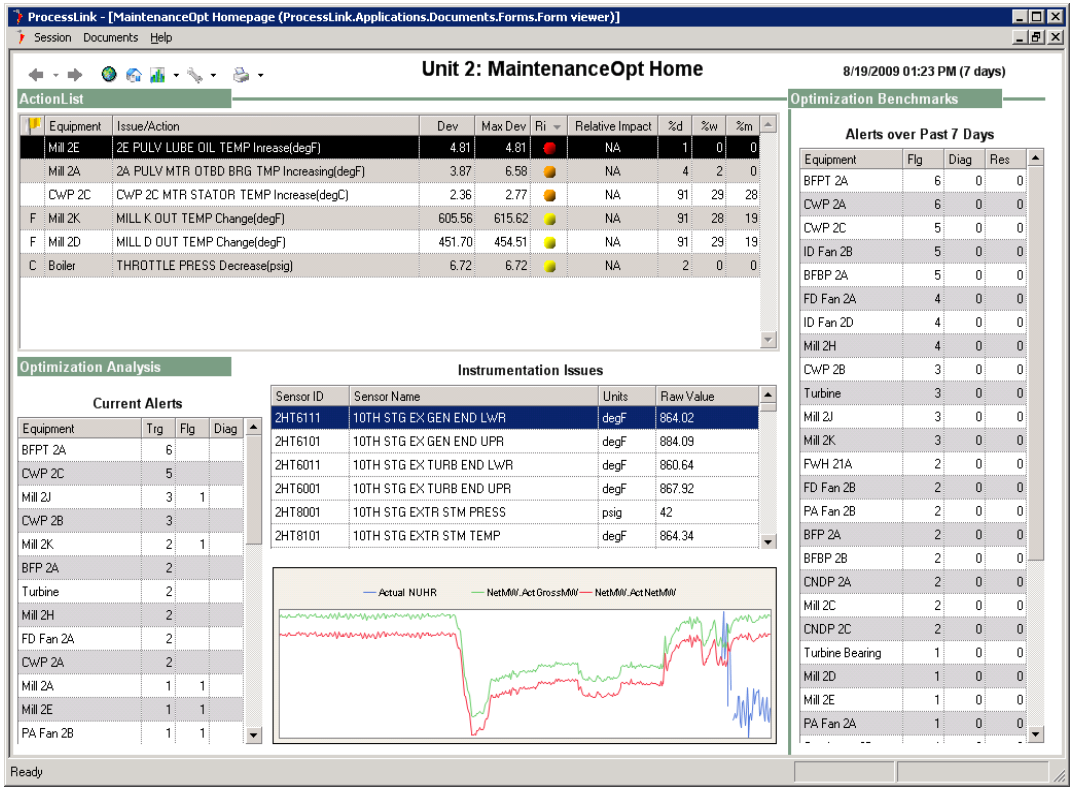
Resolution of the Problem

- During the meeting, the heater was manually vented by operations and the TTD stabilized at a reasonable level (see last 1/10th of the plot below).
- Resolution of this problem results in a ~50 Btu/kWh in Net HR improvement valued at ~$215,000 / year.



MaintenanceOpt®

- Alerts user to potential equipment health issues and expedites problem diagnosis
- Using:
  - Neural Networks
  - Expert Rules
  - Other Optimizer Alerts
- To Improve:
  - Unit uptime
  - Speed of issue resolution
  - Efficiency

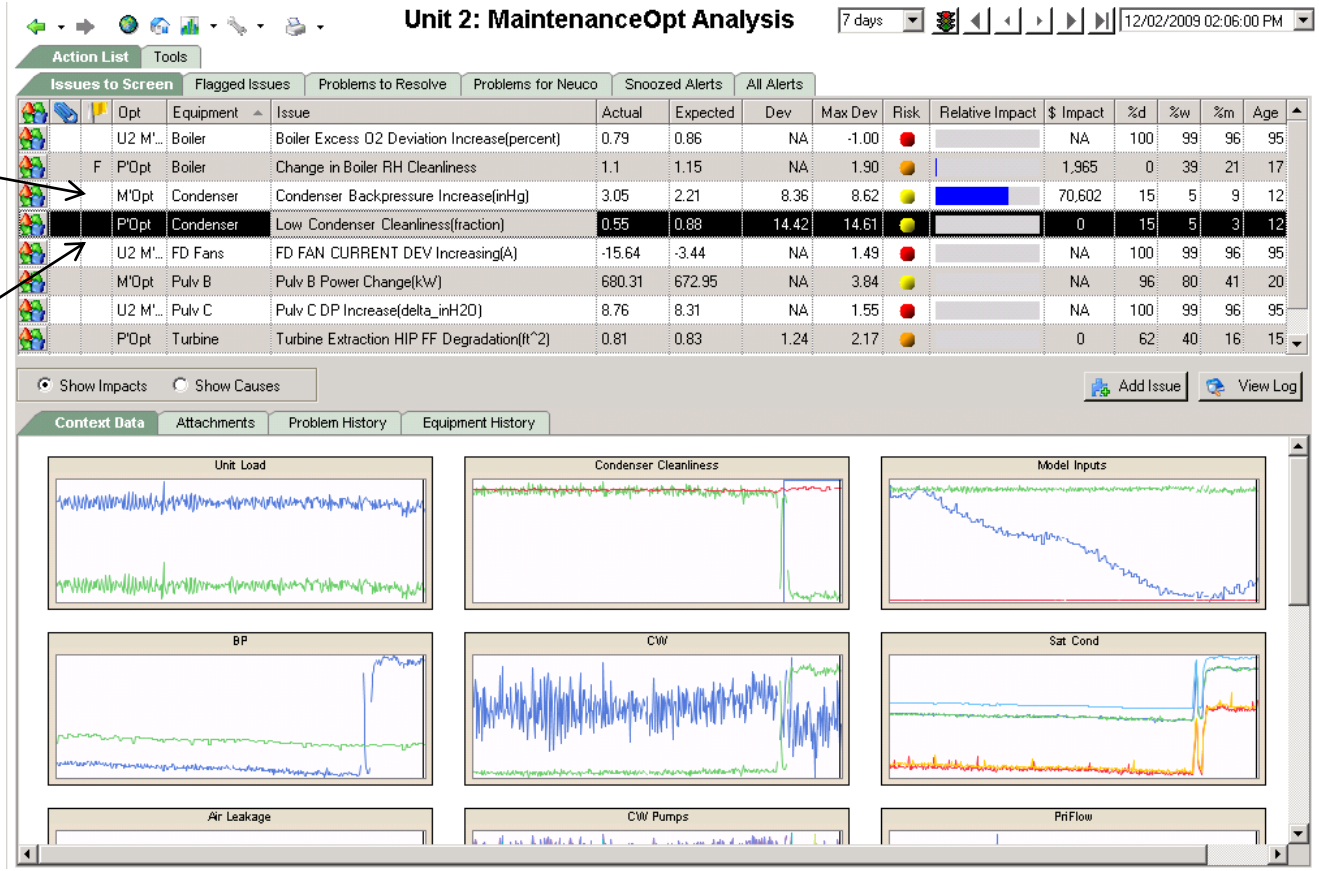


M'Opt and P'Opt Working Together

- Routine review of triggers indicates alerts on the condenser backpressure and cleanliness have triggered. Backpressure is at 3.05 when expected to be 2.2, and the cleanliness is at 0.55 when expected to be 0.88.

Backpressure Alert from M'Opt

Cleanliness Alert from P'Opt



Condenser Cleanliness

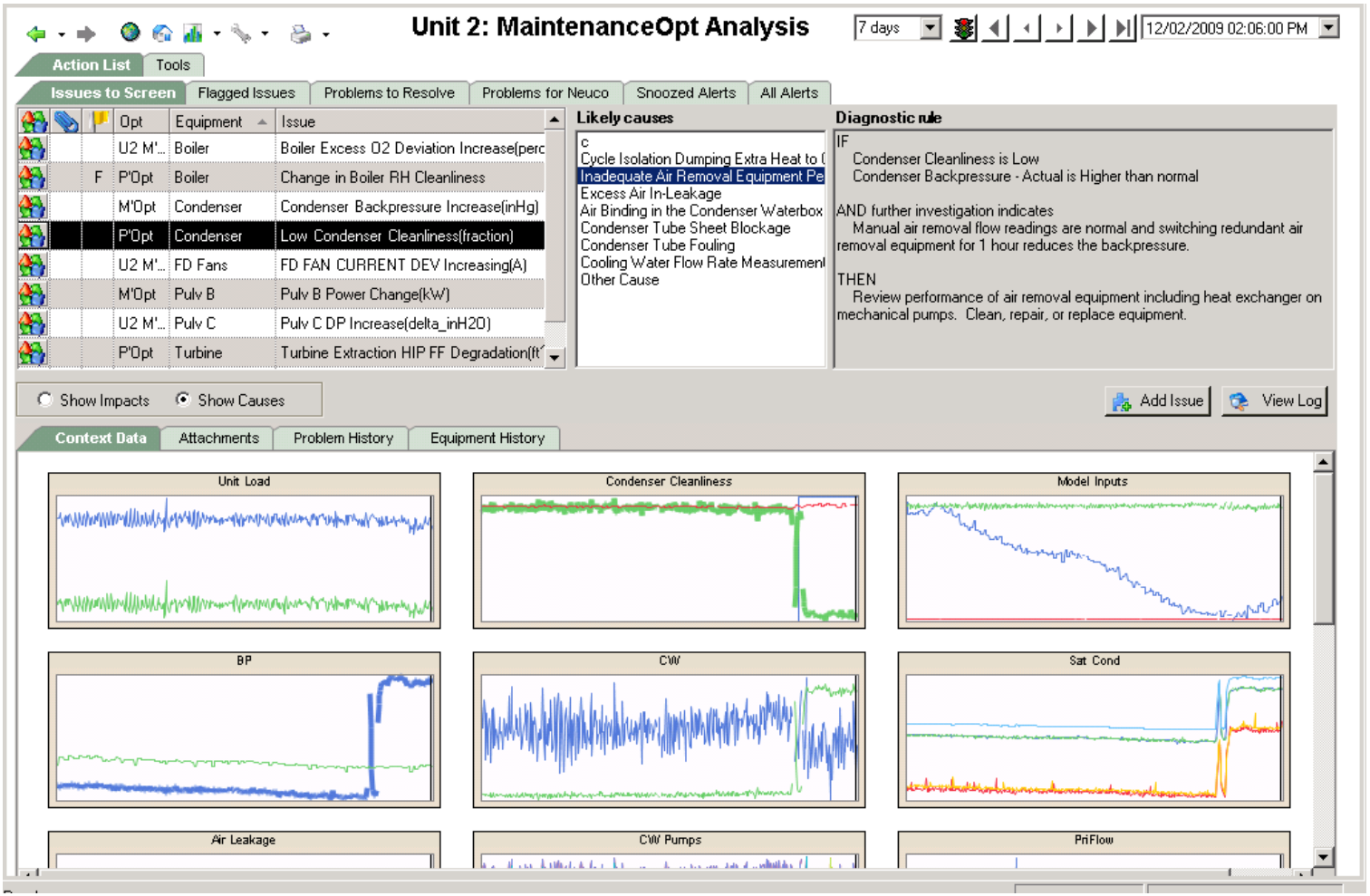
- Condenser Cleanliness significantly changes from expected at approximately 10am

Condenser Backpressure

- Condenser backpressure increases significantly at the same time

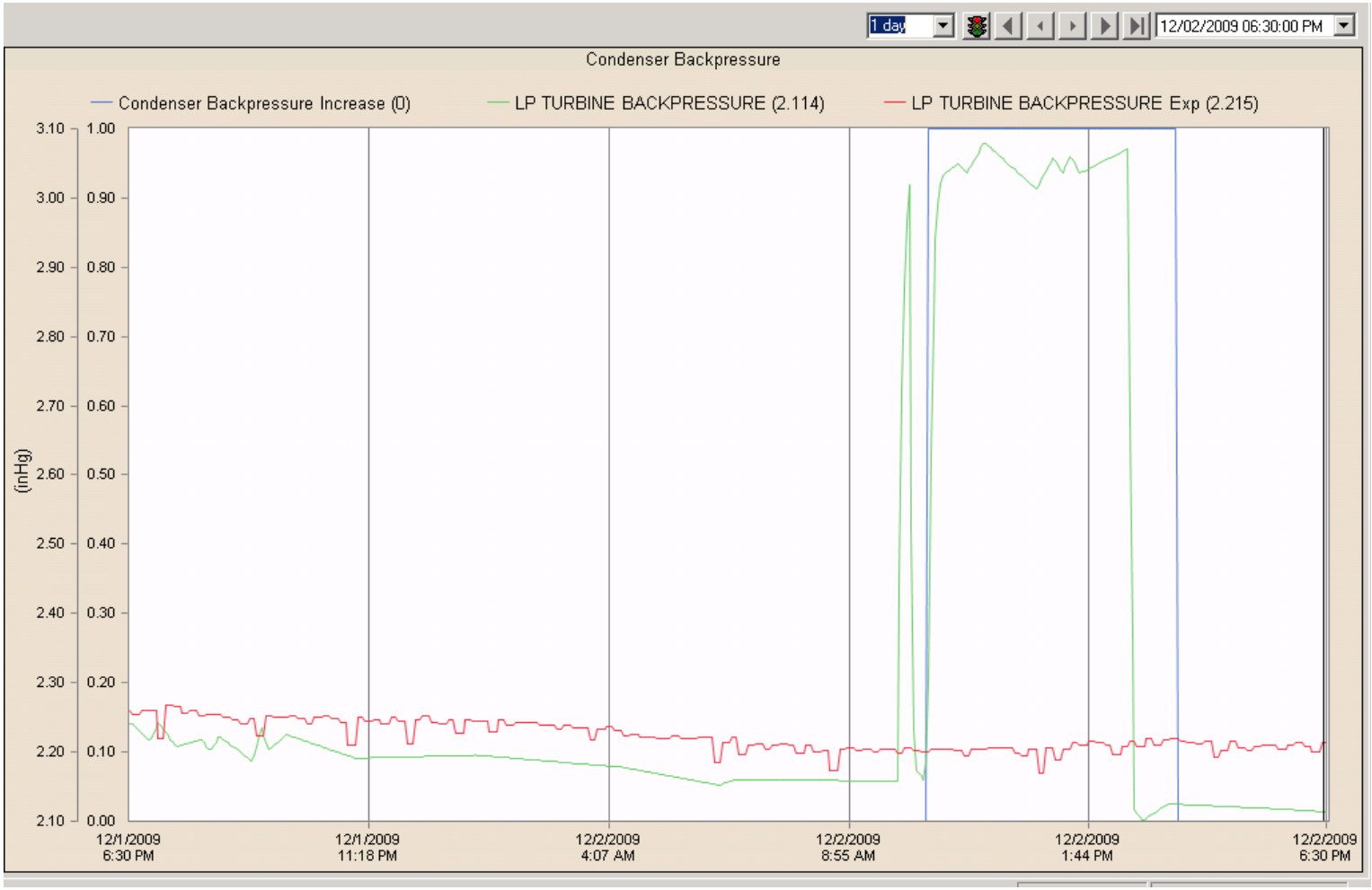
Problem Diagnosis

- Low condenser cleanliness and high condenser backpressure indicates inadequate air removal equipment performance



Problem Resolution

- Maintenance crew reconnects the vacuum pump and performance returns to normal



Benefits of ProcessLink® Integration

- PerformanceOpt indicates equipment degradation through high-fidelity model of thermal processes
- MaintenanceOpt indication of equipment degradation through empirical models of on-line signals as well as potential problems detected through manual inspection
- Some problems that would escape notice through one or the other methodology become obvious when viewed through both
- MaintenanceOpt also surfaces problems detected by NeuCo's closed-loop optimizers
- PerformanceOpt informs closed-loop optimizers though virtual on-line analyzers indicating important boiler performance parameters not directly measured
  - Coal quality, boiler efficiency and heat rate for CombustionOpt
  - Boiler cleanliness and heat rate for SootOpt

Optimization Won't Solve the Problem But Part of the Solution

- Achieve lowest-cost CO_2 reductions
- Demonstrate proactive commitment
- Simultaneously achieve operations improvements:
  - Reduced NOx and/or reagent costs
  - Improved control over CO and opacity
  - Increased reliability and commercial availability
- Newer regulations (based on tons and not lb/mmBtu rates) mean that every incremental heat rate improvement results in fewer tons of CO_2, SO_2, and Mercury

Questions

- For more information please contact:

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