Boiler Optimization for Emissions, Efficiency and Availability

McIvaine Hot Topic Webinar

September 27th, 2012

NeuCo
The Optimization Standard™

ProcessLink®

Today's Fossil Generation Challenges

- Unprecedented regulatory uncertainty
  - **Utility MACT**
  - Federal CO_2 regulation
  - Subsequent Clean Air Act Requirements (NAAQS, **Regional Haze**, etc.)
  - CSAPR???
- Traditional and new sources of market volatility
  - Demand uncertainty (fighting the last war)
  - Fuel and allowance price volatility
  - Technological uncertainties
- All add to challenges bringing new capacity on-line
- CCCTs & renewables force new operating profiles
- Aging assets operating well beyond design life
- Graying work-force and skills shortage

Do more with less and manage the risks!

MATS (aka Utility MACT) Rule

- On February 16, 2012, EPA published the Mercury and Toxics Standards (MATS) rule
- MATS establishes national emissions limitations and work practice standards for certain hazardous air pollutants (HAP) emitted from coal- and oil-fired electric utility steam generating units
- The rule will result in about a 90% reduction from uncontrolled power plant emissions of mercury, nine other toxic metals, and three acid gases, all listed as hazardous air pollutants in the 1990 Clean Air Act Amendments
- The rule affects about 1,100 coal-fired and 300 oil-fired units
- Compliance with the rule is required for existing units by April 16, 2015
- For existing units, the rule specifies both heat input-based emission limits (lb/TBtu) and electrical output-based limits (lb/GWh) for Hg.

"Best Practices" Requirements

- The rule creates a variety of new work practices standards
- Units must burn natural gas or distillate oil during periods of start-up.
- Emissions control systems must be operated during periods of start-up and shutdown.
- Optimization of NOx and CO, combined with "best practices" efforts to maximize fuel efficiency must be demonstrated and documented for the EPA
    - Intended to minimize output of non-measurable HAPs (e.g. Dioxin, Fiurin, etc.
    - Optimization of NOx and CO is required using prescribed technologies
    - All boilers subject to requirements for "tune-ups" and demonstration of best practices for boiler efficiency

Units with Neural Network Optimization Get Favorable Regulatory Treatment

- Neural network optimization is explicitly addressed by MATS in three ways
  - Neural network optimization systems qualify for the requirement in the rule for "optimizing NOx and CO."
  - Units with optimizers can defer the initial EPA "best practices" requirement by a year.
  - Units with optimizers also qualify for less frequent subsequent evaluations to every 48 months.
- These provisions provide further evidence that the US EPA recognizes the value of optimization with respect to regulatory objectives relating to emissions and efficiency

Longer-Term Strategic Implications for Current and Emerging Emissions Regulation

- Minimize capital commitments while emerging regulatory changes make clear which units can survive and which cannot
- Inform future capital decisions for surviving units with better understanding of true (optimal) baseline performance
- Better equip surviving units to cope with:
  - Greater demands on existing emissions control hardware
  - Process changes and variable costs for new emissions hardware
  - Operational profiles associated with fundamentally altered markets
    - Influx of renewables with intermittent generation output profiles
    - Reduced capacity factor due to more efficient newer capacity coming on-line
    - Problems associated with aging assets and changes from design conditions
    - Greater operational challenges with fewer skilled operators and engineers
    - Ever-greater needs to “push the envelope” in order to “stay in the money”

Integration of Emissions & Efficiency Silos

- Emissions and efficiency used to be 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

Bottom Line: Must integrate management of emissions, fuel, reagent costs and tradeoffs between them

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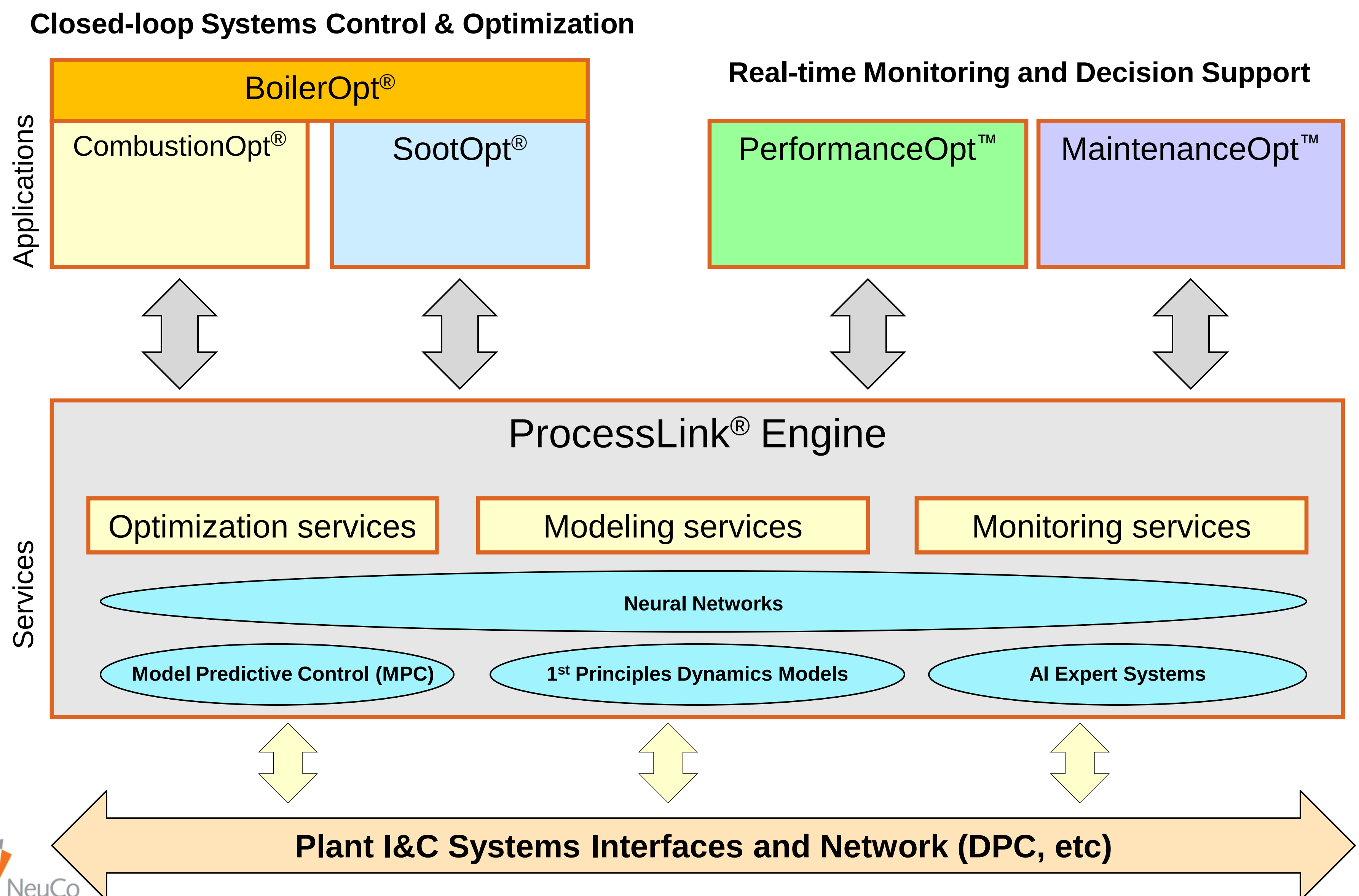
NeuCo's ProcessLink® Platform

- ProcessLink is the technology platform upon which all NeuCo optimizers are built:
  - Employs multiple modeling and optimization techniques to provide best hybrid asset optimization solutions
  - Integrates disparate data sources and knowledge, enabling objective-driven performance across units, plants or an entire fleet
  - Integrated modeling and optimization engine relates process behavior to global objectives
  - Supports optimizer integration and action coordination
  - Process behavior and equipment health issues surfaced though comprehensive alerts
  - Flexible GUIs, portals, and automated reporting

ProcessLink® System Architecture



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Asset Optimization with ProcessLink®

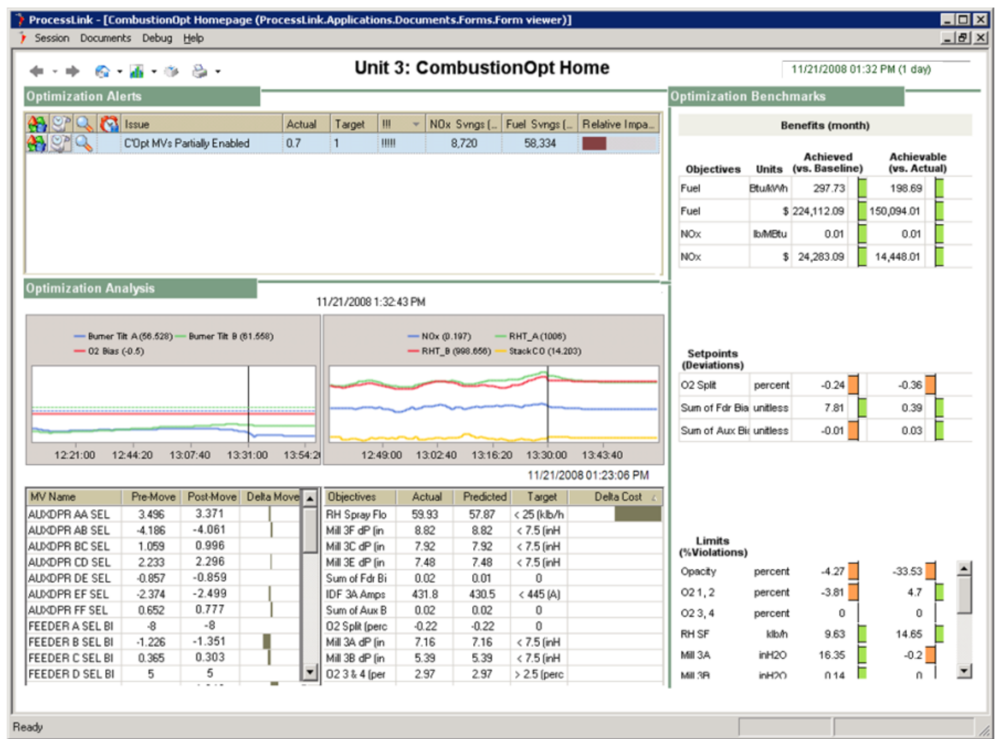
- Maximize Availability/Reliability
  - Predictive analytics for equipment health
  - Early warning for impending failures
  - Minimizing unnecessary outages
  - Better use of planned down-time
  - Reduced tube leak outages
- Minimize Operating Costs
  - Continuous heat rate minimization
  - Detection of equipment problems with efficiency impacts
  - Minimize reagent usage
- Optimize Emissions Control (NOx, CO, Opacity, CO_2)
  - Avoid exceedances and de-rates
  - Exploit allowance trading strategies
  - Optimize trade-offs between emissions and other objectives
  - Get ahead of the curve with CO_2 reductions

ProcessLink Availability Mechanisms

- Reduced Boiler Tube Leak Outages
  - Less unnecessary cleaning (SootOpt)
  - Avoided thermal stress (SootOpt & C'Opt)
- Avoided Slagging/Fouling De-Rates & Outages
  - Pro-active cleaning for vulnerable surfaces (SootOpt)
  - Improved stoichiometry control (CombustionOpt)
  - Tighter control of gas path temperatures (SootOpt & C'Opt)
  - Reduced ammonium bi-sulfate air heater pluggage (SootOpt & C'Opt)
- Fewer Equipment Failure Outages
  - Proactive detection/diagnosis of impending failures (M'Opt/P'Opt)
  - Better knowledge of equipment degradation states (M'Opt/P'Opt)
  - Generally improved situational awareness (all products & alerts)

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
  - Reagent utilization
  - Constraint performance
    (Mill Dp's, Fan Amps, O2 split)



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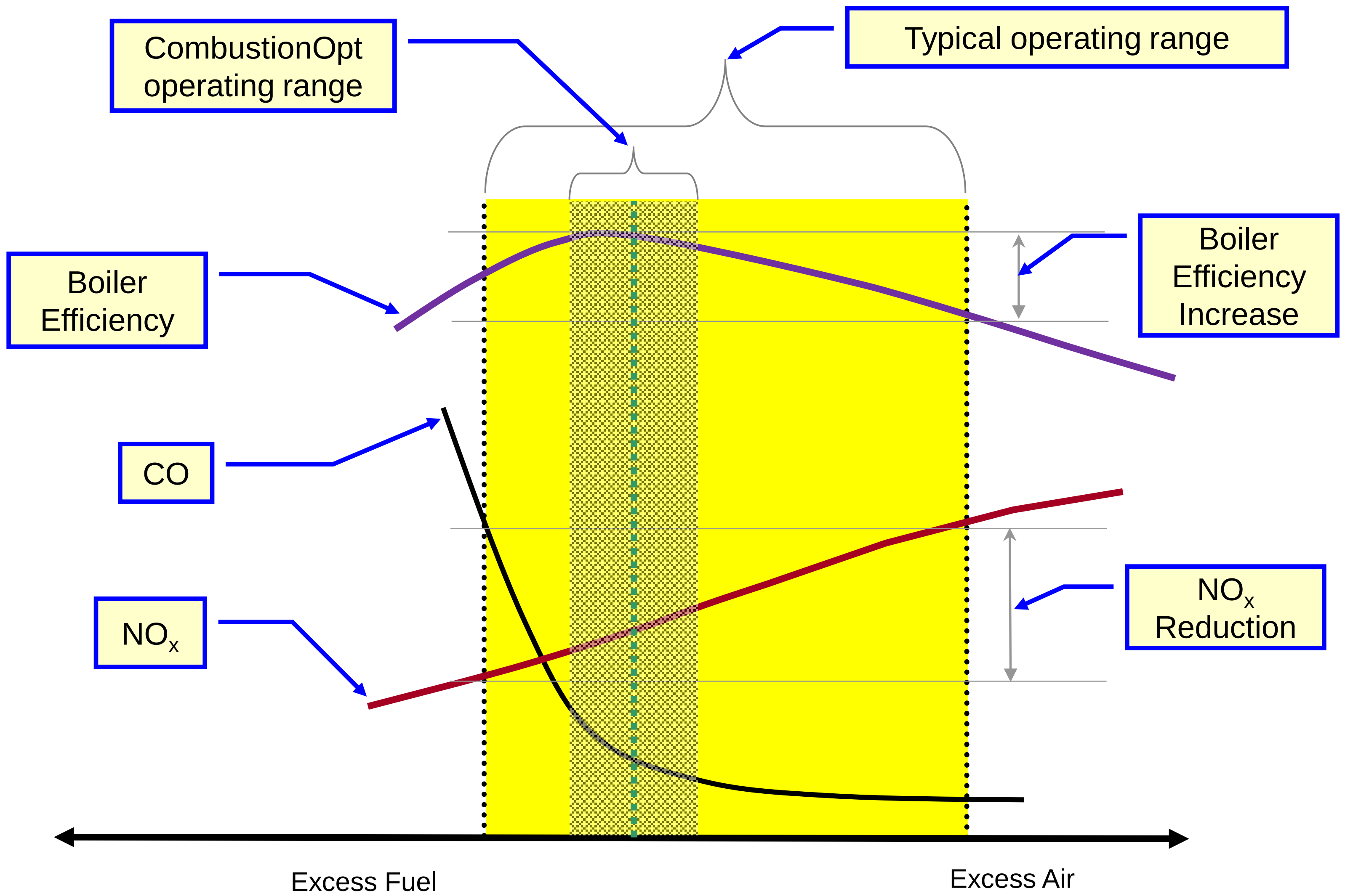
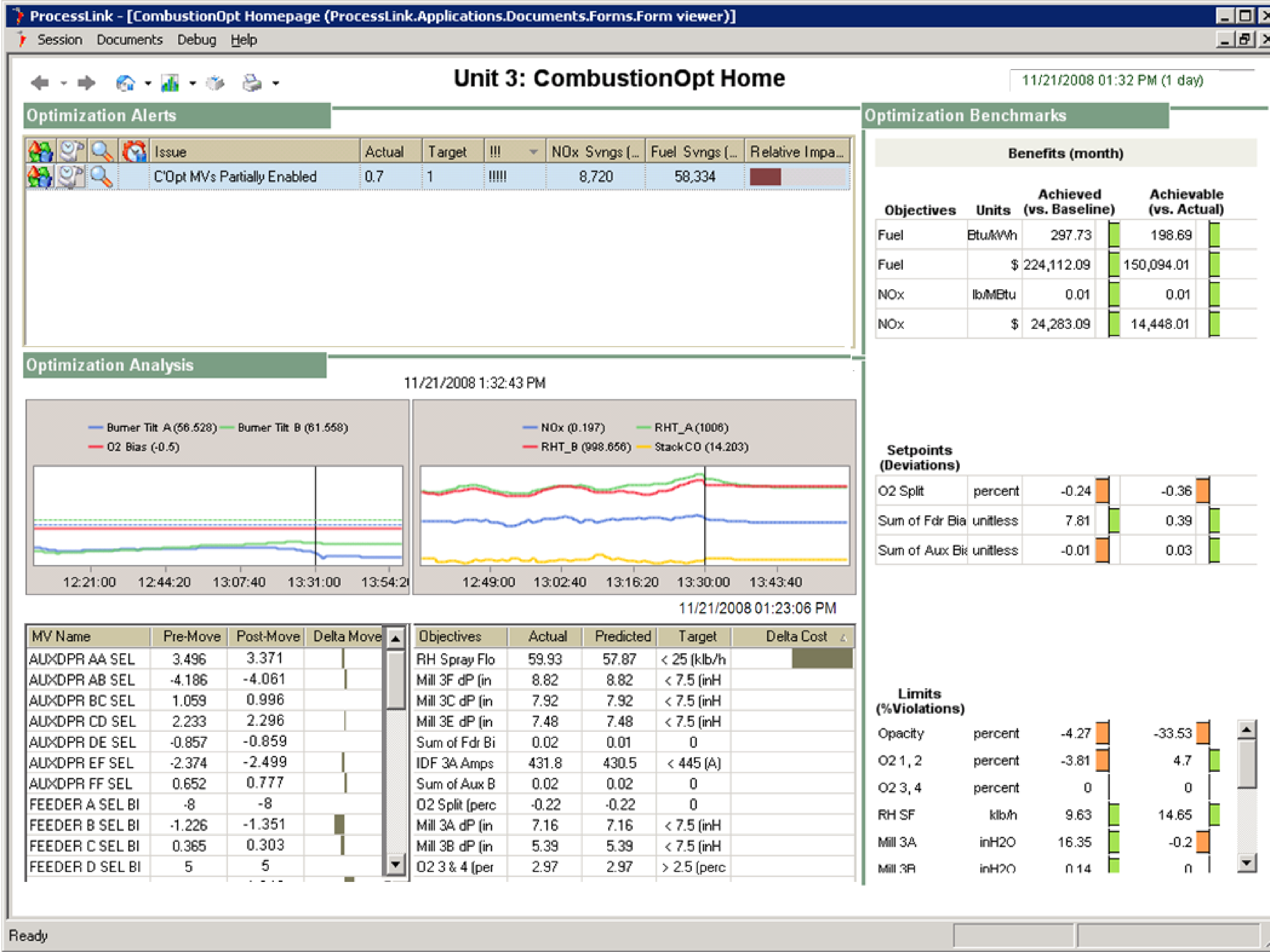
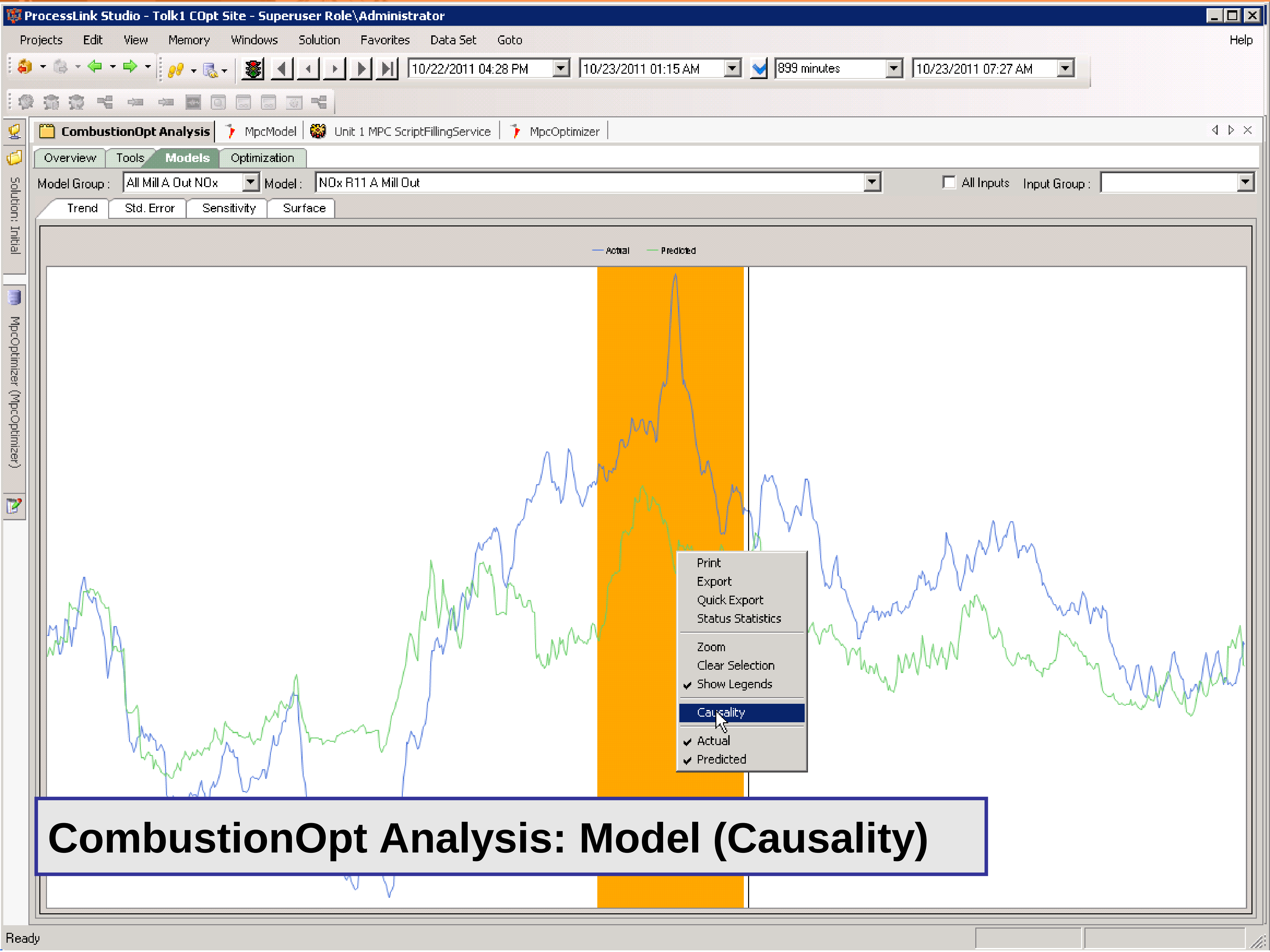
CombustionOpt Optimization

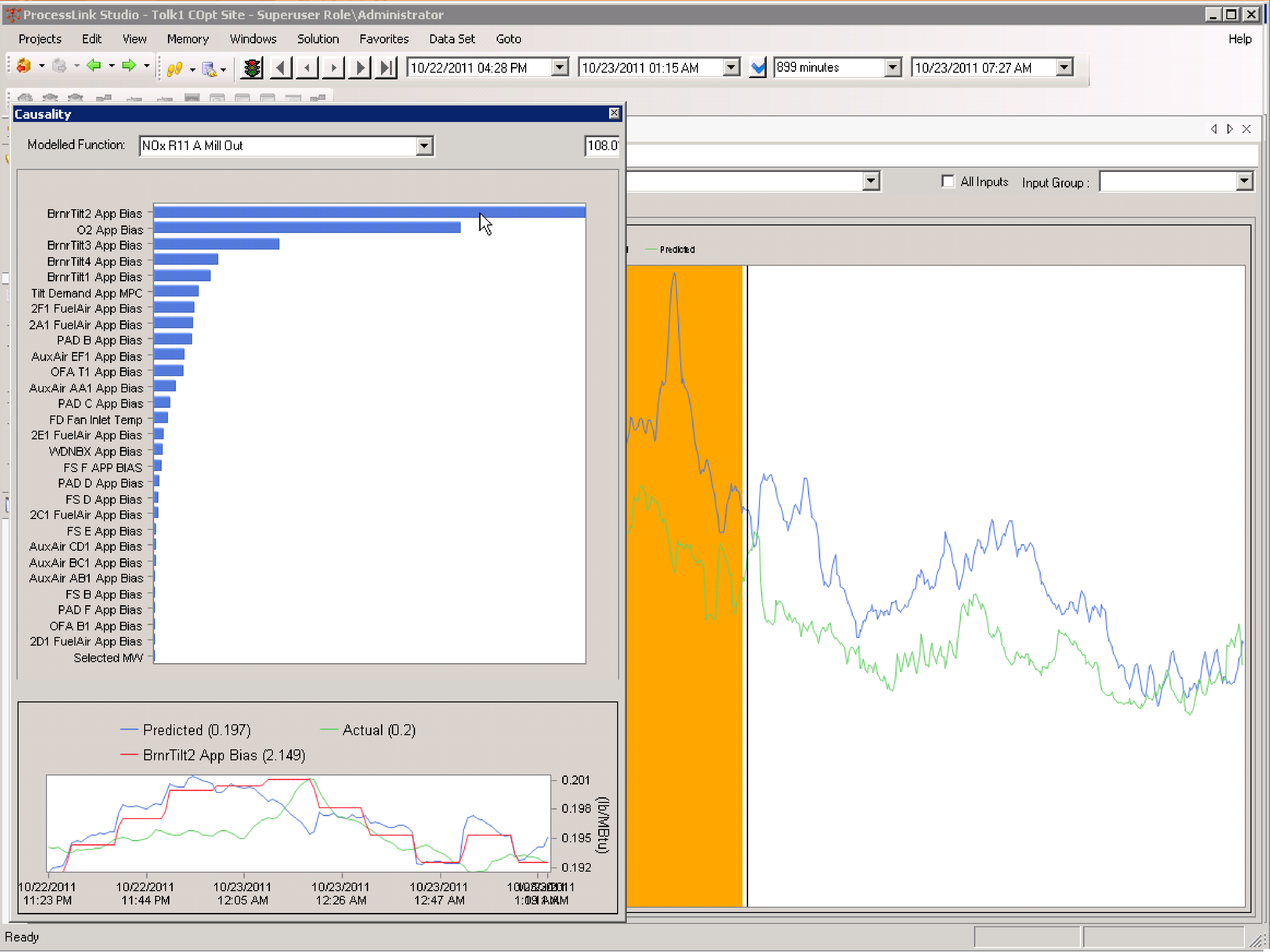




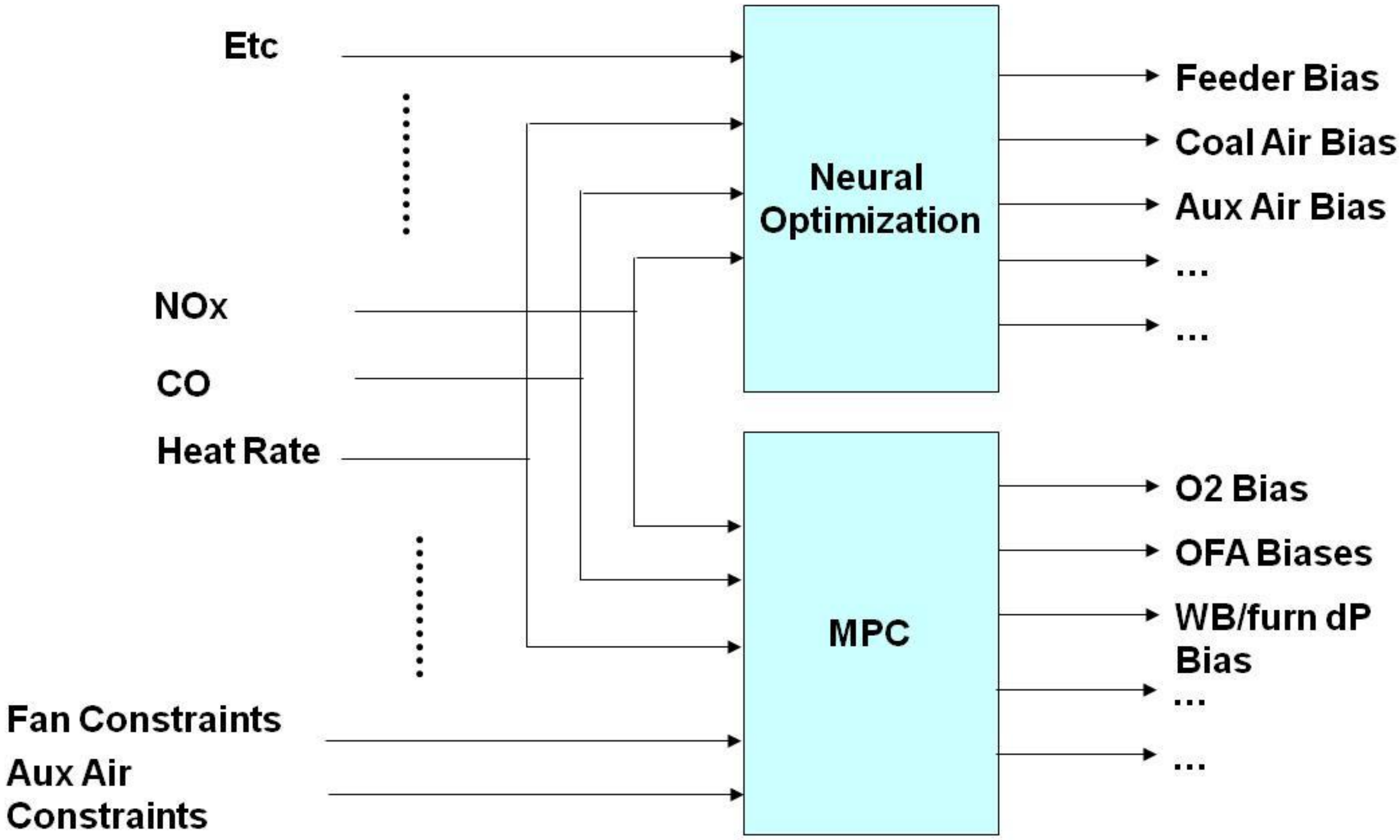
ProcessLink - [CombustionOpt Homepage (ProcessLink.Applications.Documents.Forms.Form viewer)]
Session Documents Debug Help
Unit 3: CombustionOpt Home
11/21/2008 01:32 PM (1 day)
Optimization Alerts
Issue | Actual | Target | !!! | NOx Svngs (... | Fuel Svngs (... | Relative Impa...
C'Opt MVs Partially Enabled | 0.7 | 1 | !!!!! | 8,720 | 58,334
Optimization Benchmarks
Benefits (month)
Objectives | Units | Achieved (vs. Baseline) | Achievable (vs. Actual)
Fuel | Btu/kWh | 297.73 | 198.69
Fuel | $ | 224,112.09 | 150,094.01
NOx | lb/MBtu | 0.01 | 0.01
NOx | $ | 24,283.09 | 14,448.01
Optimization Analysis
11/21/2008 1:32:43 PM
Burner Tilt A (56.528)
Burner Tilt B (61.558)
O2 Bias (-0.5)
12:21:00 12:44:20 13:07:40 13:31:00 13:54:2
NOx (0.197)
RHT_A (1006)
RHT_B (998.656)
Stack CO (14.203)
12:49:00 13:02:40 13:16:20 13:30:00 13:43:40
Setpoints (Deviations)
O2 Split | percent | -0.24 | -0.36
Sum of Fdr Bia | unitless | 7.81 | 0.39
Sum of Aux Bi | unitless | -0.01 | 0.03
11/21/2008 01:23:06 PM
MV Name | Pre-Move | Post-Move | Delta Move
AUXDPR AA SEL | 3.496 | 3.371
AUXDPR AB SEL | -4.186 | -4.061
AUXDPR BC SEL | 1.059 | 0.996
AUXDPR CD SEL | 2.233 | 2.296
AUXDPR DE SEL | -0.857 | -0.859
AUXDPR EF SEL | -2.374 | -2.499
AUXDPR FF SEL | 0.652 | 0.777
FEEDER A SEL BI | -8 | -8
FEEDER B SEL BI | -1.226 | -1.351
FEEDER C SEL BI | 0.365 | 0.303
FEEDER D SEL BI | 5 | 5
Objectives | Actual | Predicted | Target | Delta Cost
RH Spray Flo | 59.93 | 57.87 | < 25 (klb/h
Mill 3F dP (in | 8.82 | 8.82 | < 7.5 (inH
Mill 3C dP (in | 7.92 | 7.92 | < 7.5 (inH
Mill 3E dP (in | 7.48 | 7.48 | < 7.5 (inH
Sum of Fdr Bi | 0.02 | 0.01 | 0
IDF 3A Amps | 431.8 | 430.5 | < 445 (A)
Sum of Aux B | 0.02 | 0.02 | 0
O2 Split (perc | -0.22 | -0.22 | 0
Mill 3A dP (in | 7.16 | 7.16 | < 7.5 (inH
Mill 3B dP (in | 5.39 | 5.39 | < 7.5 (inH
O2 3 & 4 (per | 2.97 | 2.97 | > 2.5 (perc
Limits (%Violations)
Opacity | percent | -4.27 | -33.53
O2 1, 2 | percent | -3.81 | 4.7
O2 3, 4 | percent | 0 | 0
RH SF | klb/h | 9.63 | 14.65
Mill 3A | inH2O | 16.35 | -0.2
Mill 3B | inH2O | 0.14 | 0
Ready



CombustionOpt Analysis: Model (Causality)


ProcessLink Studio - Tolk1 COpt Site - Superuser Role\Administrator
Projects
Edit
View
Memory
Windows
Solution
Favorites
Data Set
Goto
Help
10/22/2011 04:28 PM
10/23/2011 01:15 AM
899 minutes
10/23/2011 07:27 AM
Causality
Modelled Function:
NOx R11 A Mill Out
108.0
All Inputs
Input Group :
Predicted
BrnrTilt2 App Bias
O2 App Bias
BrnrTilt3 App Bias
BrnrTilt4 App Bias
BrnrTilt1 App Bias
Tilt Demand App MPC
2F1 FuelAir App Bias
2A1 FuelAir App Bias
PAD B App Bias
AuxAir EF1 App Bias
OFA T1 App Bias
AuxAir AA1 App Bias
PAD C App Bias
FD Fan Inlet Temp
2E1 FuelAir App Bias
WDNBX App Bias
FS F APP BIAS
PAD D App Bias
FS D App Bias
2C1 FuelAir App Bias
FS E App Bias
AuxAir CD1 App Bias
AuxAir BC1 App Bias
AuxAir AB1 App Bias
FS B App Bias
PAD F App Bias
OFA B1 App Bias
2D1 FuelAir App Bias
Selected MW
Predicted (0.197)
Actual (0.2)
BrnrTilt2 App Bias (2.149)
0.201
0.198
0.195
0.192
(lb/MBtu)
10/22/2011 11:23 PM
10/22/2011 11:44 PM
10/23/2011 12:05 AM
10/23/2011 12:26 AM
10/23/2011 12:47 AM
10/23/2011 1:09 AM
Ready

Combining Neural with MPC



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Expert Rules and Other Techniques

In addition to Direct Search and NN & MPC models, NeuCo may use Expert Rules to:

- Calculate MV constraints
- Use reactive override under special conditions (e.g., high CO)
- Exclude model training data under certain conditions
- Define models and/or objectives specific to mill combinations
- Switch entire constraint and/or objective profiles

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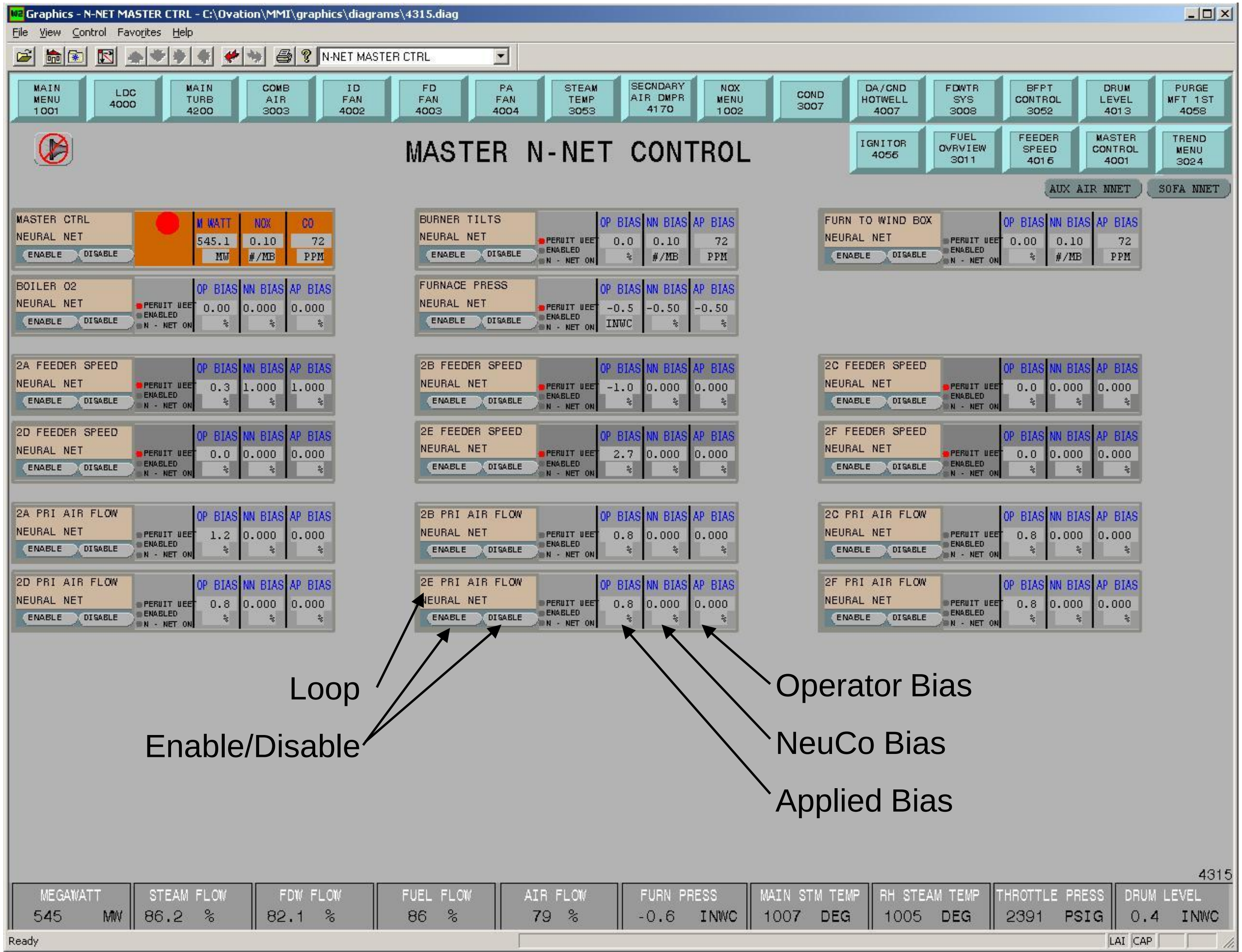
How CombustionOpt Addresses Fuel Changes

- All CombustionOpt installations have coal variability
- Many have fuel blending (PRB/Bituminous/Lignite, etc.)
- In most cases there is no real-time fuel quality measurement
- In some cases manual inputs used, but not many
- CombustionOpt's inputs infer fuel quality from many data sources
- Optimization uses directional as opposed to absolute process knowledge
- On-line learning and model validation finds models best-suited for current fuel blend from past history

DCS Integration



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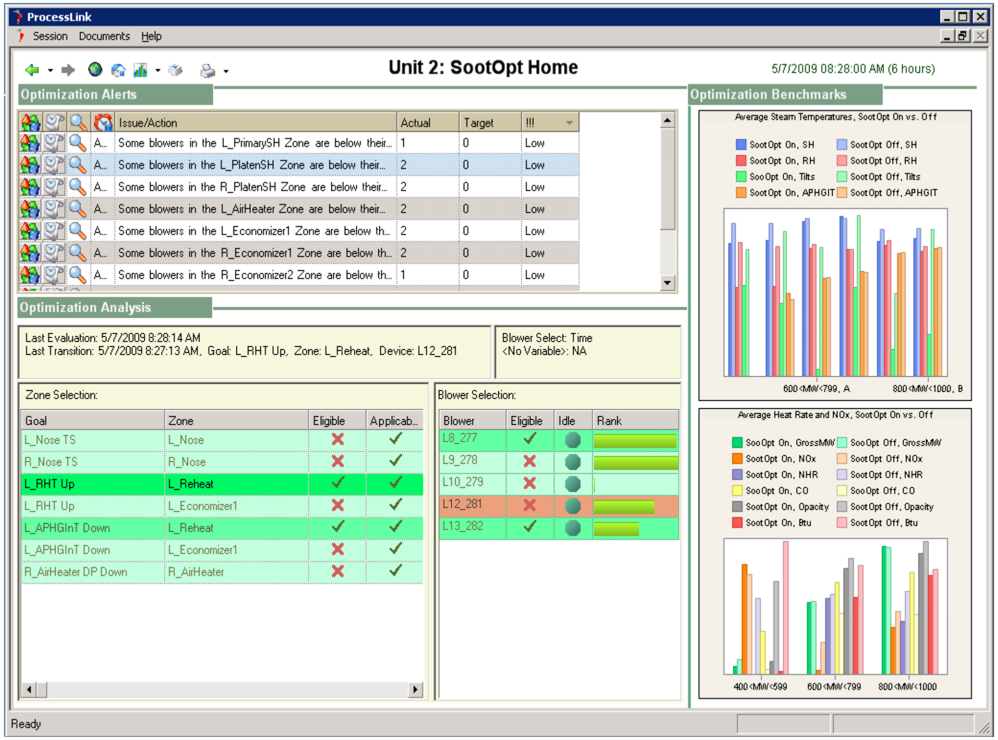
SootOpt ®

- 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



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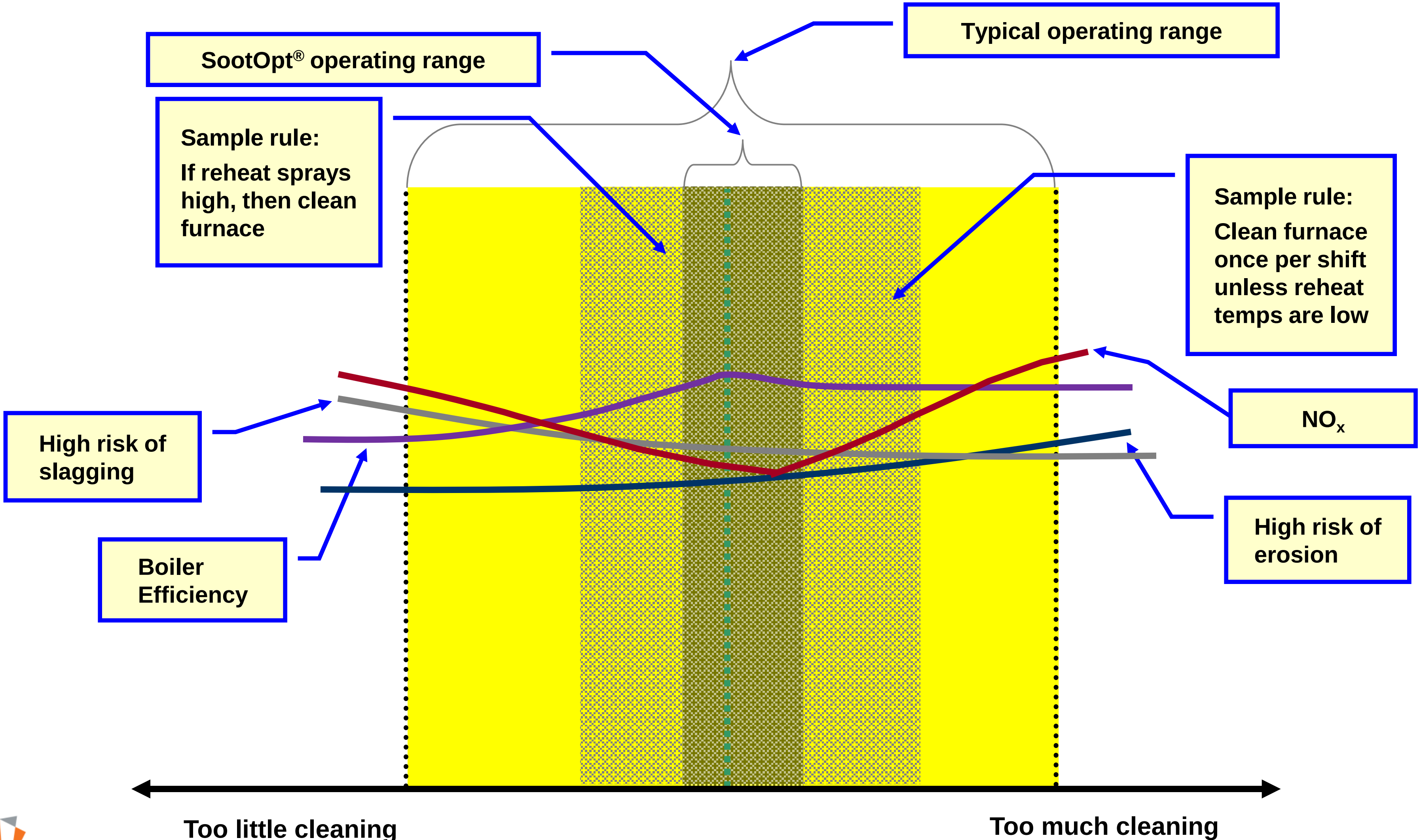
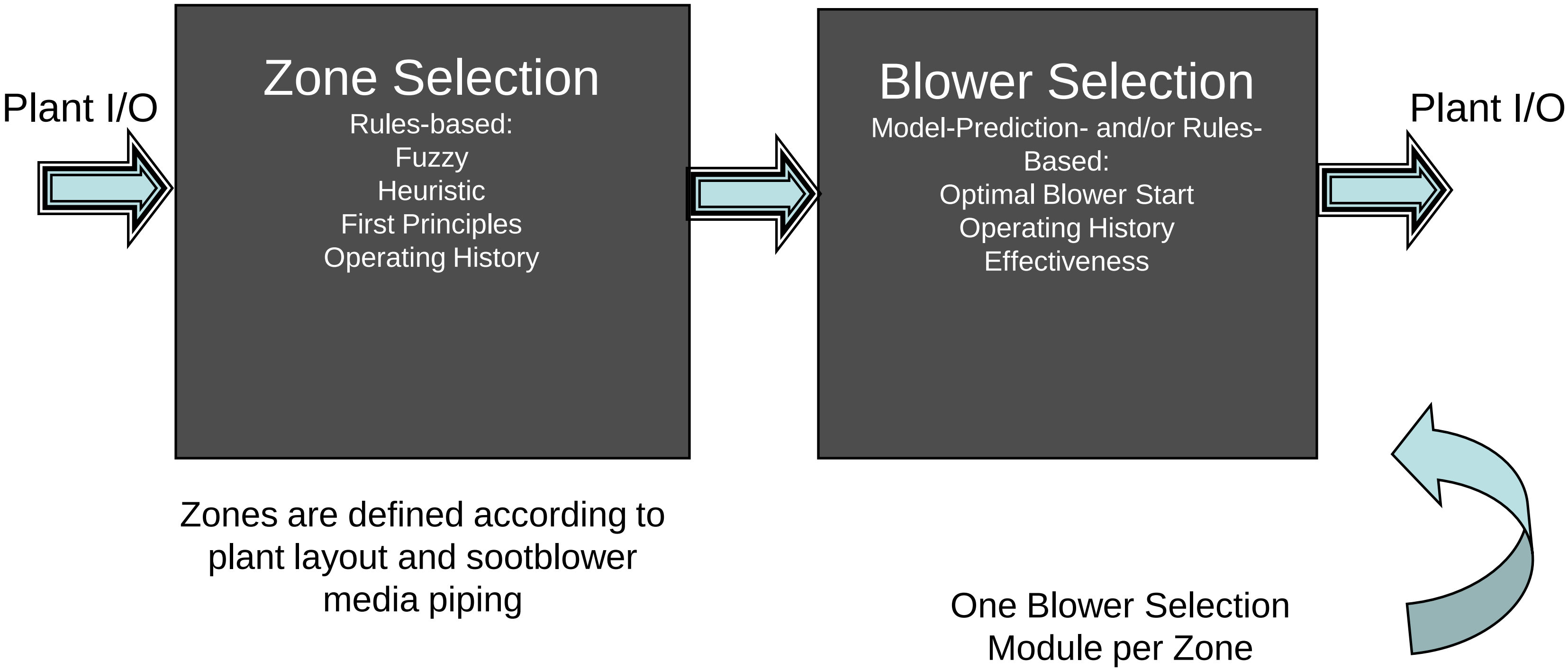
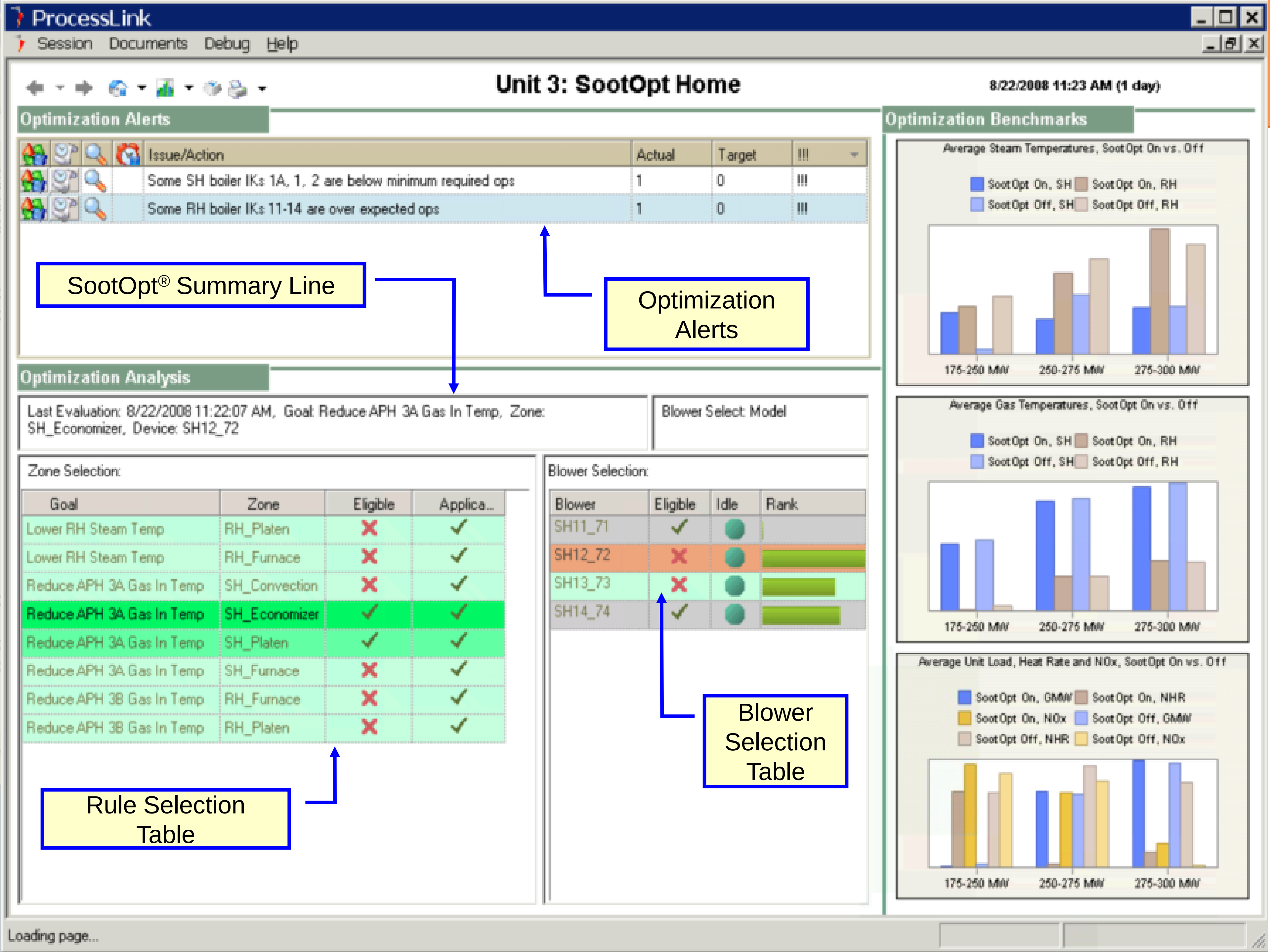
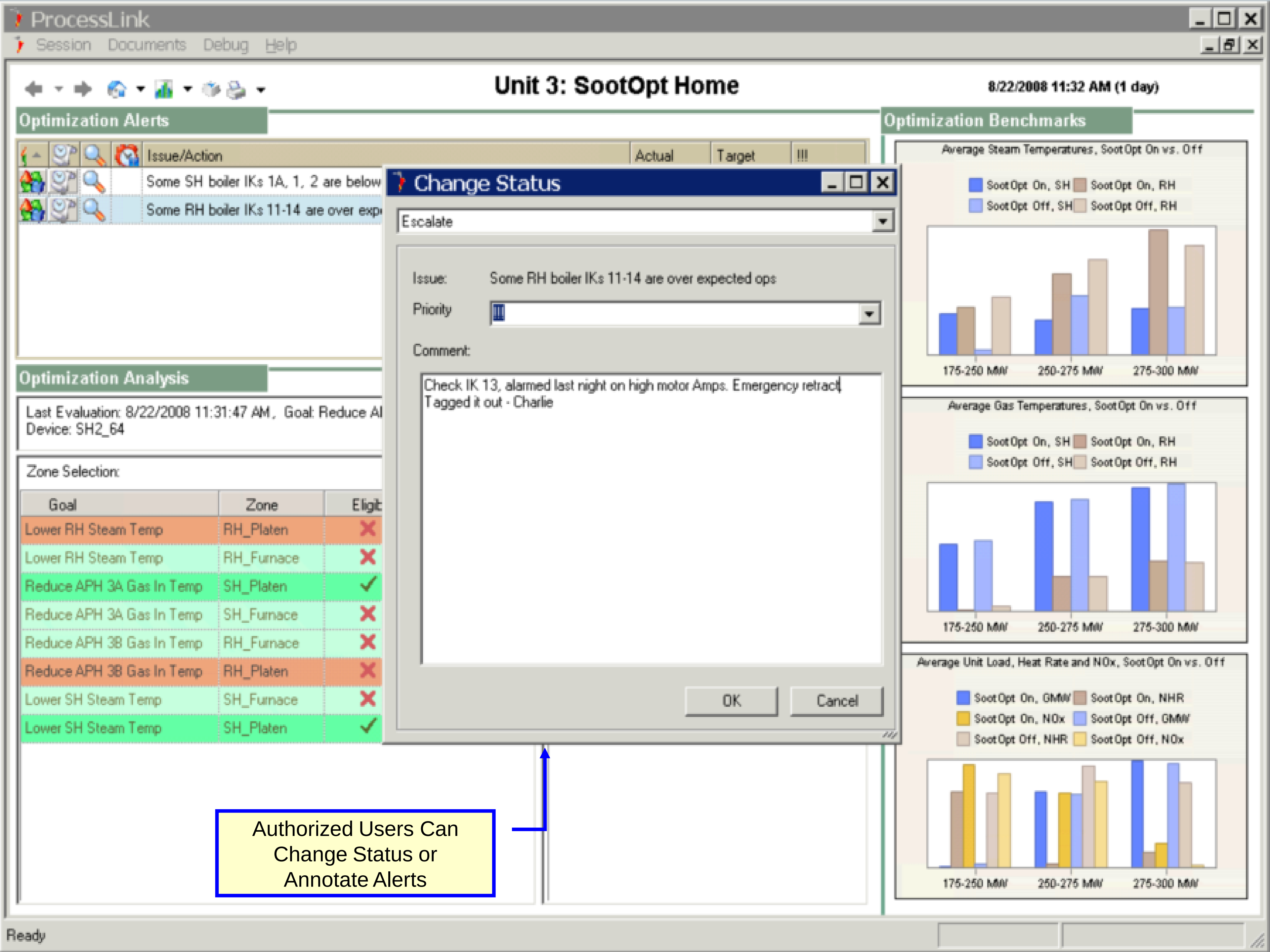
Boiler Cleanliness Optimization



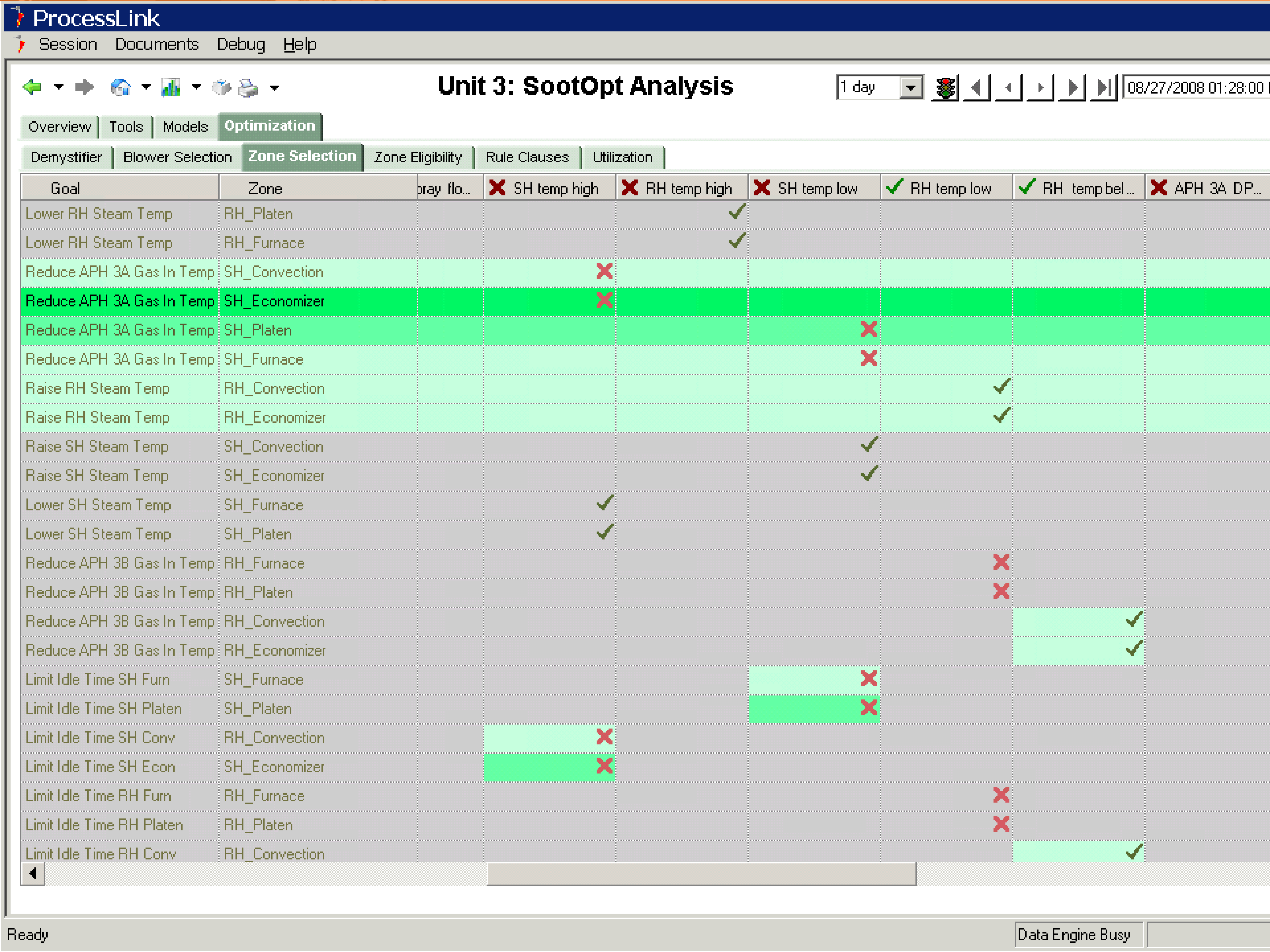
Overview: How SootOpt Works




ProcessLink
Session Documents Debug Help
Unit 3: SootOpt Home
8/22/2008 11:23 AM (1 day)
Optimization Alerts
Issue/Action | Actual | Target | !!!
Some SH boiler IKs 1A, 1, 2 are below minimum required ops | 1 | 0 | !!!
Some RH boiler IKs 11-14 are over expected ops | 1 | 0 | !!!
SootOpt® Summary Line
Optimization Alerts
Optimization Analysis
Last Evaluation: 8/22/2008 11:22:07 AM, Goal: Reduce APH 3A Gas In Temp, Zone: SH_Economizer, Device: SH12_72
Blower Select: Model
Zone Selection:
Goal | Zone | Eligible | Applica...
Lower RH Steam Temp | RH_Platen
Lower RH Steam Temp | RH_Furnace
Reduce APH 3A Gas In Temp | SH_Convection
Reduce APH 3A Gas In Temp | SH_Economizer
Reduce APH 3A Gas In Temp | SH_Platen
Reduce APH 3A Gas In Temp | SH_Furnace
Reduce APH 3B Gas In Temp | RH_Furnace
Reduce APH 3B Gas In Temp | RH_Platen
Rule Selection Table
Blower Selection:
Blower | Eligible | Idle | Rank
SH11_71
SH12_72
SH13_73
SH14_74
Blower Selection Table
Optimization Benchmarks
Average Steam Temperatures, SootOpt On vs. Off
SootOpt On, SH
SootOpt On, RH
SootOpt Off, SH
SootOpt Off, RH
175-250 MW
250-275 MW
275-300 MW
Average Gas Temperatures, SootOpt On vs. Off
SootOpt On, SH
SootOpt On, RH
SootOpt Off, SH
SootOpt Off, RH
175-250 MW
250-275 MW
275-300 MW
Average Unit Load, Heat Rate and NOx, SootOpt On vs. Off
SootOpt On, GMW
SootOpt On, NHR
SootOpt On, NOx
SootOpt Off, GMW
SootOpt Off, NHR
SootOpt Off, NOx
175-250 MW
250-275 MW
275-300 MW
Loading page...



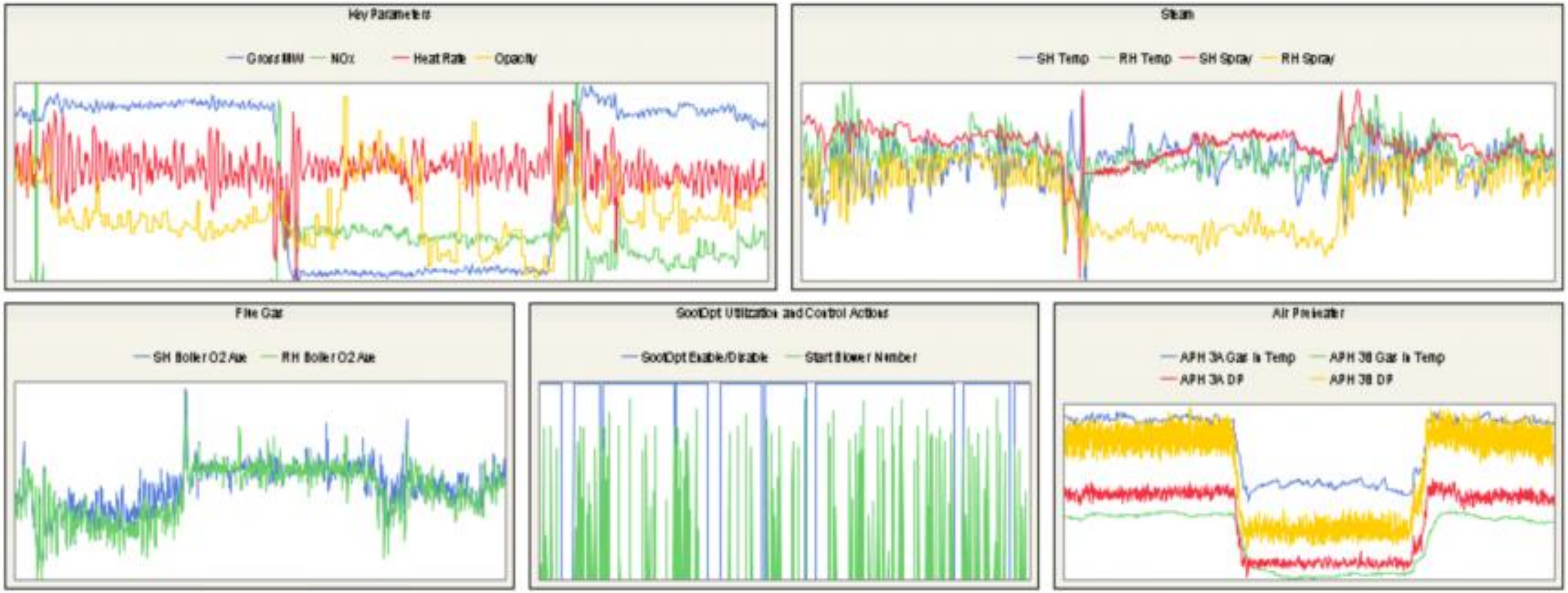
ProcessLink
Session Documents Debug Help
Unit 3: SootOpt Home
8/22/2008 11:32 AM (1 day)
Optimization Alerts
Issue/Action
Actual
Target
Some SH boiler IKs 1A, 1, 2 are below
Some RH boiler IKs 11-14 are over exp
Optimization Analysis
Last Evaluation: 8/22/2008 11:31:47 AM, Goal: Reduce Al
Device: SH2_64
Zone Selection:
Goal
Zone
Eligi
Lower RH Steam Temp
RH_Platen
Lower RH Steam Temp
RH_Furnace
Reduce APH 3A Gas In Temp
SH_Platen
Reduce APH 3A Gas In Temp
SH_Furnace
Reduce APH 3B Gas In Temp
RH_Furnace
Reduce APH 3B Gas In Temp
RH_Platen
Lower SH Steam Temp
SH_Furnace
Lower SH Steam Temp
SH_Platen
Change Status
Escalate
Issue:
Some RH boiler IKs 11-14 are over expected ops
Priority
Comment:
Check IK 13, alarmed last night on high motor Amps. Emergency retract.
Tagged it out - Charlie
OK
Cancel
Optimization Benchmarks
Average Steam Temperatures, SootOpt On vs. Off
SootOpt On, SH
SootOpt On, RH
SootOpt Off, SH
SootOpt Off, RH
175-250 MW
250-275 MW
275-300 MW
Average Gas Temperatures, SootOpt On vs. Off
SootOpt On, SH
SootOpt On, RH
SootOpt Off, SH
SootOpt Off, RH
175-250 MW
250-275 MW
275-300 MW
Average Unit Load, Heat Rate and NOx, SootOpt On vs. Off
SootOpt On, GMW
SootOpt On, NHR
SootOpt On, NOx
SootOpt Off, GMW
SootOpt Off, NHR
SootOpt Off, NOx
175-250 MW
250-275 MW
275-300 MW
Authorized Users Can Change Status or Annotate Alerts
Ready

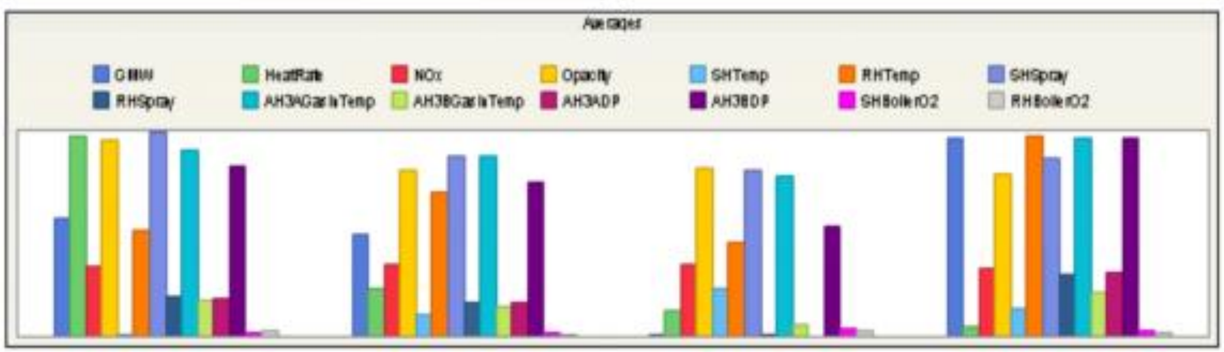


Goal	Zone	...ray flo...	✗ SH temp high	✗ RH temp high	✗ SH temp low	✓ RH temp low	✓ RH temp bel...	✗ APH 3A DP...
Lower RH Steam Temp	RH_Platen			✓				
Lower RH Steam Temp	RH_Furnace			✓				
Reduce APH 3A Gas In Temp	SH_Convection		✗					
Reduce APH 3A Gas In Temp	SH_Economizer		✗					
Reduce APH 3A Gas In Temp	SH_Platen				✗			
Reduce APH 3A Gas In Temp	SH_Furnace				✗			
Raise RH Steam Temp	RH_Convection					✓		
Raise RH Steam Temp	RH_Economizer					✓		
Raise SH Steam Temp	SH_Convection				✓			
Raise SH Steam Temp	SH_Economizer				✓			
Lower SH Steam Temp	SH_Furnace		✓					
Lower SH Steam Temp	SH_Platen		✓					
Reduce APH 3B Gas In Temp	RH_Furnace					✗		
Reduce APH 3B Gas In Temp	RH_Platen					✗		
Reduce APH 3B Gas In Temp	RH_Convection						✓	
Reduce APH 3B Gas In Temp	RH_Economizer						✓	
Limit Idle Time SH Furn	SH_Furnace				✗			
Limit Idle Time SH Platen	SH_Platen				✗			
Limit Idle Time SH Conv	RH_Convection		✗					
Limit Idle Time SH Econ	SH_Economizer		✗					
Limit Idle Time RH Furn	RH_Furnace					✗		
Limit Idle Time RH Platen	RH_Platen					✗		
Limit Idle Time RH Conv	RH_Convection						✓	

Unit 3: SootOpt Analysis

Overview of Boiler Performance Parameters and Associated Sootblower Activities

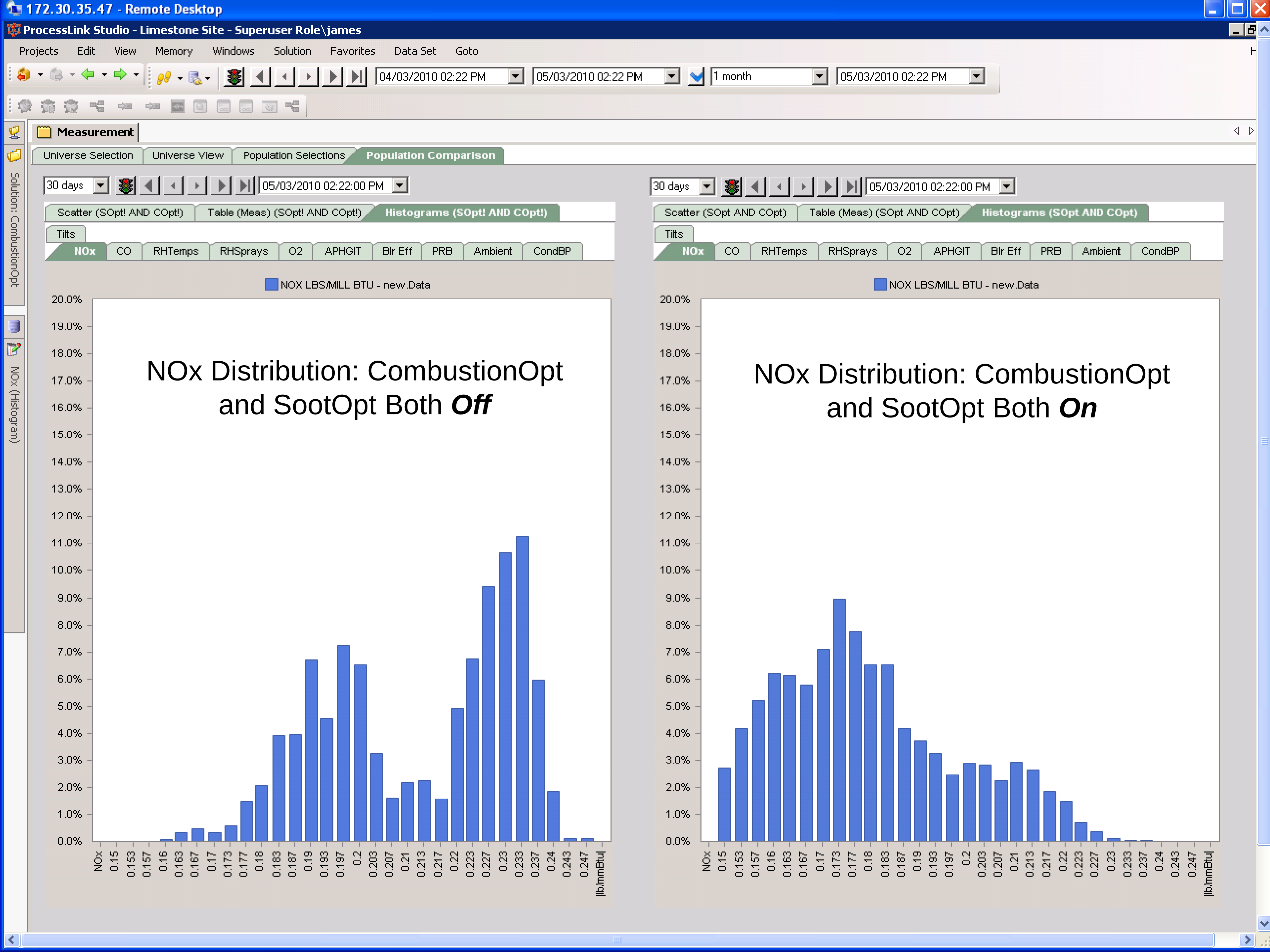


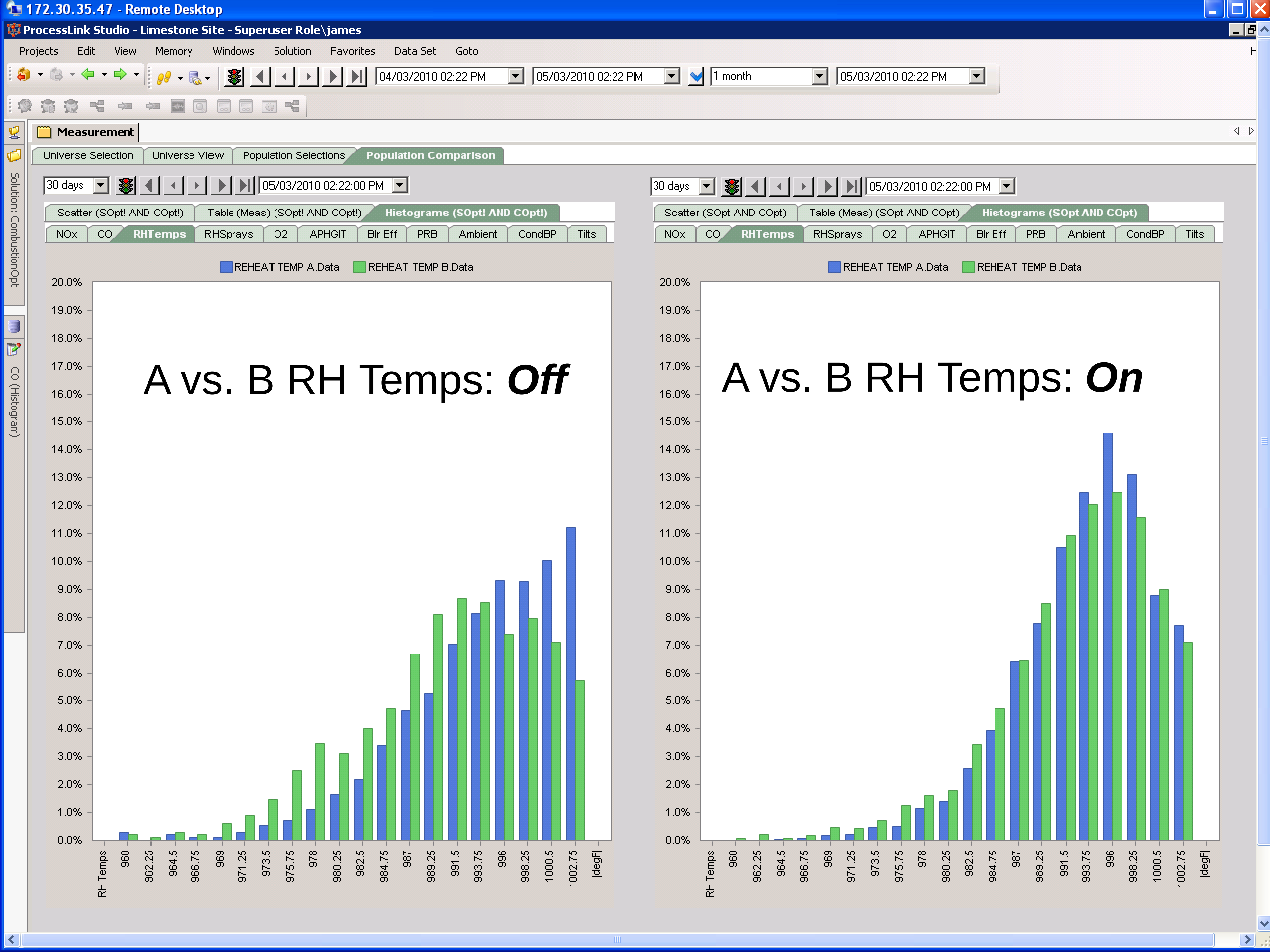


Blower Operations	48 Hrs	24 Hrs	16 Hrs	8 Hrs
SH-IRs	99	51	31	22
SH-IKs	181	94	53	36
SH-APH	5	2	1	0
RH-IRs	149	75	45	25
RH-IKs	184	98	63	30
RH-APH	9	4	3	2

NRG Texas Limestone Generating Station

- T-fired boiler 913 MW firing Lignite and PRB
- Ten fuel elevations equipped with a low-NOx burner/over-fire air system
- Cold-side ESP and wet FGD
- DCS control system is a Bailey Infi-90


172.30.35.47 - Remote Desktop
ProcessLink Studio - Limestone Site - Superuser Role\james
Projects Edit View Memory Windows Solution Favorites Data Set Goto
04/03/2010 02:22 PM
05/03/2010 02:22 PM
1 month
05/03/2010 02:22 PM
Measurement
Universe Selection
Universe View
Population Selections
Population Comparison
Solution: CombustionOpt
NOx (Histogram)
30 days
05/03/2010 02:22:00 PM
Scatter (SOpt! AND COpt!)
Table (Meas) (SOpt! AND COpt!)
Histograms (SOpt! AND COpt!)
Tilts
NOx CO RHTemps RHSprays O2 APHGIT Blr Eff PRB Ambient CondBP
NOX LBS/MILL BTU - new.Data
NOx Distribution: CombustionOpt and SootOpt Both Off
20.0% 19.0% 18.0% 17.0% 16.0% 15.0% 14.0% 13.0% 12.0% 11.0% 10.0% 9.0% 8.0% 7.0% 6.0% 5.0% 4.0% 3.0% 2.0% 1.0% 0.0%
NOx 0.15 0.153 0.157 0.16 0.163 0.167 0.17 0.173 0.177 0.18 0.183 0.187 0.19 0.193 0.197 0.2 0.203 0.207 0.21 0.213 0.217 0.22 0.223 0.227 0.23 0.233 0.237 0.24 0.243 0.247 [lb/mmBtu]
30 days
05/03/2010 02:22:00 PM
Scatter (SOpt AND COpt)
Table (Meas) (SOpt AND COpt)
Histograms (SOpt AND COpt)
Tilts
NOx CO RHTemps RHSprays O2 APHGIT Blr Eff PRB Ambient CondBP
NOX LBS/MILL BTU - new.Data
NOx Distribution: CombustionOpt and SootOpt Both On
20.0% 19.0% 18.0% 17.0% 16.0% 15.0% 14.0% 13.0% 12.0% 11.0% 10.0% 9.0% 8.0% 7.0% 6.0% 5.0% 4.0% 3.0% 2.0% 1.0% 0.0%
NOx 0.15 0.153 0.157 0.16 0.163 0.167 0.17 0.173 0.177 0.18 0.183 0.187 0.19 0.193 0.197 0.2 0.203 0.207 0.21 0.213 0.217 0.22 0.223 0.227 0.23 0.233 0.237 0.24 0.243 0.247 [lb/mmBtu]


172.30.35.47 - Remote Desktop
ProcessLink Studio - Limestone Site - Superuser Role\james
Measurement
Universe Selection
Universe View
Population Selections
Population Comparison
Histograms (SOpt! AND COpt!)
Histograms (SOpt AND COpt)
REHEAT TEMP A.Data
REHEAT TEMP B.Data
A vs. B RH Temps: ***Off***
A vs. B RH Temps: ***On***
RH Temps
[degF]

Optimization History at CPS Energy

- CombustionOpt on coal-fired units for NOx reduction
  - Spruce: 546 MW CE t-fired w/Ovation DCS: Installation 2001
  - Deely: 2 x 446 MW CE t-fired w/Honeywell DCS: Installation 2004
- Multivariate predictive control added in 2007 for:
  - Explicit steam temperature control
  - Minimize attemperation sprays
  - Incremental heat rate and NOx reduction
- SootOpt added in 2010/2011 for availability/efficiency

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J.K. Spruce Power Plant

- Calaveras Power Plant Complex, South East of San Antonio, TX
- J.K. Spruce 1 commissioned in 1990
- 600 MW Alstom-CE T-fired units
- Emerson Ovation DCS
- Spruce 2 commissioned 2011: 750 MW CE T-fired boiler with SCR

Analysis of Integrated BoilerOpt Benefits at JK Spruce Unit 1

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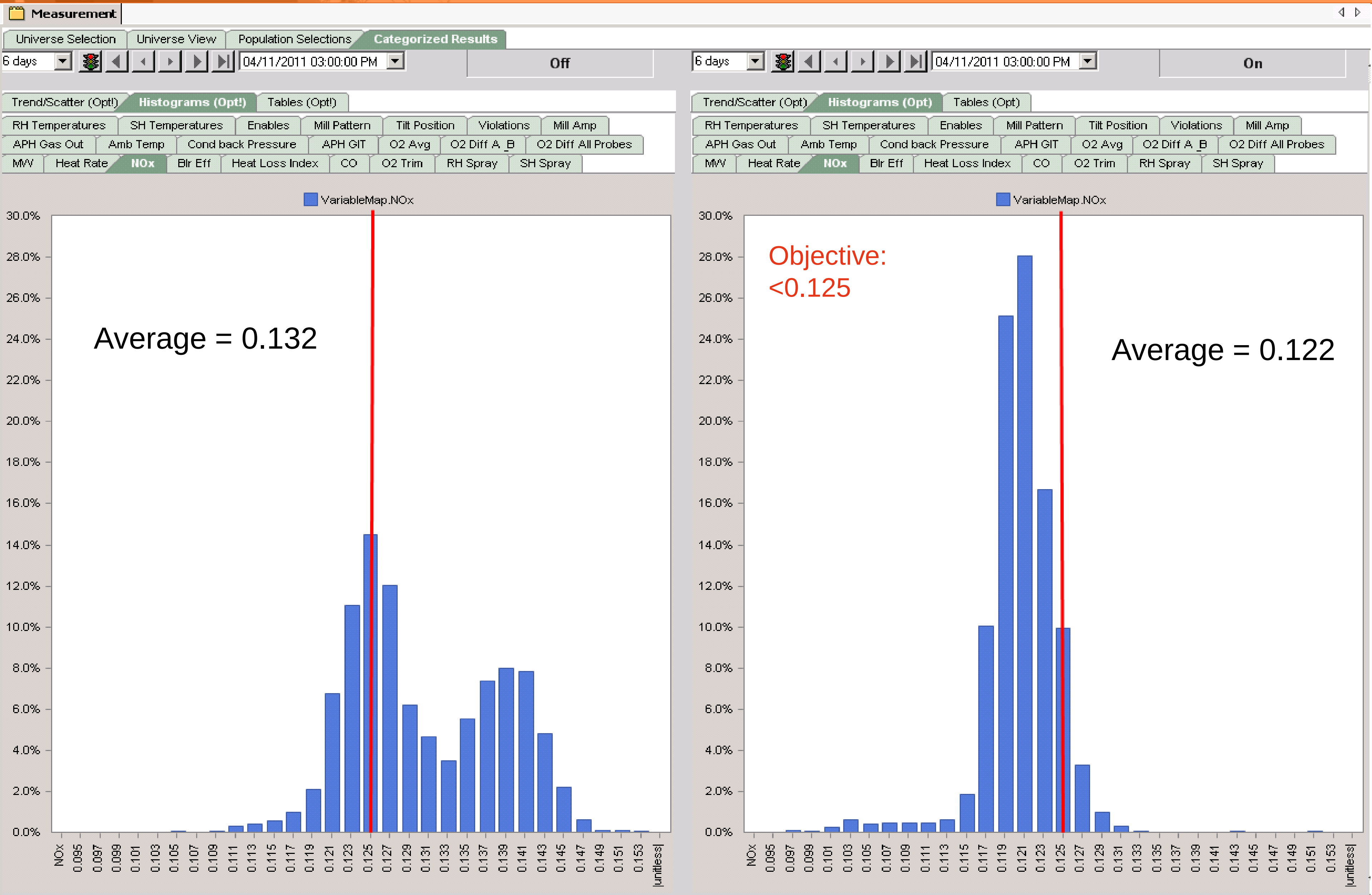
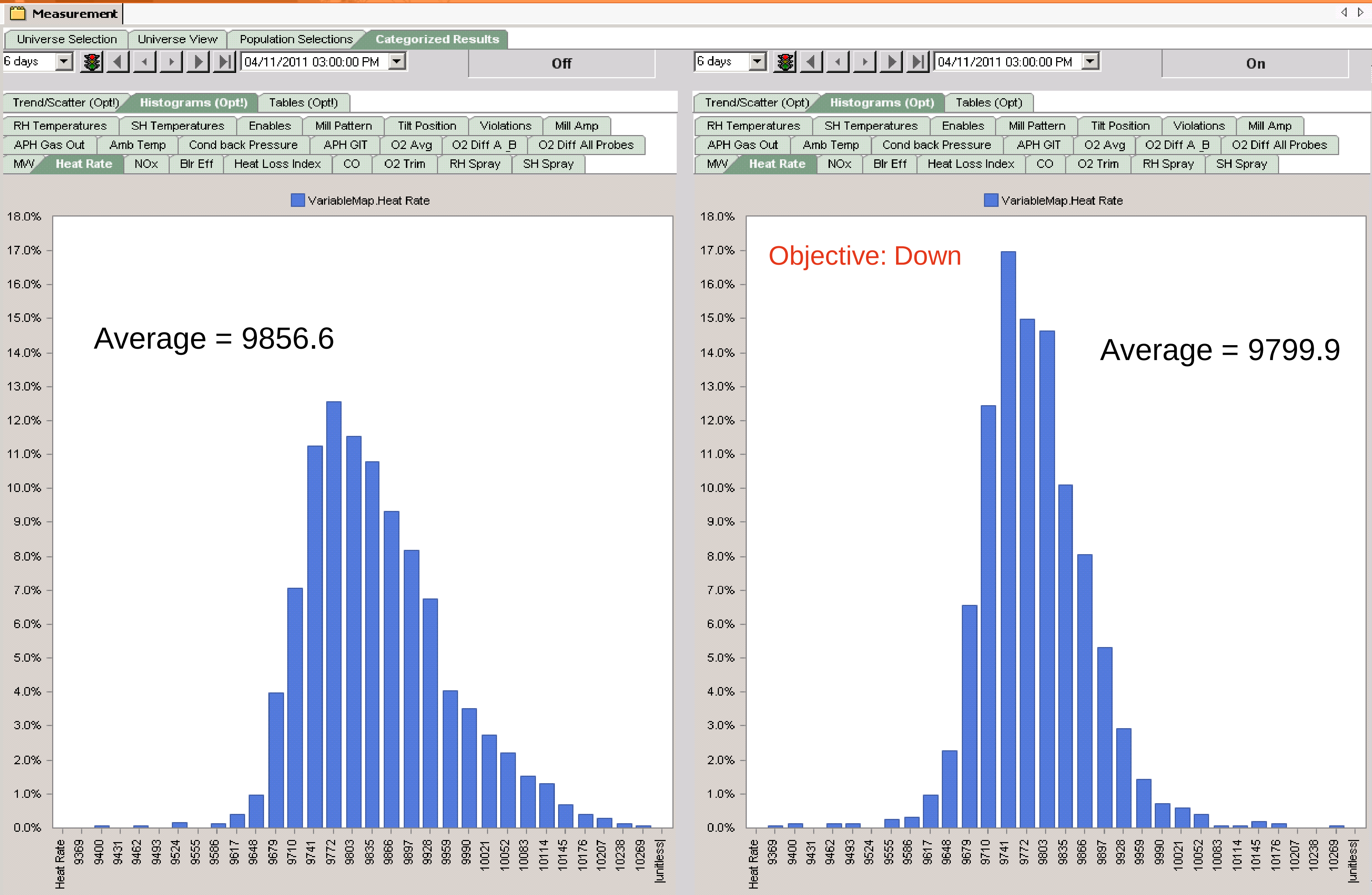
JK Spruce 1 BoilerOpt Benefits Summary April 2011 Analysis

- Heat Rate improvement of 0.5-1.0%
- Losses Boiler Efficiency of 0.13-0.78%
- NOx reduction of 4-8%
- Improved control of
  - O2 Average Minimum and Balance
  - APHGIT Max and Balance
  - SH and RH Sprays and Balance
  - SH and RH Temps and Balance
- Reduction in Blower Operations
  - Average 20%
  - No economizer tube leaks since SootOpt installed

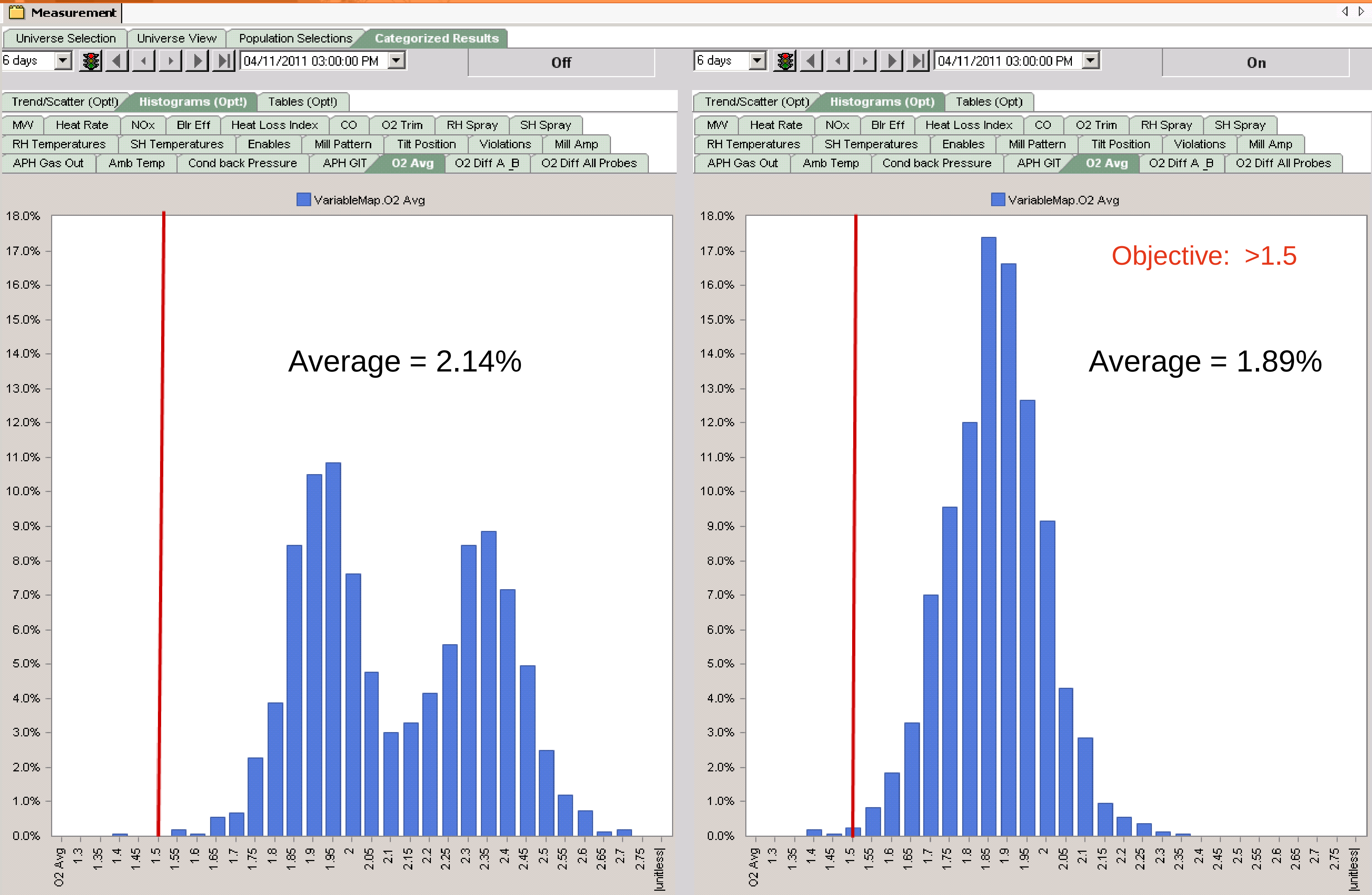
BoilerOpt Impact on Spruce 1 NOx



BoilerOpt Impact on Spruce 1 Heat Rate



BoilerOpt Impact on Spruce 1 O_2 Average



Spruce 1 BoilerOpt KPI Summary

Spruce Unit 1						
KPI	**Units**	**OFF**	**ON**	**Delta (ON - OFF)**	**Delta (%)**	**+/-**
Gross MW	MW	571.15	564.57			
Heat Rate	Btu/kWh	9661.32	9556.74	-104.58	-1.08%	✓
Blr Eff	%	83.99	84.77	0.78	0.93%	✓
NOx	#/MMBtu	0.127	0.121	-0.006	-4.72%	✓
CO	ppm	107.06	123.06	16	14.94%	✗
O2 Avg	%	2.277	1.912	-0.365	-16.03%	✓
RH Temp E	degF	1003.64	1003.88	0.24	0.02%	✓
RH Temp W	degF	1002.96	1003.33	0.37	0.04%	✓
RH Spray	klb/h	91.43	87.54	-3.89	-4.25%	✓
SH Temp E	degF	1003.26	1004.12	0.86	0.09%	✓
SH Temp W	degF	1000.16	1003.84	3.68	0.37%	✓
SH Spray	klb/h	14.9	21.89	6.99	46.91%	✗

Overall Xcel SPS Optimization Initiative

- Xcel SPS decided to adopt boiler optimization software (fuel-air and heat transfer components)
- Tested NeuCo's BoilerOpt® system at Tolk station early-mid 2009
- Applied to Harrington Unit 3 in October 2009
- Rolled out to Harrington Unit 2 and Unit 1
- Sootblowing optimization on Unit 1 was last component to be completed

BoilerOpt at Xcel Harrington

- Units 1, 2 and 3 similar units:
  - CE T-Fired boilers
  - 360 MW each
  - Often on AGC between 180 and 360
  - 5 Pulverizers
  - LNBs, CCOFA and SOFA
  - Foxboro I/A DCS
- Baghouses on U2 & U3
- ESP on U1

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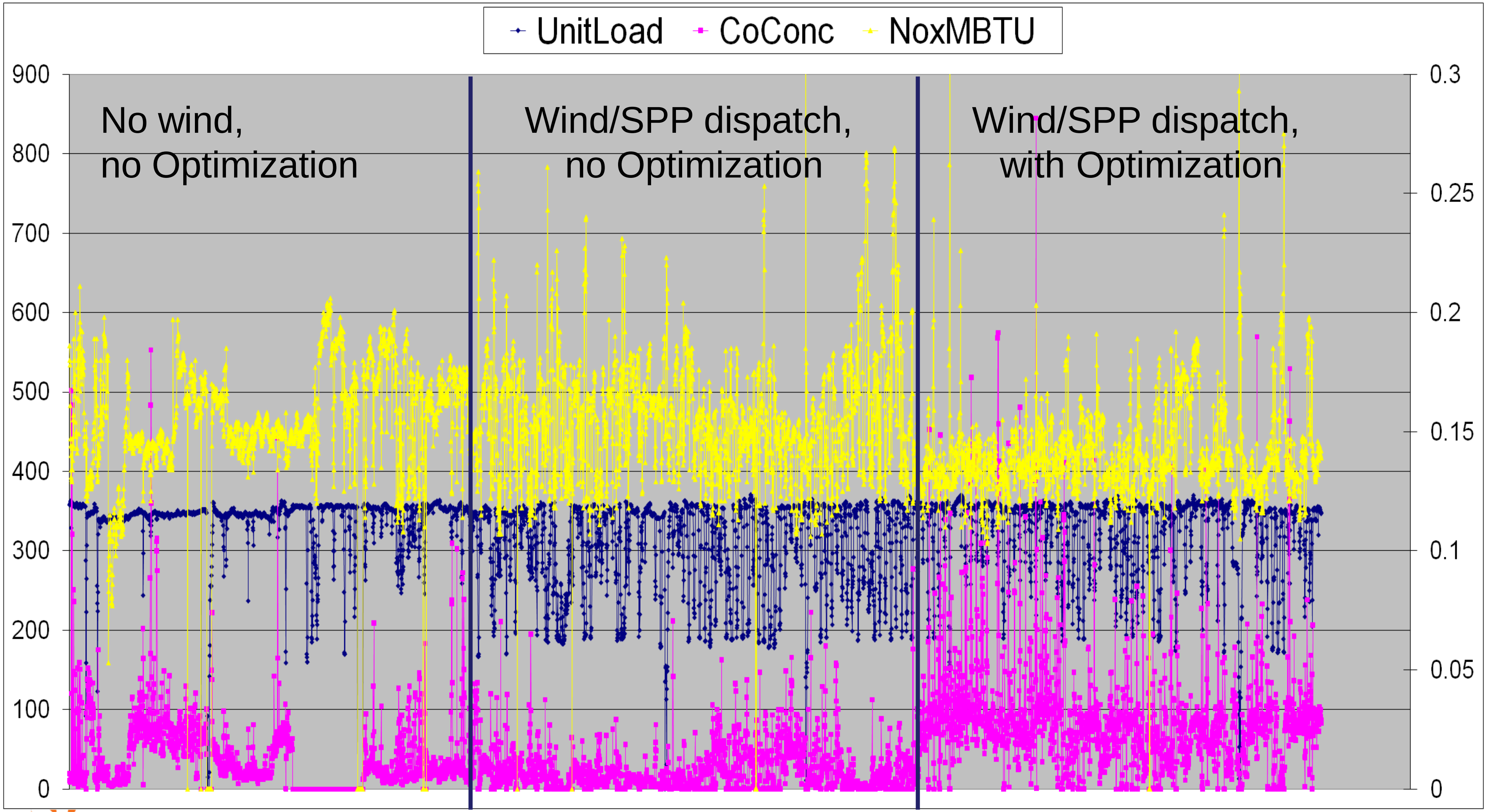
Harrington 3 Long-Term Trends



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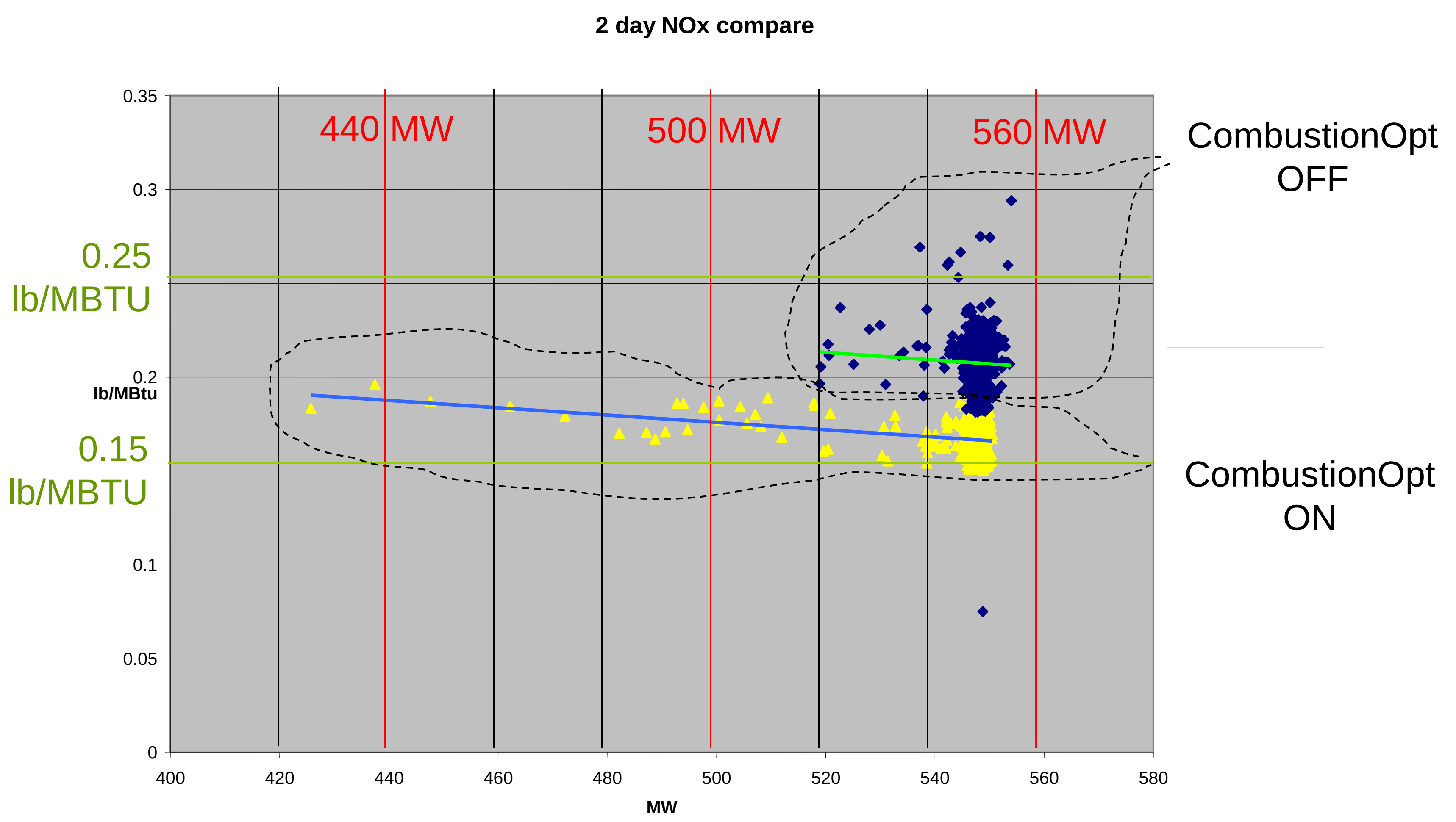
Harrington Benefits Summary: All Three Units

- NOx reductions 10-12%
- Improved consistency of operations both in Combustion and Sootblowing domains
  - Better balanced process, temps, sprays, CEMS, O2, CO
  - Fewer IR operations
  - Able to move load around with wind without CEMS penalty
  - More insight and awareness into what's going
  - Optimizers provide the tools to effect change in complex situation
  - Continuing to see improvement

Initial Tolk 2 CombustionOpt Results : NOx



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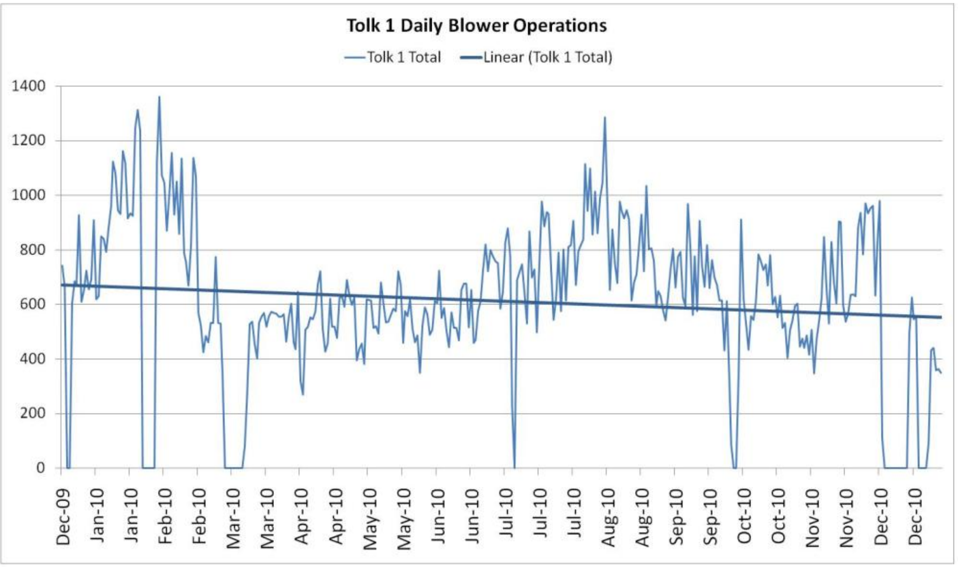
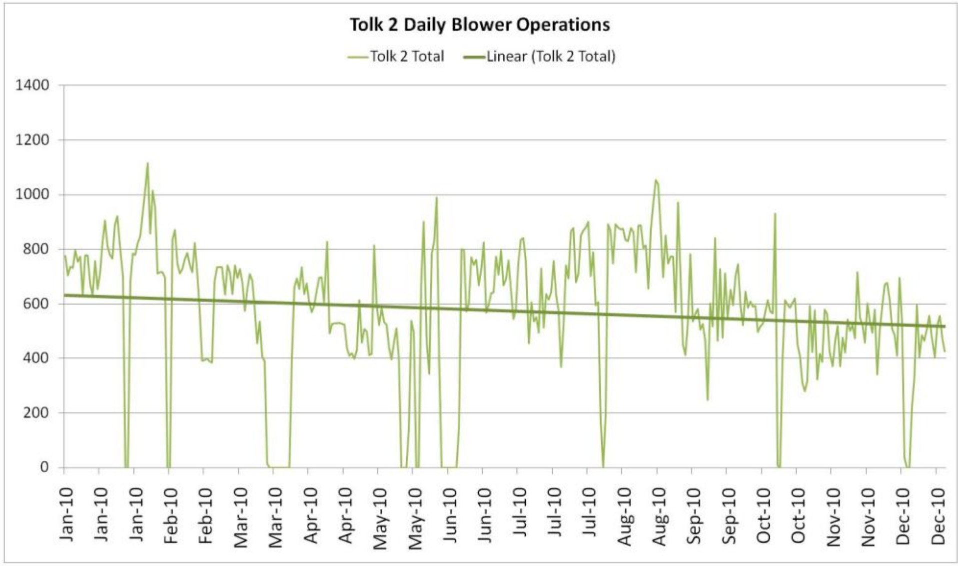
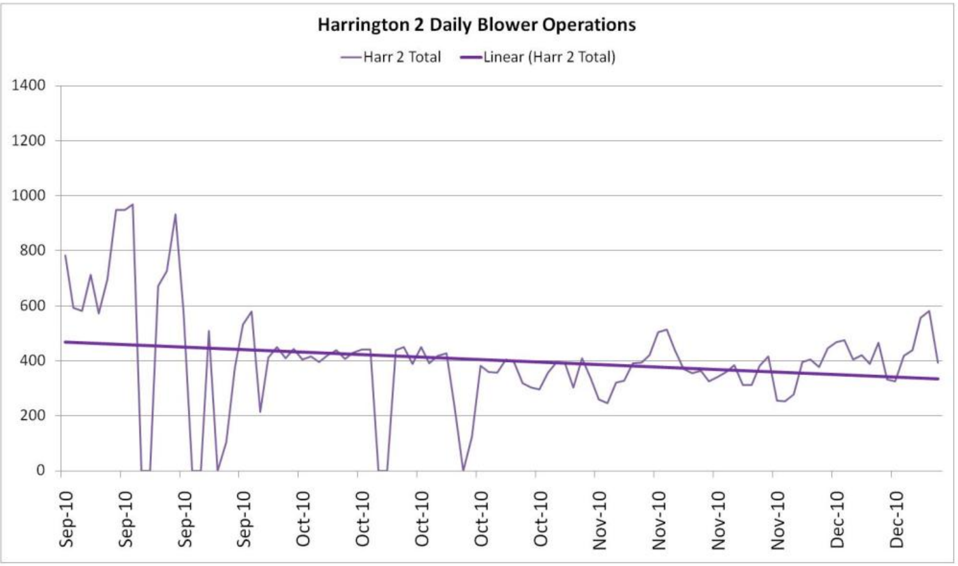
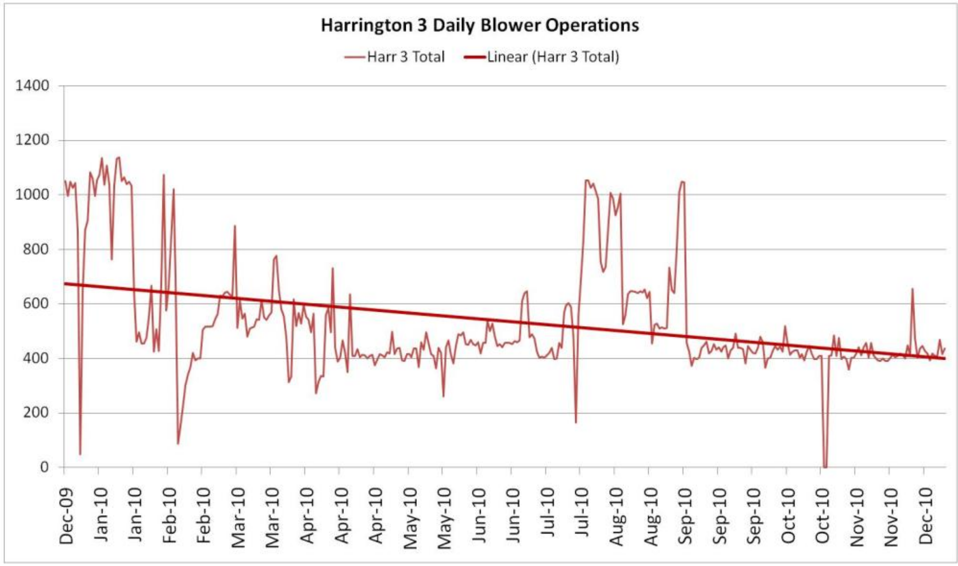
Tolk Blower Count Trends









Initial Results at Xcel Tolk 2: SootOpt

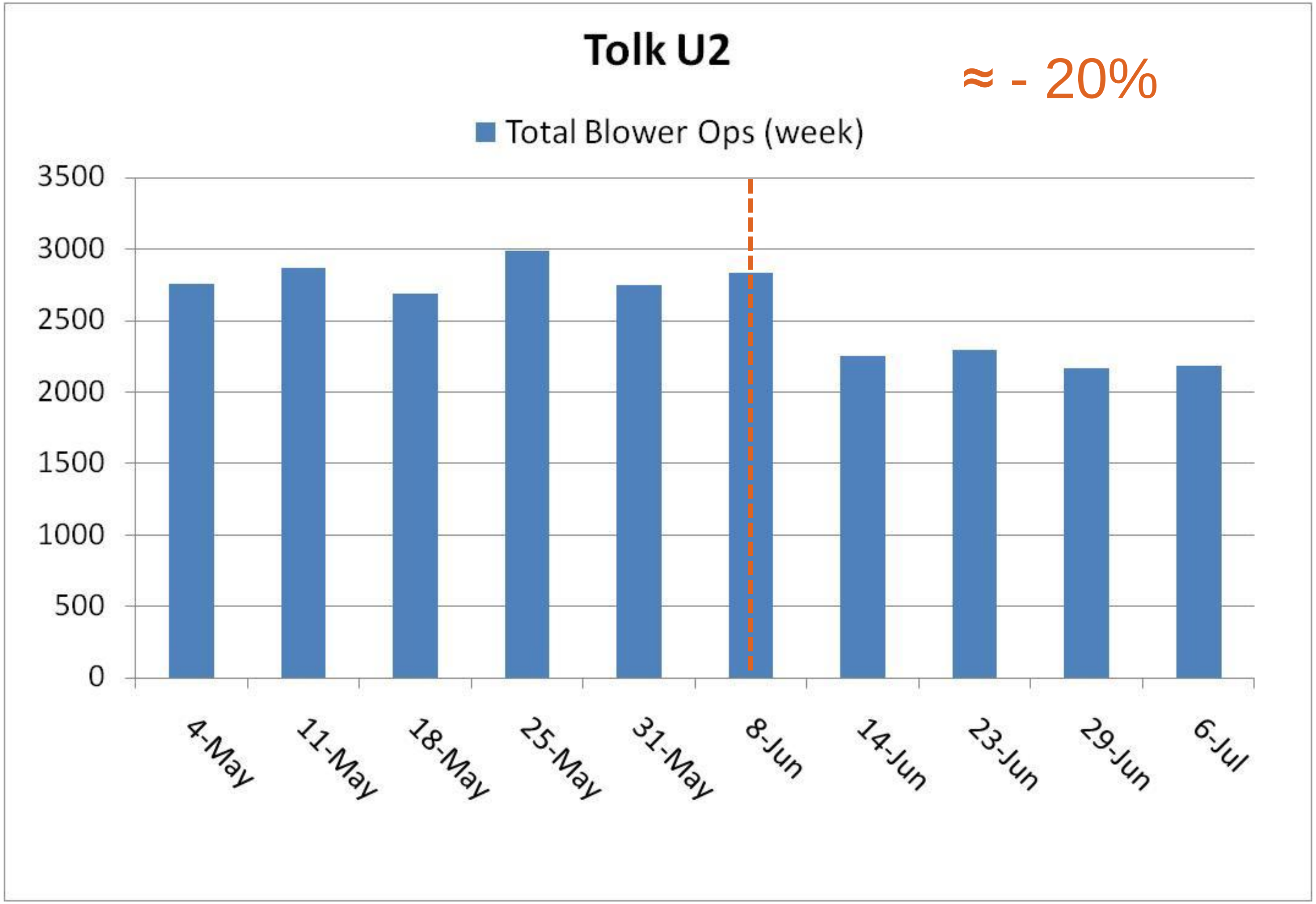
- Operators have less to worry about
  - Takes the right actions, consistently
- Changing MW profile not a problem
- SH & RH temps better balanced
- Attemperation sprays significantly reduced
- Air Preheater gas inlet temps significantly reduced
- Boiler Efficiency increased

Continuous Improvement
Xcel Tolk example

Using new knowledge

- After reviewing the results and our recommendations with plant
  - Adjustments were made to the existing Zone/blower map in SootOpt to account for blowers affecting both RH and Platen sections.
  - Adjustment were made to deal with a cross-over between DivSH and PlatenSH that had a noticeable effect
  - Adjusted existing rules and thresholds
  - Added rules that inhibit cleaning when section deltaTemp is at or above it's normal mean, given operating conditions
  - [Next] Add rules that propose cleaning when section deltaTemp is sufficiently below it's normal mean

Recent Results: Blower Counts



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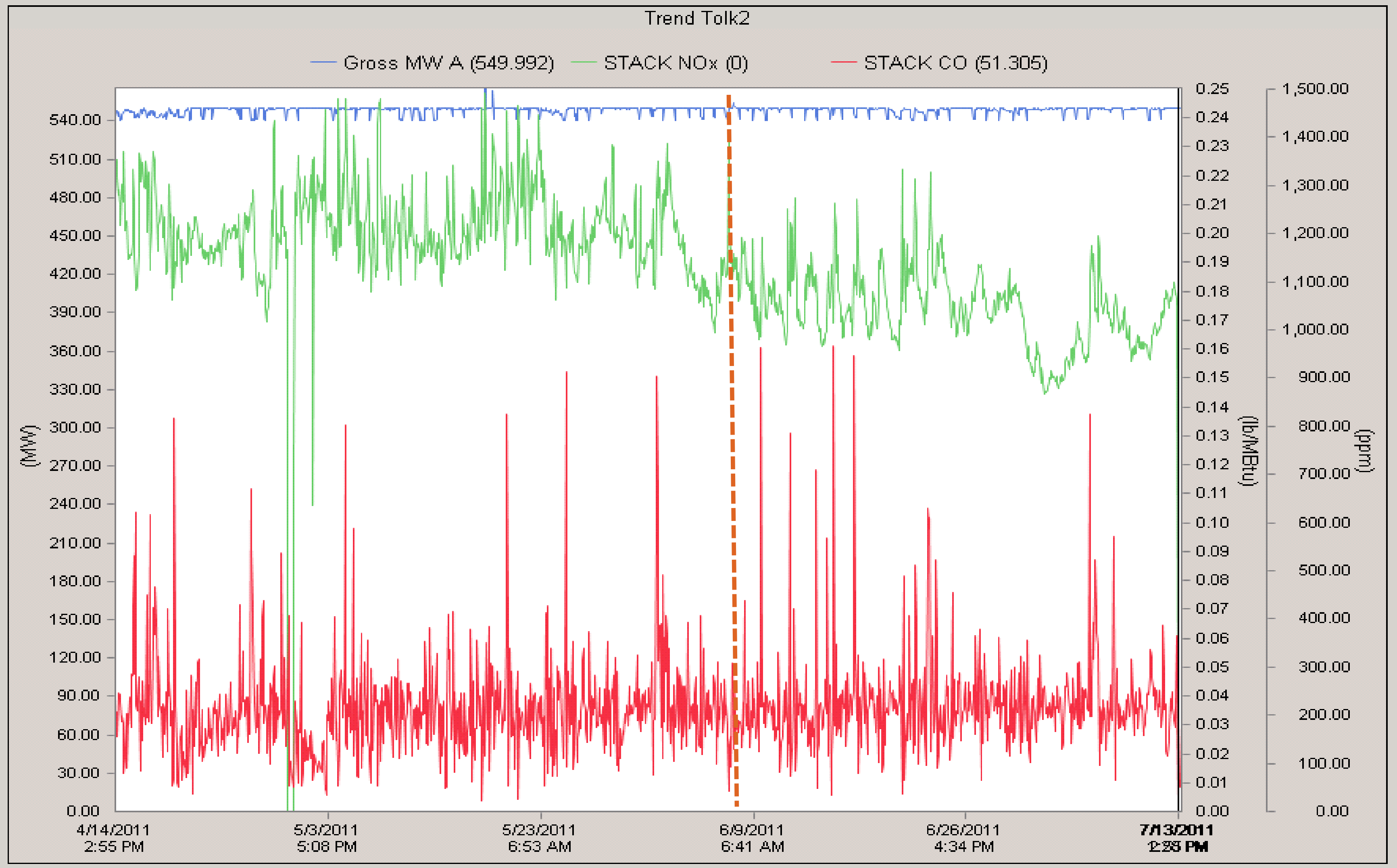
Recent Results: NOx, CO



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Recent Results: RH Temps

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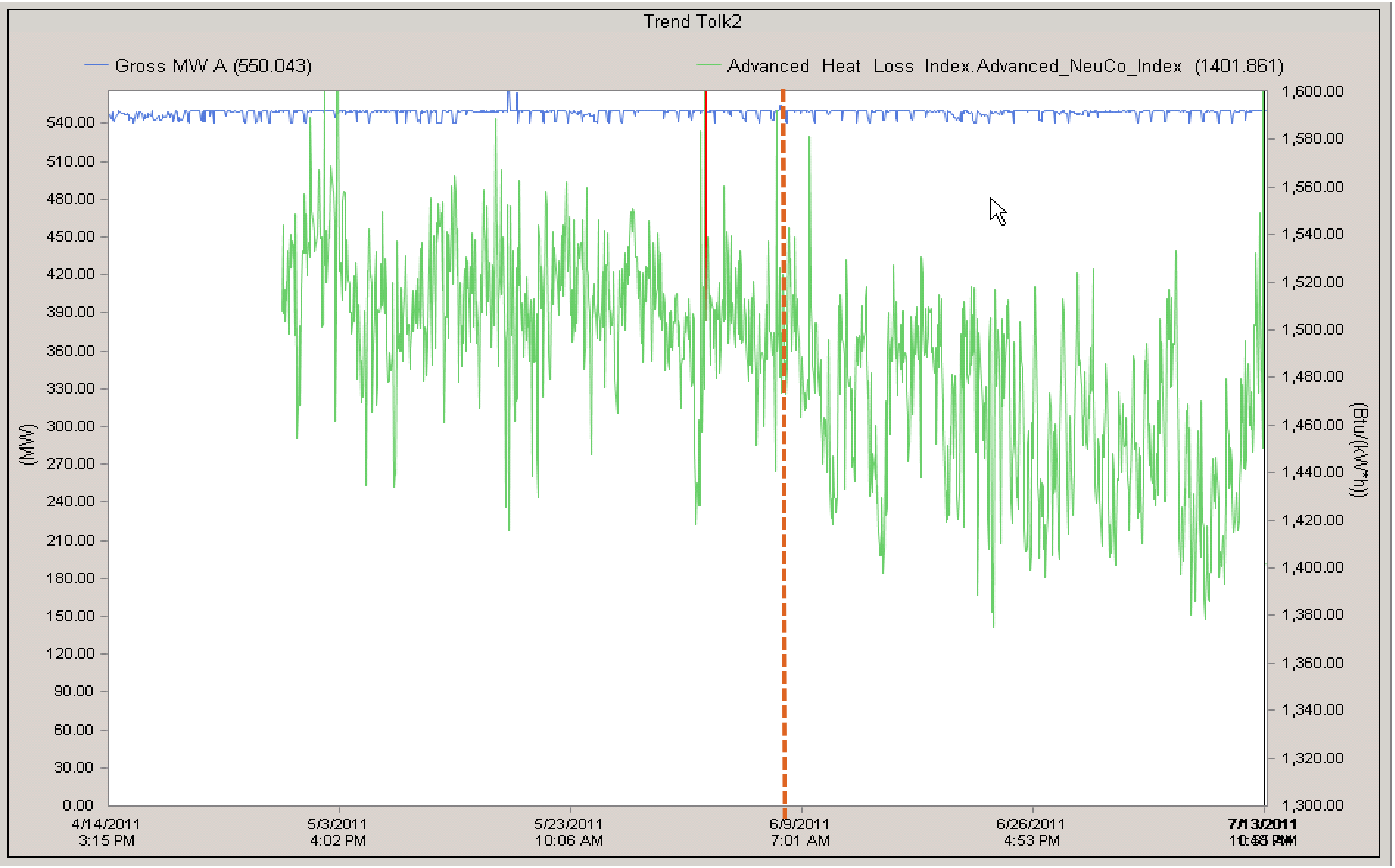
Recent Results: Heat Loss Index



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SCR/SNCR Systems & Optimization

- Reduce Reagent Usage
- Lengthen Maintenance Intervals
- Avoid Ammonia Slip
- Reduce risk of Ammonium Bisulfate & Sulfur Trioxide deposits
- Control "Blue-Plume" Opacity Excursions
- Tighter, condition-based gas temperature control
- Better Manage System Interactions

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Boiler Optimization for Improving SCR Operations

- Challenge: to operate boiler with acceptable SCR performance under changing operating conditions
  - Acceptable NOx removal levels
  - Minimizing NH_3 usage and slip
  - Avoiding SO3-related issues (visible plume, air heater fouling)
- CombustionOpt
  - Lower, more balanced NOx profile at SCR inlet
  - Compensating for local catalyst degradation or fouling
  - Less & more balanced NOx = less close to SCR design limits
- SootOpt
  - Better control of temperatures throughout the gas path
  - Sootblowing informed my load, gas temps, NOx, etc.
  - Tighter control keeps temps within window needed by SCR
  - Avoiding temp excursions on high side reduces SO2=>SO3 conversion rate and associated side-effects

Indirect Optimization Benefits

- Process Illumination
- Tradeoff Management
- Expertise Codification
- KPI-Focused Workflow
- Analysis & Decision Support
- Set-Point Refinement
- Dynamic Uncertainty Management

Breadth, Depth, and Flexibility

- Optimization can provide benefits in all these areas:
  - Heat Rate – NOx – MW – Commercial Availability
  - CO_2 – Opacity – SO_2 – Equipment Reliability
  - LOI – Particulates – Hg – Steam Temps
  - CO – Ramp Rates – NH_3 usage – Attemperation Sprays
  - Aux Power – Operational Consistency – Slagging & Fouling
- Maximum benefits can only be achieved with an integrated platform approach
- Platform designed for fleet-wide application, where benefits can be realized in manner best suited to differing organizations
  - Plant use
  - Centralized "war room"
  - Tailored service offering
  - Any combination of these

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Questions?

Contact Information

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