Reinhold Environmental Ltd.

2010 NOx-Combustion Round Table & Expo Presentation

February 8 & 9, 2010   Chattanooga, TN

Boiler Combustion Advancements

Ray Johnson

Reinhold NOx Conference
Chattanooga, TN
February 8, 2010

NeuCo

The Optimization Standard™

ProcessLink®

Agenda

- Review of ProcessLink & solutions
- Review traditional combustion optimization results
- Introduce alternative combustion optimization benefits
- Discuss comprehensive boiler optimization

NeuCo's ProcessLink® Platform

- ProcessLink is the optimization technology platform upon which all NeuCo optimizers are built:
  - Utilizes multiple modeling and optimization techniques to deliver superior results
  - Supports optimizer integration and action coordination

A Platform for Holistic Optimization

- Enterprise Data Management
  - Integrate from any source
  - Validate and replace if necessary
  - Aggregate and manage calculations
- Hybrid Modeling Methods
  - First-Principles: Proven equations to represent a process
  - Neural Networks/MPC: Start with data and learn relationships
  - Heuristics: Represent knowledge in the form of situation-action rules
- Integrated Optimization Engine
  - Coordinate local decisions based on global impact
  - Action-Centric Portals
  - Present actionable knowledge to people
  - Allow user to drill-down all of the details upon which the knowledge is based

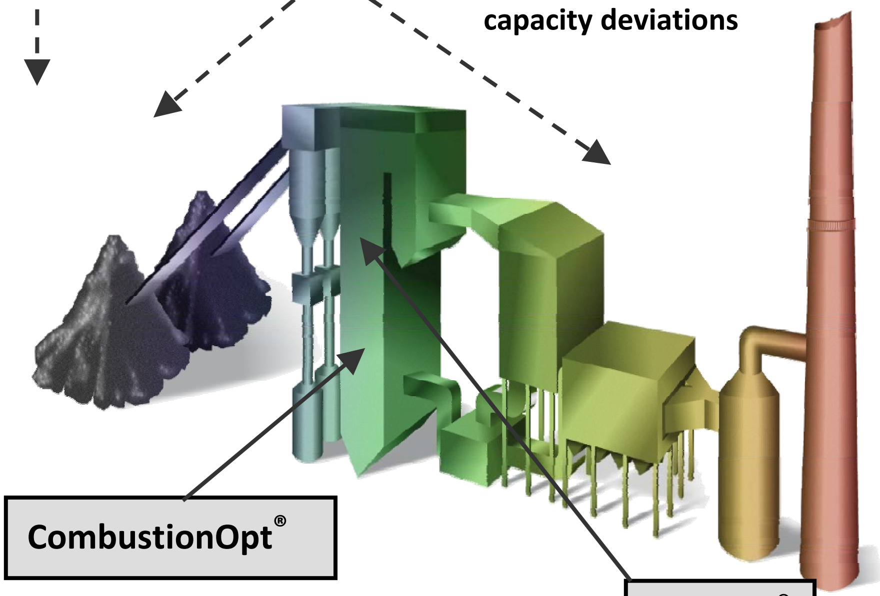
NeuCo Optimization Suite

MaintenanceOpt®

Alerts user to potential equipment health issues and expedites problem diagnosis

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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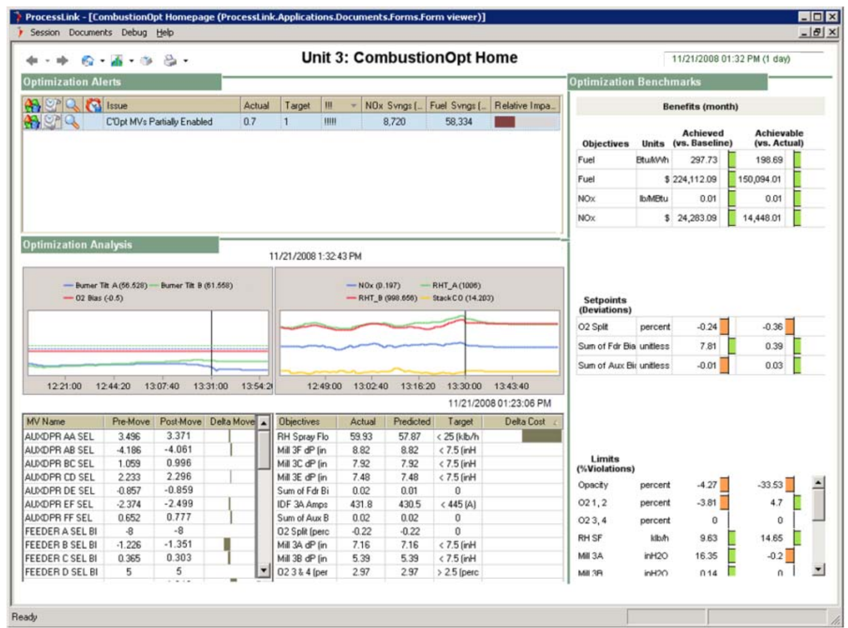
The Optimization Standard™

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)



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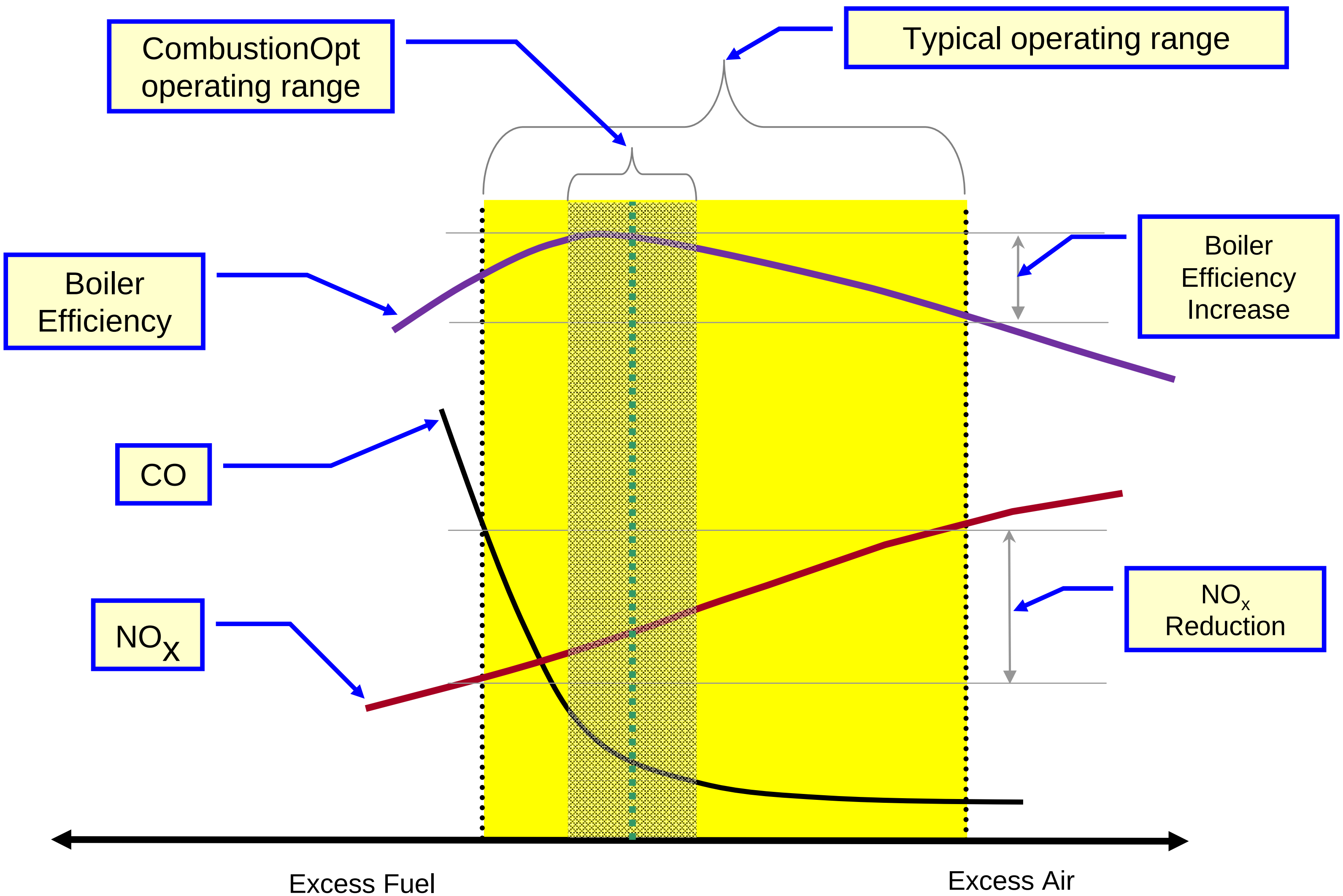
CombustionOpt Optimization



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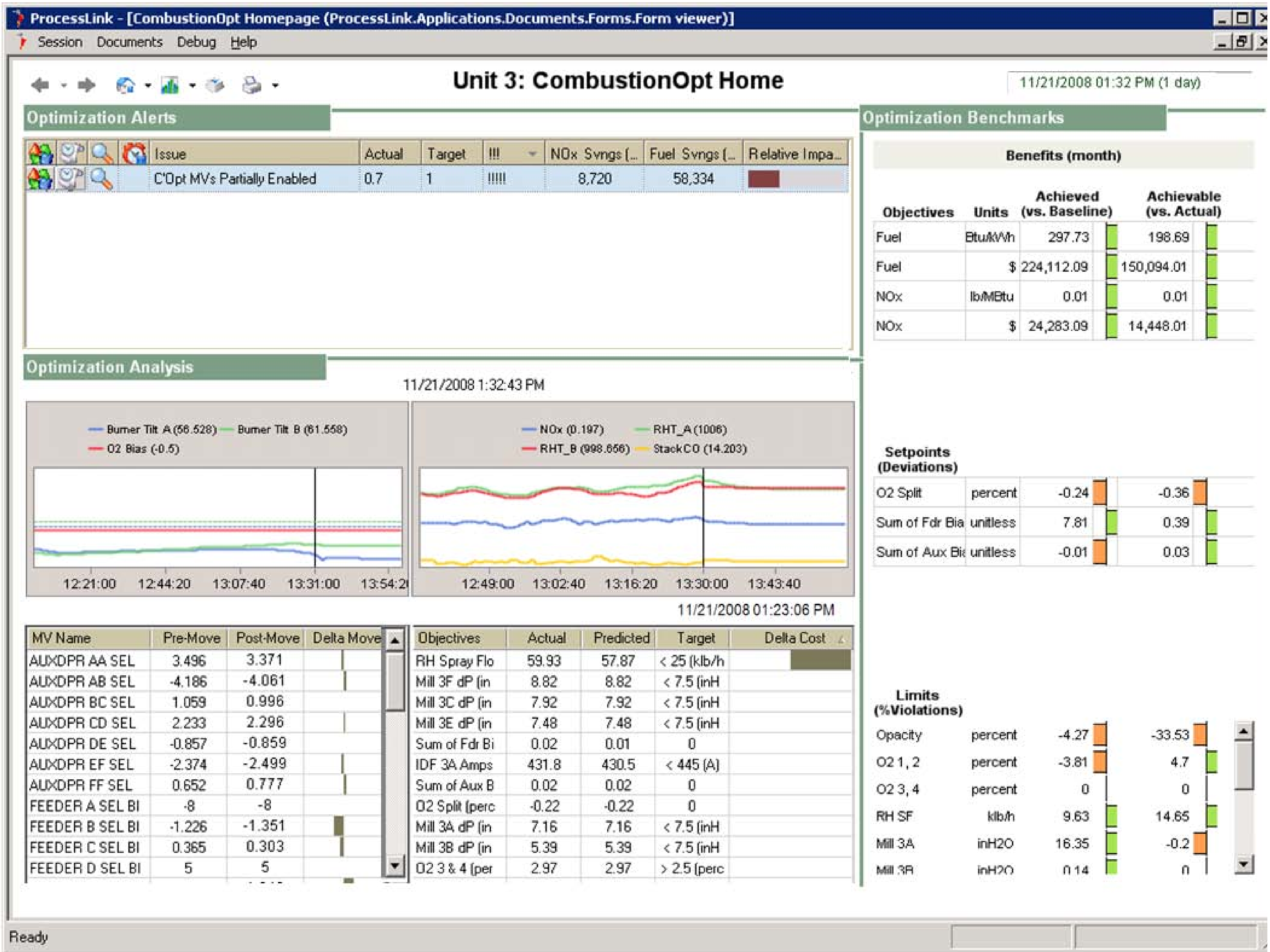
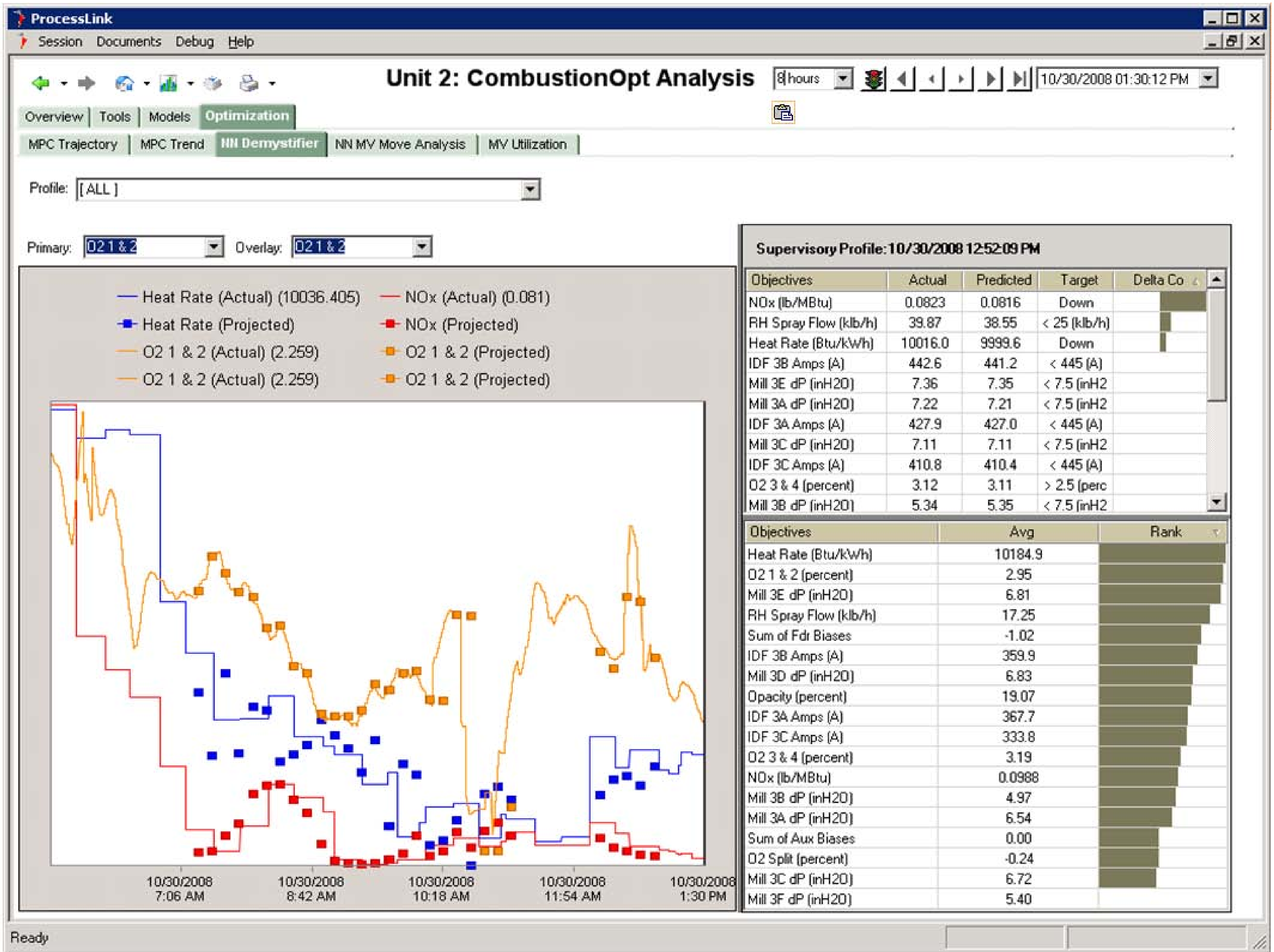
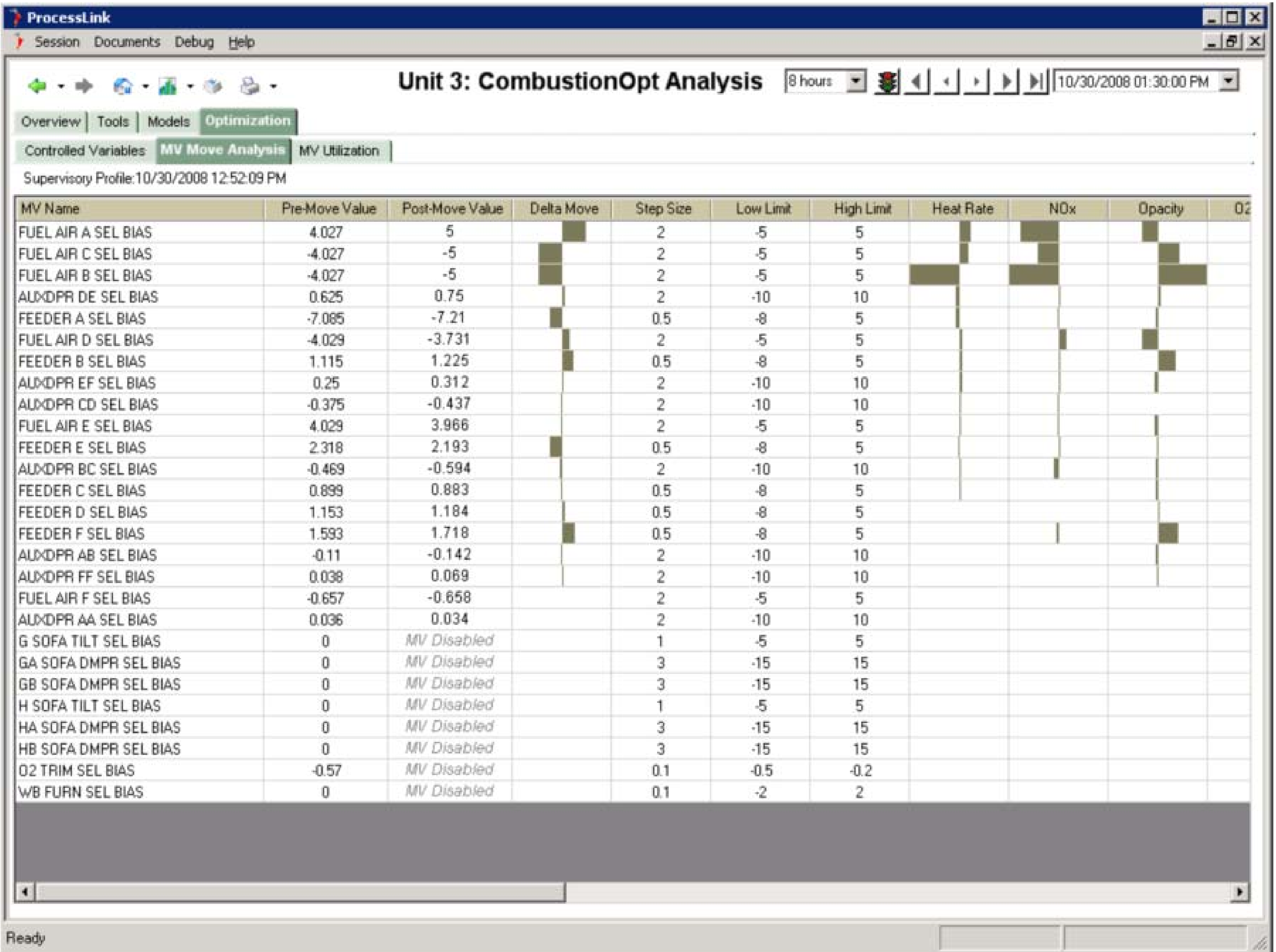

ProcessLink - [CombustionOpt Homepage (ProcessLink.Applications.Documents.Forms.Form viewer)]
Session Documents Debug Help
Unit 3: CombustionOpt Home
11/21/2008 01:32 PM (1 day)
Optimization Alerts
Issue Actual Target !!! NOx Svngs (... Fuel Svngs (... Relative Impa...
C'Opt MVs Partially Enabled 0.7 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) StackCO (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


ProcessLink
Session Documents Debug Help
Unit 2: CombustionOpt Analysis
8 hours
10/30/2008 01:30:12 PM
Overview
Tools
Models
Optimization
MPC Trajectory
MPC Trend
NN Demystifier
NN MV Move Analysis
MV Utilization
Profile: [ALL]
Primary: O2 1 & 2
Overlay: O2 1 & 2
Heat Rate (Actual) (10036.405)
NOx (Actual) (0.081)
Heat Rate (Projected)
NOx (Projected)
O2 1 & 2 (Actual) (2.259)
O2 1 & 2 (Projected)
O2 1 & 2 (Actual) (2.259)
O2 1 & 2 (Projected)
10/30/2008 7:06 AM
10/30/2008 8:42 AM
10/30/2008 10:18 AM
10/30/2008 11:54 AM
10/30/2008 1:30 PM
Supervisory Profile: 10/30/2008 12:52:09 PM
Objectives | Actual | Predicted | Target | Delta Co
NOx (lb/MBtu) | 0.0823 | 0.0816 | Down
RH Spray Flow (klb/h) | 39.87 | 38.55 | < 25 (klb/h)
Heat Rate (Btu/kWh) | 10016.0 | 9999.6 | Down
IDF 3B Amps (A) | 442.6 | 441.2 | < 445 (A)
Mill 3E dP (inH2O) | 7.36 | 7.35 | < 7.5 (inH2
Mill 3A dP (inH2O) | 7.22 | 7.21 | < 7.5 (inH2
IDF 3A Amps (A) | 427.9 | 427.0 | < 445 (A)
Mill 3C dP (inH2O) | 7.11 | 7.11 | < 7.5 (inH2
IDF 3C Amps (A) | 410.8 | 410.4 | < 445 (A)
O2 3 & 4 (percent) | 3.12 | 3.11 | > 2.5 (perc
Mill 3B dP (inH2O) | 5.34 | 5.35 | < 7.5 (inH2
Objectives | Avg | Rank
Heat Rate (Btu/kWh) | 10184.9
O2 1 & 2 (percent) | 2.95
Mill 3E dP (inH2O) | 6.81
RH Spray Flow (klb/h) | 17.25
Sum of Fdr Biases | -1.02
IDF 3B Amps (A) | 359.9
Mill 3D dP (inH2O) | 6.83
Opacity (percent) | 19.07
IDF 3A Amps (A) | 367.7
IDF 3C Amps (A) | 333.8
O2 3 & 4 (percent) | 3.19
NOx (lb/MBtu) | 0.0988
Mill 3B dP (inH2O) | 4.97
Mill 3A dP (inH2O) | 6.54
Sum of Aux Biases | 0.00
O2 Split (percent) | -0.24
Mill 3C dP (inH2O) | 6.72
Mill 3F dP (inH2O) | 5.40
Ready

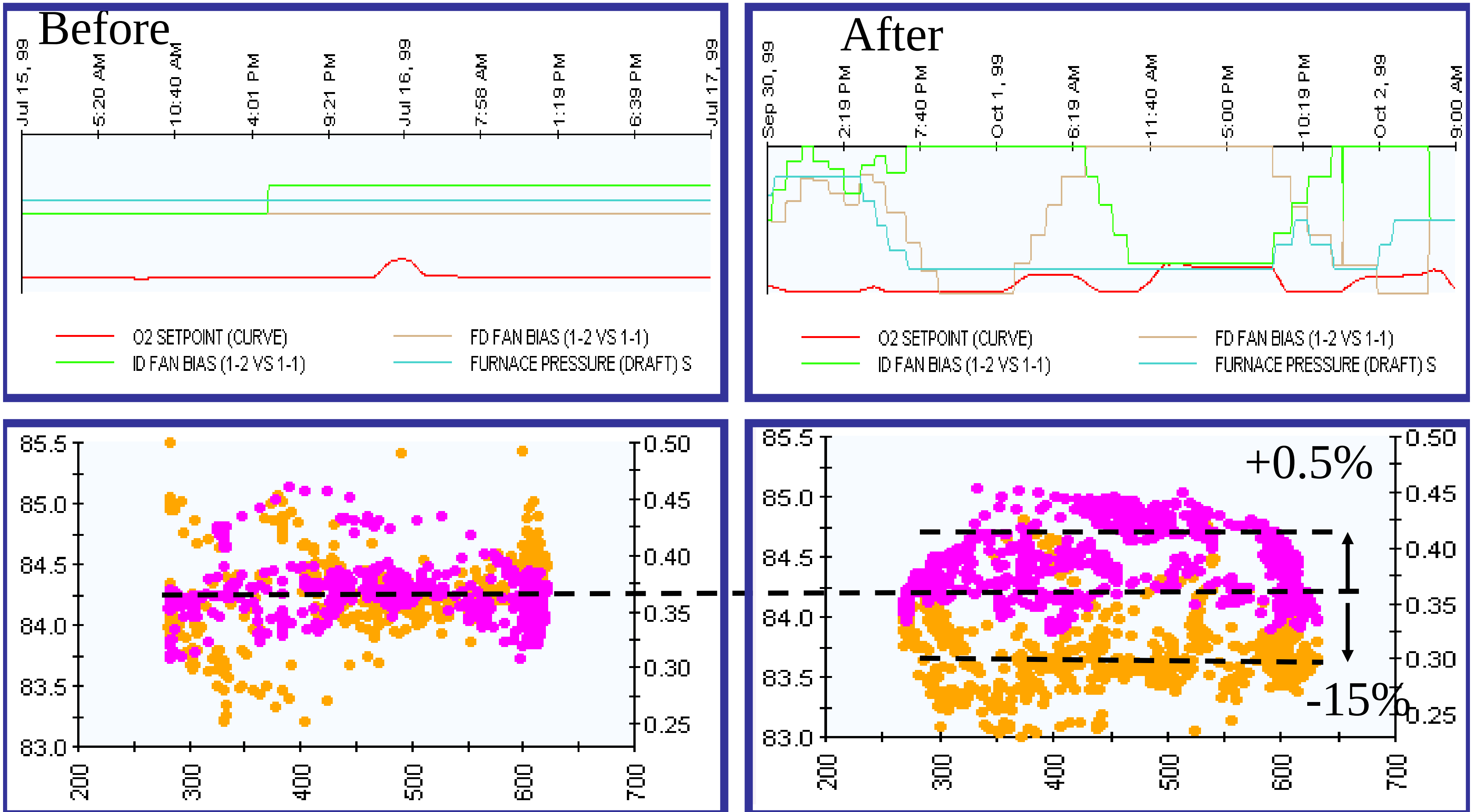


MV Name	Pre-Move Value	Post-Move Value	Delta Move	Step Size	Low Limit	High Limit	Heat Rate	NOx	Opacity	O2
FUEL AIR A SEL BIAS	4.027	5		2	-5	5				
FUEL AIR C SEL BIAS	-4.027	-5		2	-5	5				
FUEL AIR B SEL BIAS	-4.027	-5		2	-5	5				
AUXDPR DE SEL BIAS	0.625	0.75		2	-10	10				
FEEDER A SEL BIAS	-7.085	-7.21		0.5	-8	5				
FUEL AIR D SEL BIAS	-4.029	-3.731		2	-5	5				
FEEDER B SEL BIAS	1.115	1.225		0.5	-8	5				
AUXDPR EF SEL BIAS	0.25	0.312		2	-10	10				
AUXDPR CD SEL BIAS	-0.375	-0.437		2	-10	10				
FUEL AIR E SEL BIAS	4.029	3.966		2	-5	5				
FEEDER E SEL BIAS	2.318	2.193		0.5	-8	5				
AUXDPR BC SEL BIAS	-0.469	-0.594		2	-10	10				
FEEDER C SEL BIAS	0.899	0.883		0.5	-8	5				
FEEDER D SEL BIAS	1.153	1.184		0.5	-8	5				
FEEDER F SEL BIAS	1.593	1.718		0.5	-8	5				
AUXDPR AB SEL BIAS	-0.11	-0.142		2	-10	10				
AUXDPR FF SEL BIAS	0.038	0.069		2	-10	10				
FUEL AIR F SEL BIAS	-0.657	-0.658		2	-5	5				
AUXDPR AA SEL BIAS	0.036	0.034		2	-10	10				
G SOFA TILT SEL BIAS	0	MV Disabled		1	-5	5				
GA SOFA DMPR SEL BIAS	0	MV Disabled		3	-15	15				
GB SOFA DMPR SEL BIAS	0	MV Disabled		3	-15	15				
H SOFA TILT SEL BIAS	0	MV Disabled		1	-5	5				
HA SOFA DMPR SEL BIAS	0	MV Disabled		3	-15	15				
HB SOFA DMPR SEL BIAS	0	MV Disabled		3	-15	15				
O2 TRIM SEL BIAS	-0.57	MV Disabled		0.1	-0.5	-0.2				
WB FURN SEL BIAS	0	MV Disabled		0.1	-2	2				

NRG Big Cajun II Case Study

- Asset: Three 600 MW coal-fired units (Riley Turbo and B&W Opposed)
- Stage 1: Combustion Optimization on Two Units
  - CombustionOpt® on Units 1 & 2
- Stage 2: Combustion Optimization Expansion
  - Added manipulated variables available via the addition of new NOx control hardware installed at Units 1 and 2
  - Installed CombustionOpt at Unit 3
- Stage 3: Real-Time Performance Management & Combustion Optimization Upgrades
  - Upgrading CombustionOpt on all three units
  - PerformanceOpt® on all three units
  - MaintenanceOpt planned for this coming year

Impact on Operations & Performance



Boiler Efficiency NOx

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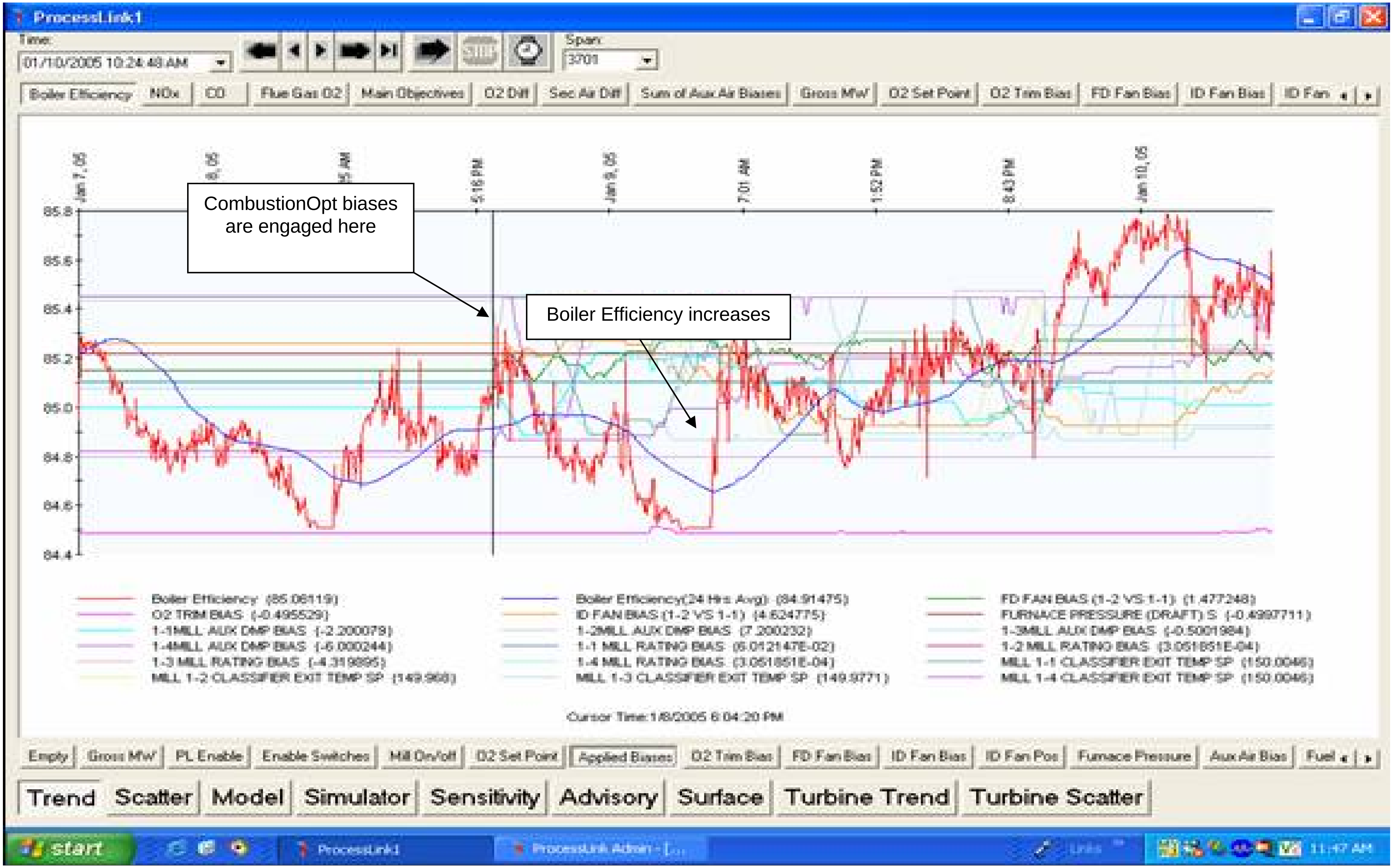
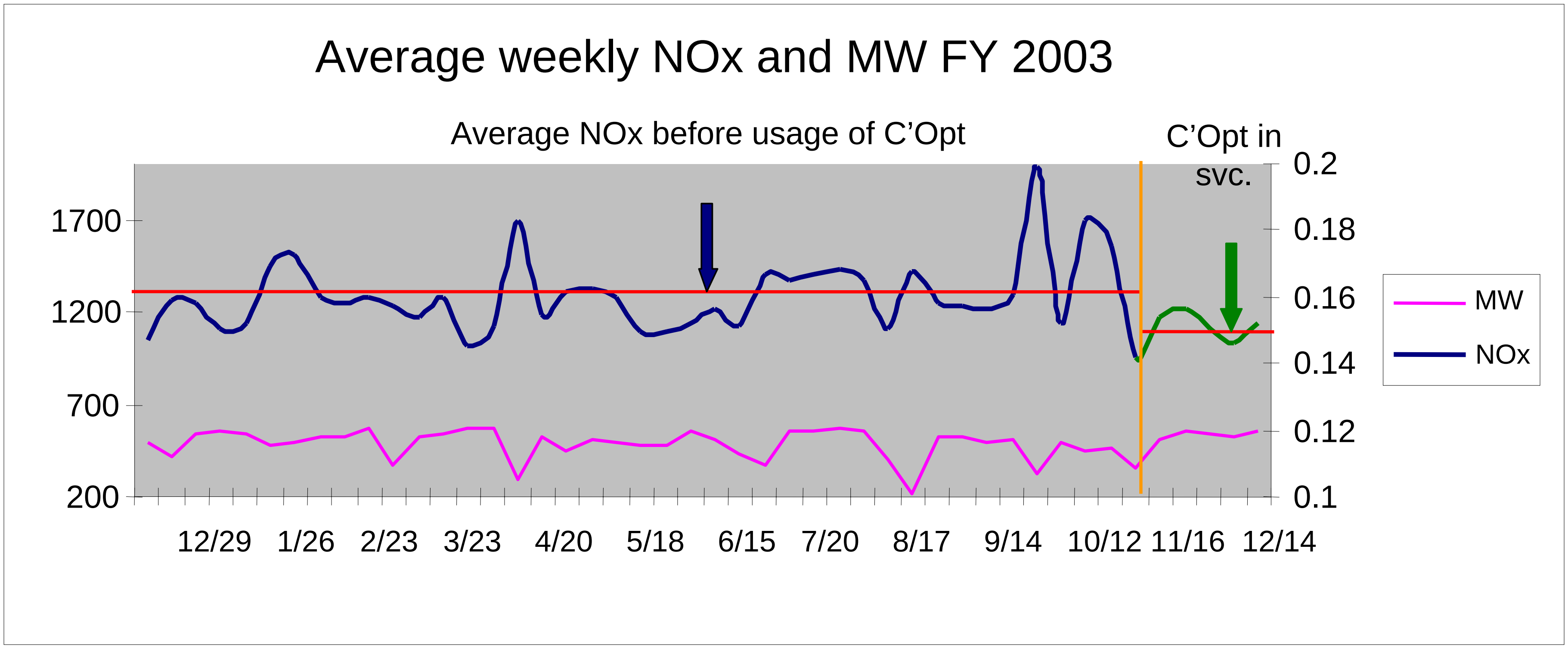
BC-II Unit 1 Five Years Later (1/1/05)



Initial Unit 3 (B&W Opposed) Results

- 10% NOx reduction
- 0.55% heat rate improvement



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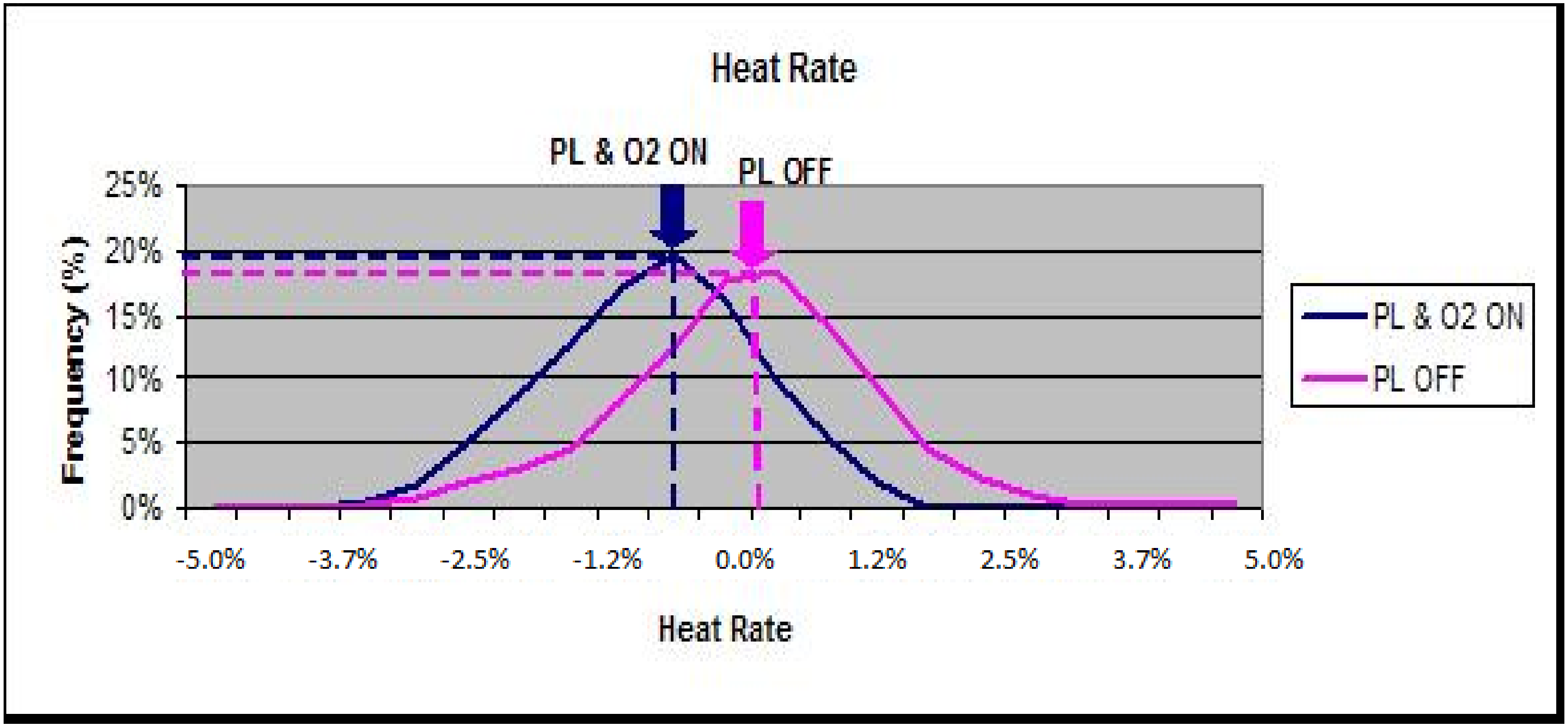
Initial BC-II Unit 3 Heat Rate Improvement



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Initial Impact on Unit 3 Avg O_2 & CO

	Average O2			
	450-500	500-530	530-550	550-605
PL & O2 = ON	2.296	2.170	2.096	2.014
PL = ON O2 = OFF	2.563	2.415	2.295	2.084
PL = OFF	2.615	2.479	2.383	2.013
PL & O2 ON vs PL OFF	-12.22%	-12.47%	-12.05%	0.03%

	Average CO			
	450-500	500-530	530-550	550-605
PL & O2 = ON	109.9998507	171.299547	243.0881189	237.2359043
PL = ON O2 = OFF	219.5955206	268.7387142	300.3420735	352.5672106
PL = OFF	154.3105887	193.9514151	253.8182942	373.9144061
PL & O2 ON vs PL OFF	-28.72%	-11.68%	-4.23%	-36.55%

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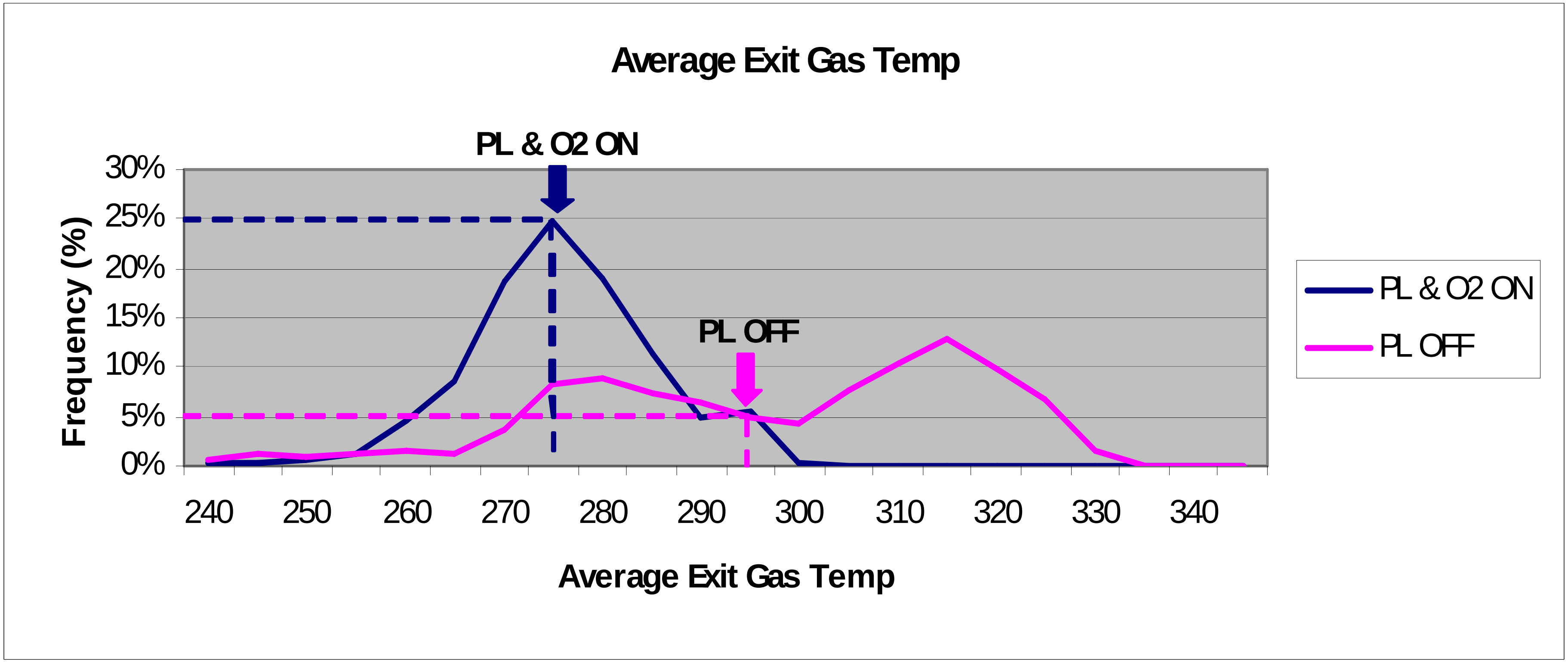
Initial Unit 3 Exit Gas Temperature Impact



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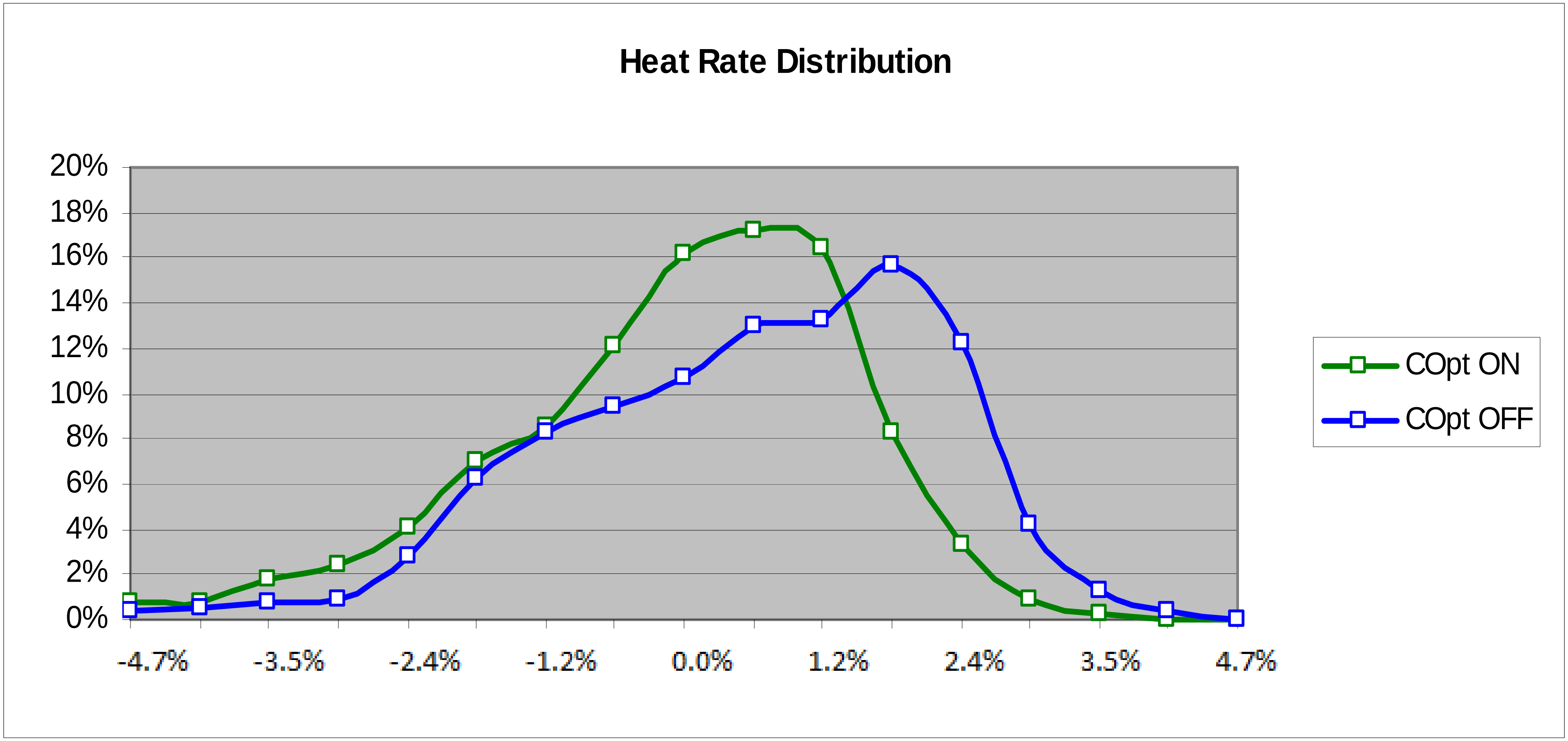
On vs. Off Freq Dist for 2008 Unit 3 HR



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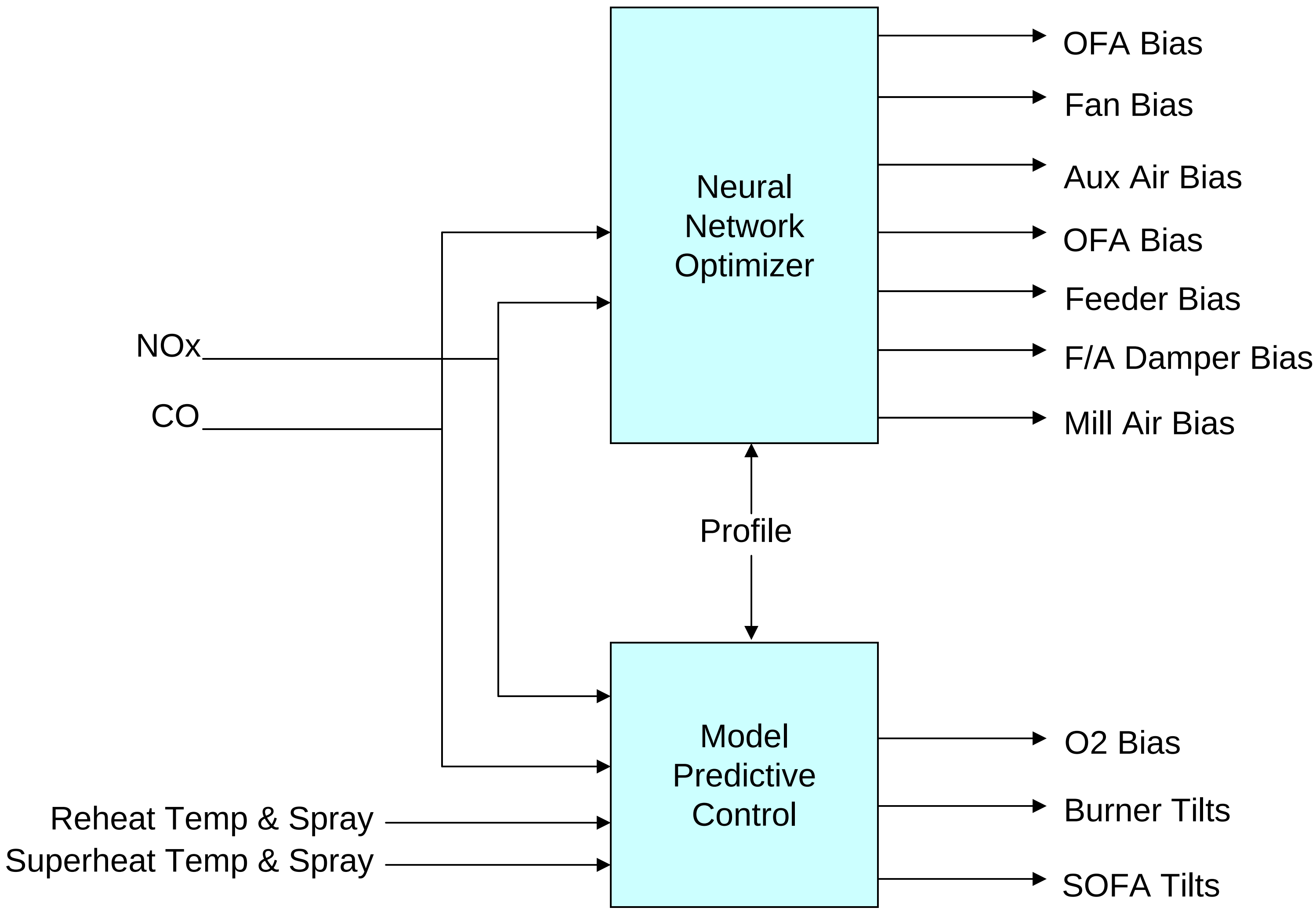
CombustionOpt at CPS Energy

- CombustionOpt on all coal-fired units
  - Spruce: 546 MW CE t-fired w/Ovation DCS
  - Deely: 2 x 446 MW CE t-fired w/Honeywell DCS
- First installed at Spruce in 2001
- Installed at both Deely units in 2004
- Primary objective is NOx
- Model predictive control (MPC) added in 2007
- Additional objectives addressed through MPC
  - Explicit steam temperature control
  - Minimize attemperation sprays
  - Incremental heat rate and NOx reduction

CombustionOpt at CPS Deely 1-2



Pre-Zolo CombustionOpt Deely Results

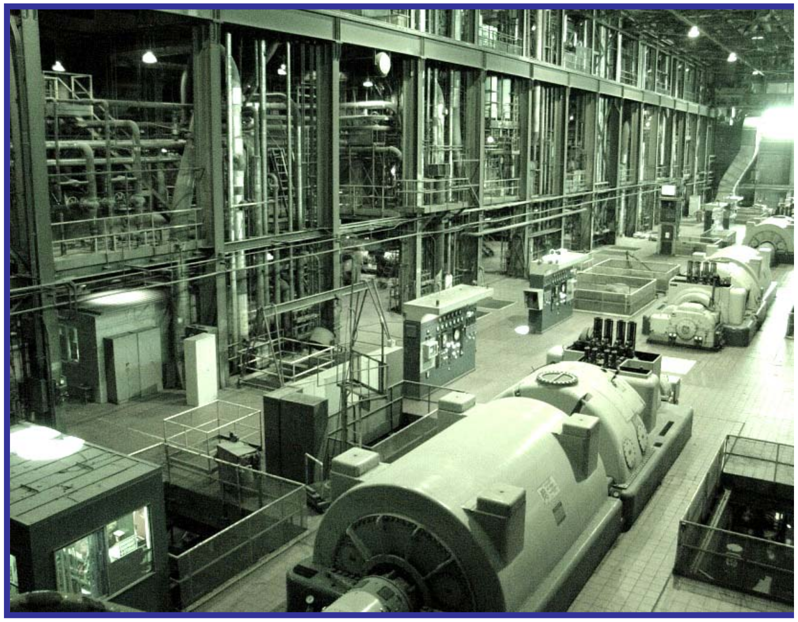
- Reduction of NOx by 12% ($650,000 per year savings*)
- Reduction in reheat and superheat spray by 30% ($100,000 per year savings**)
- Increase in reheat temperature by average of three degrees. ($25,000 per year**)
- Total benefit of CombustionOpt is estimated at $775,000 per year
- Wide operator acceptance

* NOx credits at $2,500 per ton
** Fuel price at 1.25 dollars per mmBtu

Deely On vs. Off Test Results 4/29-5/6/09

COpt&O2 ON vs COpt OFF Comparison				
Performance Parameter	COpt OFF	COpt&O2 ON	Diff	Diff %
NOx	0.138	0.112	-0.026	-18.55%
Average O2	2.69	2.30	-0.39	-14.60%
PerfIndex	776	772	-4	-0.58%
Opacity A	2.95	2.40	-0.54	-18.46%
Opacity B	6.97	6.50	-0.47	-6.68%

CombustionOpt at AMP-Ohio RH Gorsuch



- Goals
  - Reduce NOx
  - Improve fuel efficiency
- Challenges
  - Small units
  - Old DCS with limited connectivity
  - Concern in achieving ROI for ROFA units
- Initial approach
  - Apply standard CombustionOpt at all four units
  - Added OSI PI for historian and DCS connectivity
- CombustionOpt Extension on Units 2 and 3
  - Added connection to Mobotec ROFA controls
  - Required close collaboration between AMP, NeuCo, and Mobotec

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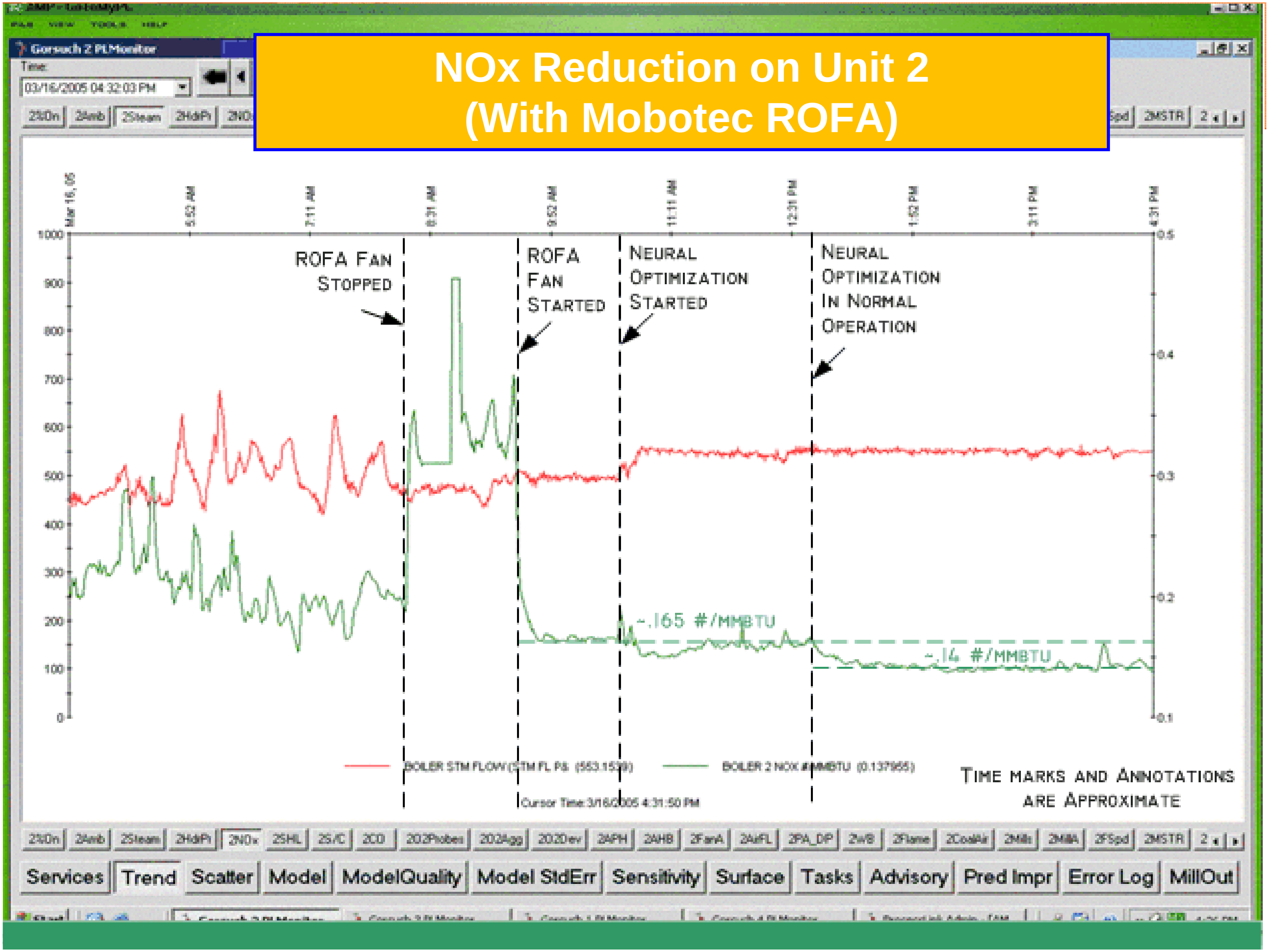
NOx Reduction on Unit 2
(With Mobotec ROFA)



Recent Results for Unit 2

(From Q3-06 AM&S Quarterly Report)

CombustionOpt Variables	PL&O2 ON vs PL OFF Comparison			
	PL&O2 ON	PL OFF	Diff	Diff%
NOx	0.274	0.340	-0.066	-19.35%
Opacity	6.43	5.75	0.68	11.80%
Heat Loss	7.82	8.32		-0.50%

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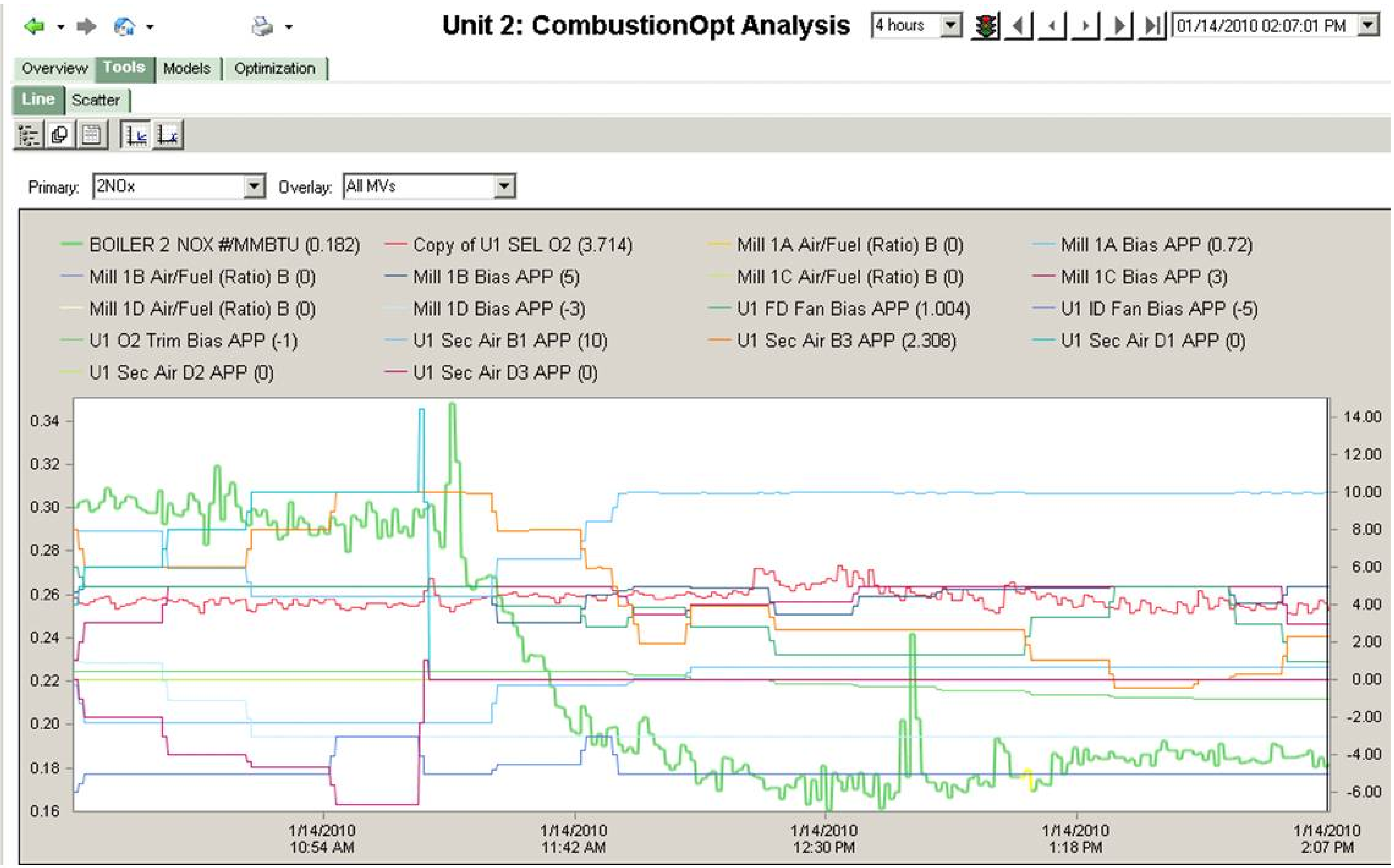
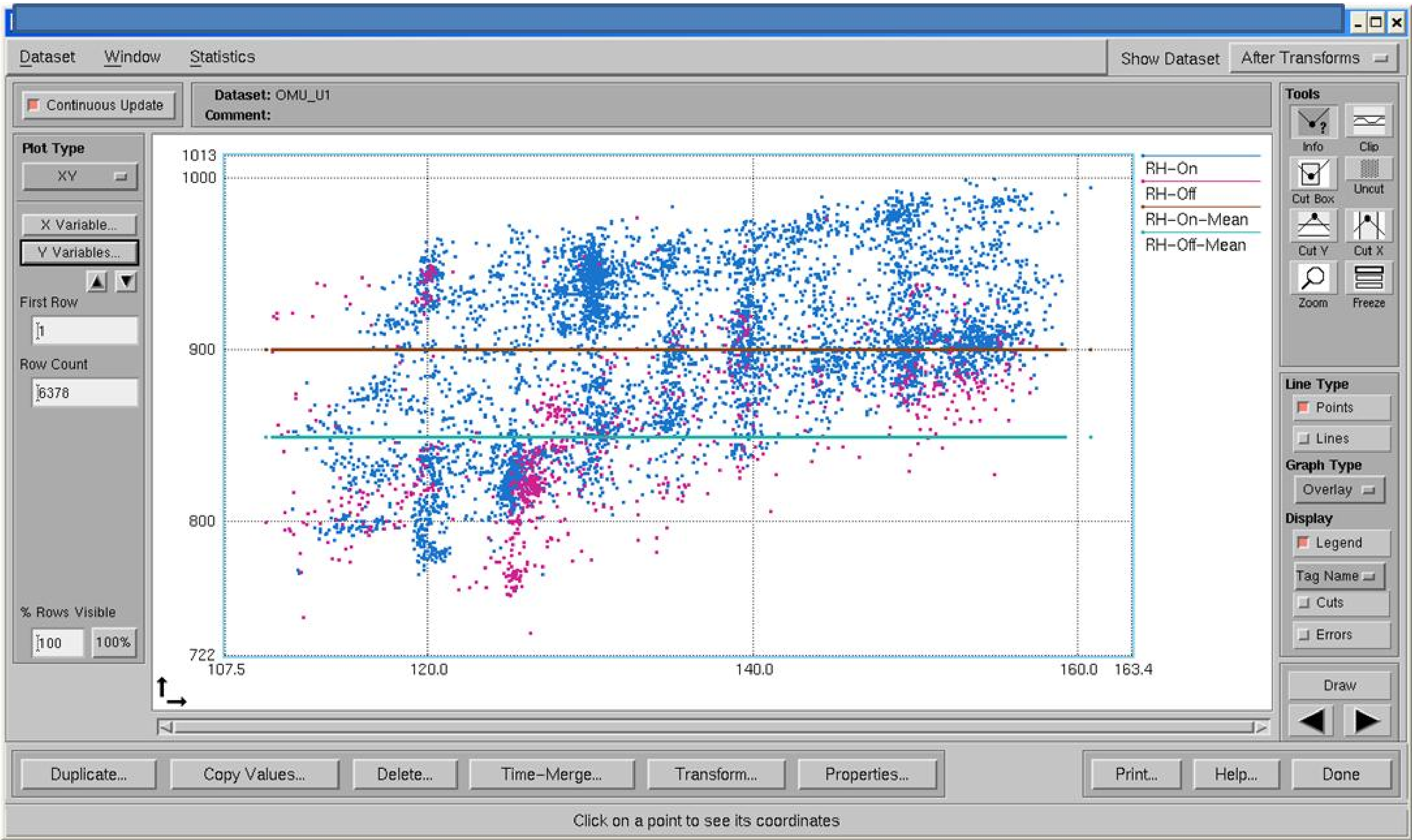
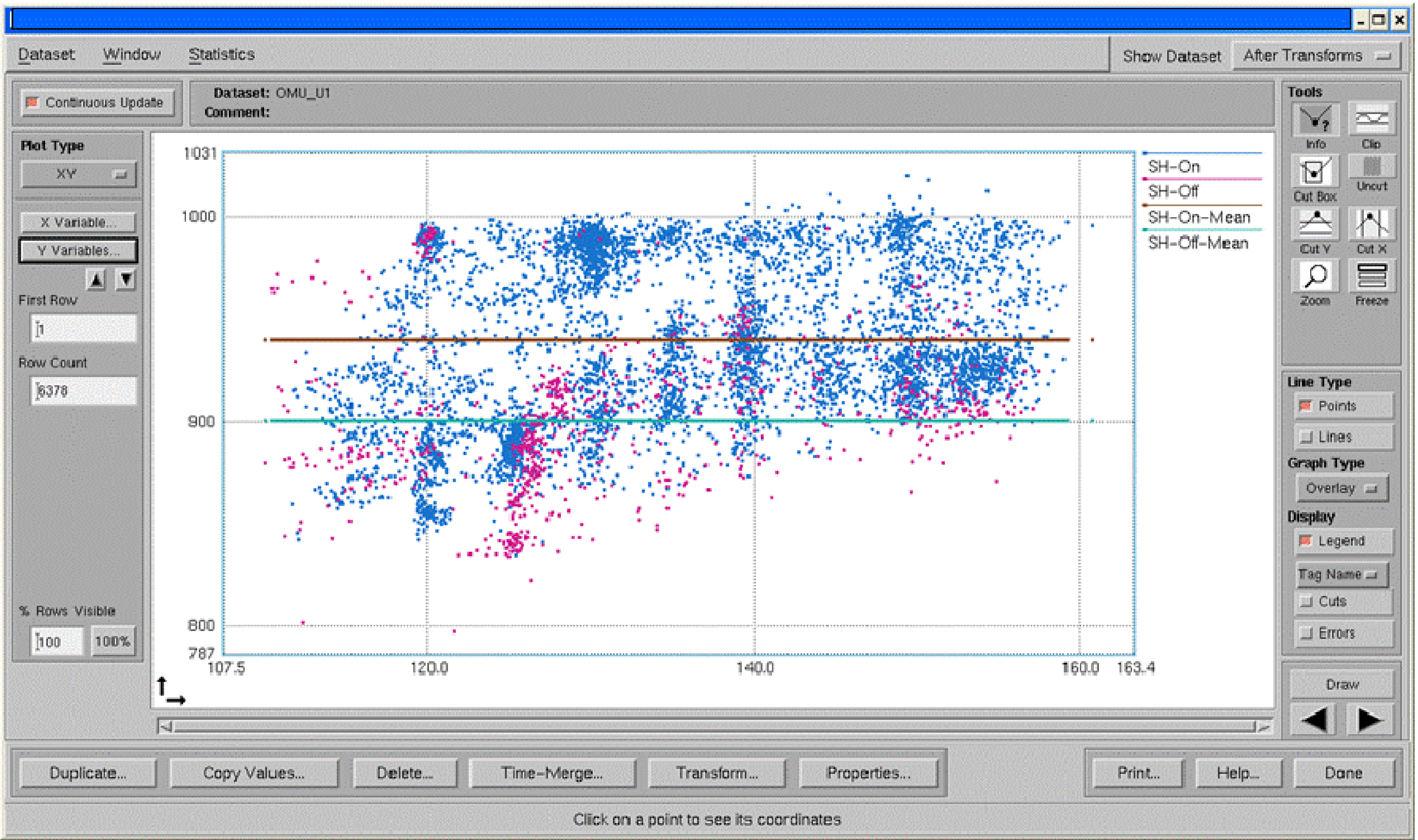
CombustionOpt V2 at Unit 2: w/ROFA



OMU Unit 1 RH Temps



OMU Unit 1 SH Temps



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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” Excursions
- Better Manage System Interactions

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SCR/SNCR Systems & Optimization

- ~40 units with SCRs and CombustionOpt
  - Include reagent flow as objective
  - Reduce boiler NOx
  - Reduce variability of NOx and inlet gas temps
- ~20 units with SNCRs and CombustionOpt
  - Reduce variability of NOx and inlet gas temps

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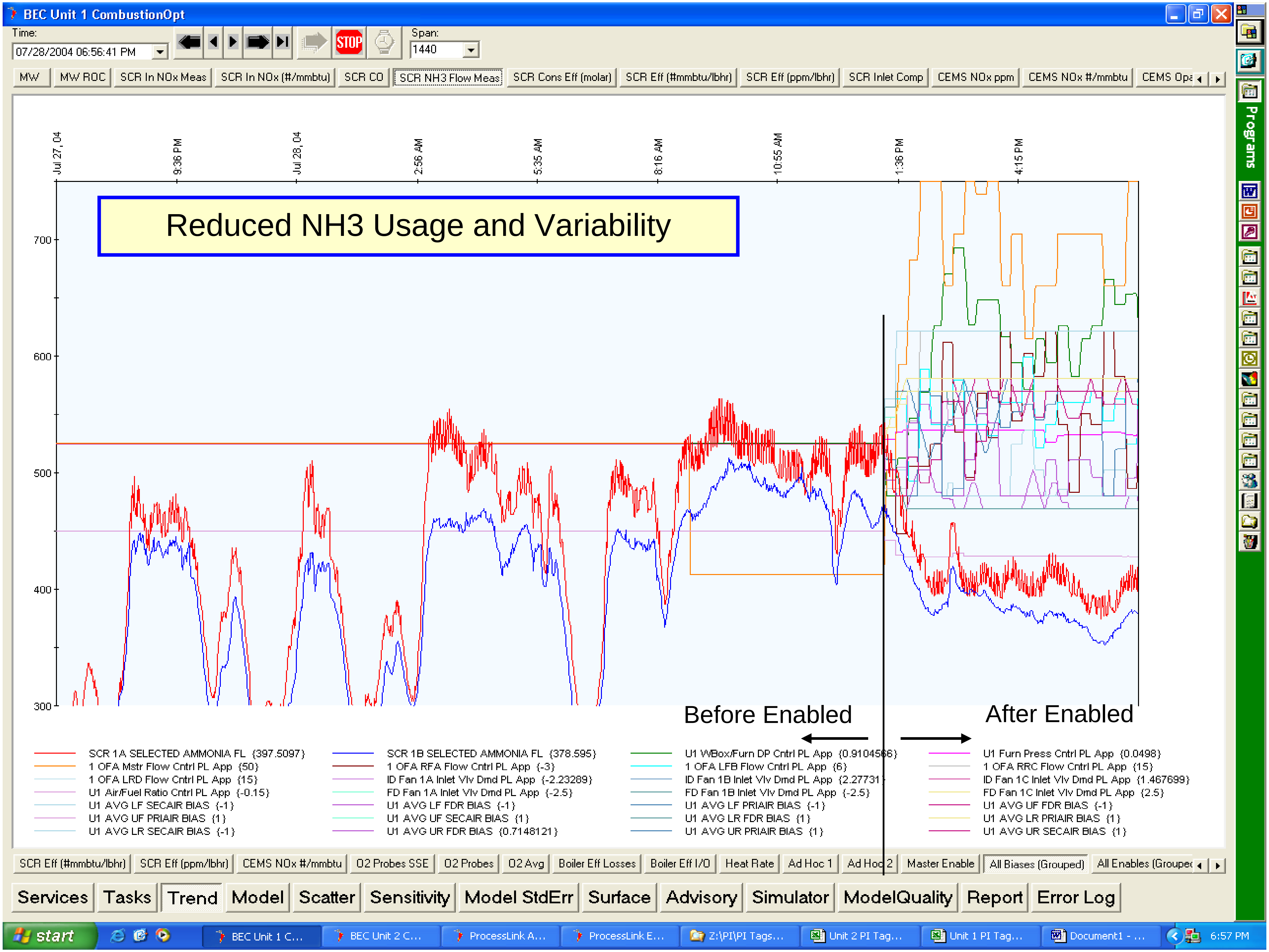
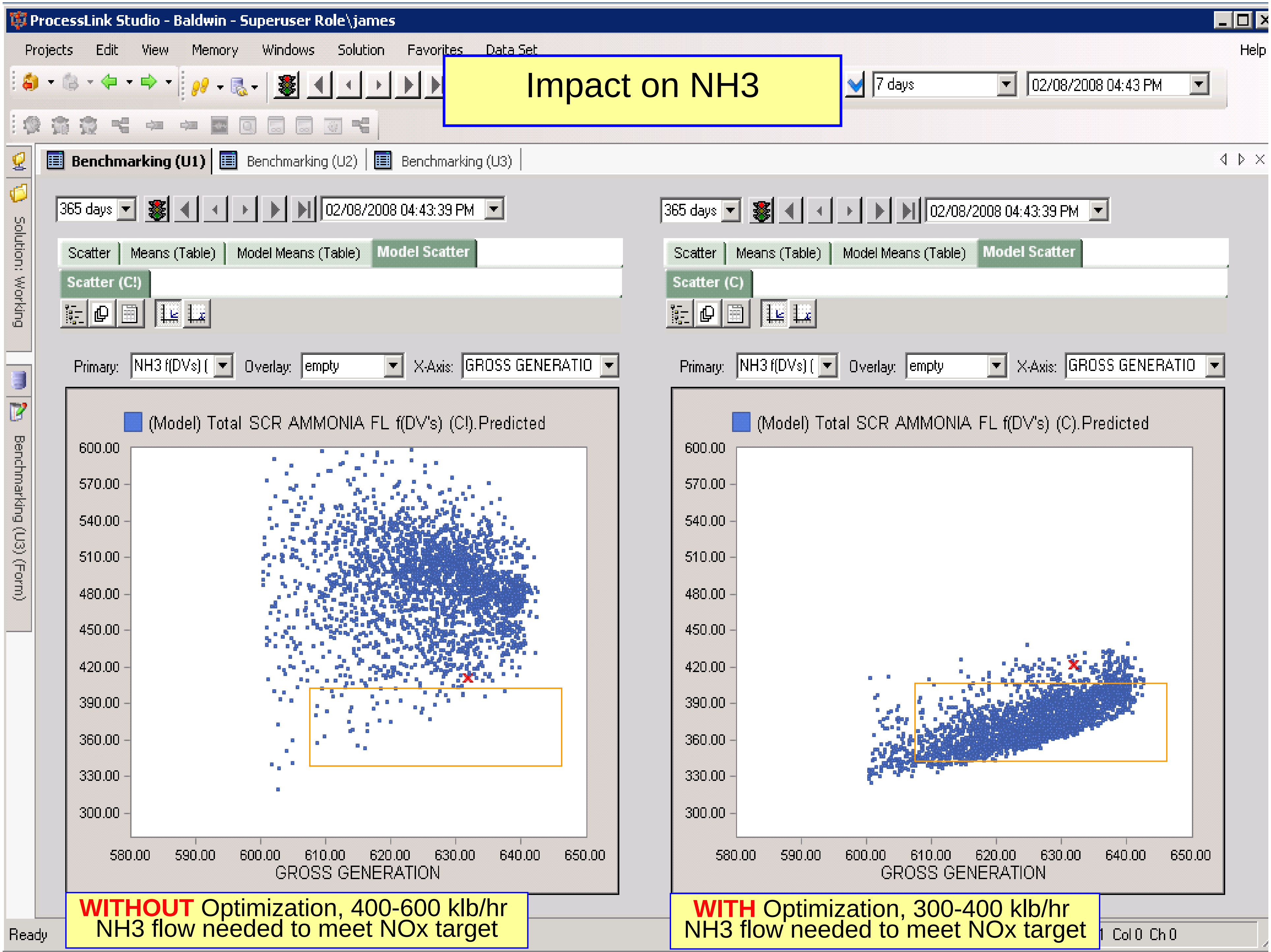

BEC Unit 1 CombustionOpt
Time:
07/28/2004 06:56:41 PM
Span:
1440
MW
MW ROC
SCR In NOx Meas
SCR In NOx (#/mmbtu)
SCR CO
SCR NH3 Flow Meas
SCR Cons Eff (molar)
SCR Eff (#mmbtu/lbhr)
SCR Eff (ppm/lbhr)
SCR Inlet Comp
CEMS NOx ppm
CEMS NOx #/mmbtu
Jul 27, 04
9:36 PM
Jul 28, 04
2:56 AM
5:35 AM
8:16 AM
10:55 AM
1:36 PM
4:15 PM
700
600
500
400
300
Reduced NH3 Usage and Variability
Before Enabled
After Enabled
SCR 1A SELECTED AMMONIA FL {397.5097}
1 OFA Mstr Flow Cntrl PL App {50}
1 OFA LRD Flow Cntrl PL App {15}
U1 Air/Fuel Ratio Cntrl PL App {-0.15}
U1 AVG LF SECAIR BIAS {-1}
U1 AVG UF PRIAIR BIAS {1}
U1 AVG LR SECAIR BIAS {-1}
SCR 1B SELECTED AMMONIA FL {378.595}
1 OFA RFA Flow Cntrl PL App {-3}
ID Fan 1A Inlet Vlv Dmd PL App {-2.23289}
FD Fan 1A Inlet Vlv Dmd PL App {-2.5}
U1 AVG LF FDR BIAS {-1}
U1 AVG UF SECAIR BIAS {1}
U1 AVG UR FDR BIAS {0.7148121}
U1 WBox/Furn DP Cntrl PL App {0.9104566}
1 OFA LFB Flow Cntrl PL App {6}
ID Fan 1B Inlet Vlv Dmd PL App {2.27731}
FD Fan 1B Inlet Vlv Dmd PL App {-2.5}
U1 AVG LF PRIAIR BIAS {-1}
U1 AVG LR FDR BIAS {1}
U1 AVG UR PRIAIR BIAS {1}
U1 Furn Press Cntrl PL App {0.0498}
1 OFA RRC Flow Cntrl PL App {15}
ID Fan 1C Inlet Vlv Dmd PL App {1.467699}
FD Fan 1C Inlet Vlv Dmd PL App {2.5}
U1 AVG UF FDR BIAS {-1}
U1 AVG LR PRIAIR BIAS {1}
U1 AVG UR SECAIR BIAS {1}
SCR Eff (#mmbtu/lbhr)
SCR Eff (ppm/lbhr)
CEMS NOx #/mmbtu
O2 Probes SSE
O2 Probes
O2 Avg
Boiler Eff Losses
Boiler Eff I/O
Heat Rate
Ad Hoc 1
Ad Hoc 2
Master Enable
All Biases (Grouped)
Services
Tasks
Trend
Model
Scatter
Sensitivity
Model StdErr
Surface
Advisory
Simulator
ModelQuality
Report
Error Log
start
BEC Unit 1 C...
BEC Unit 2 C...
ProcessLink A...
ProcessLink E...
Z:\PI\PI Tags...
Unit 2 PI Tag...
Unit 1 PI Tag...
Document1 - ...
6:57 PM
Programs

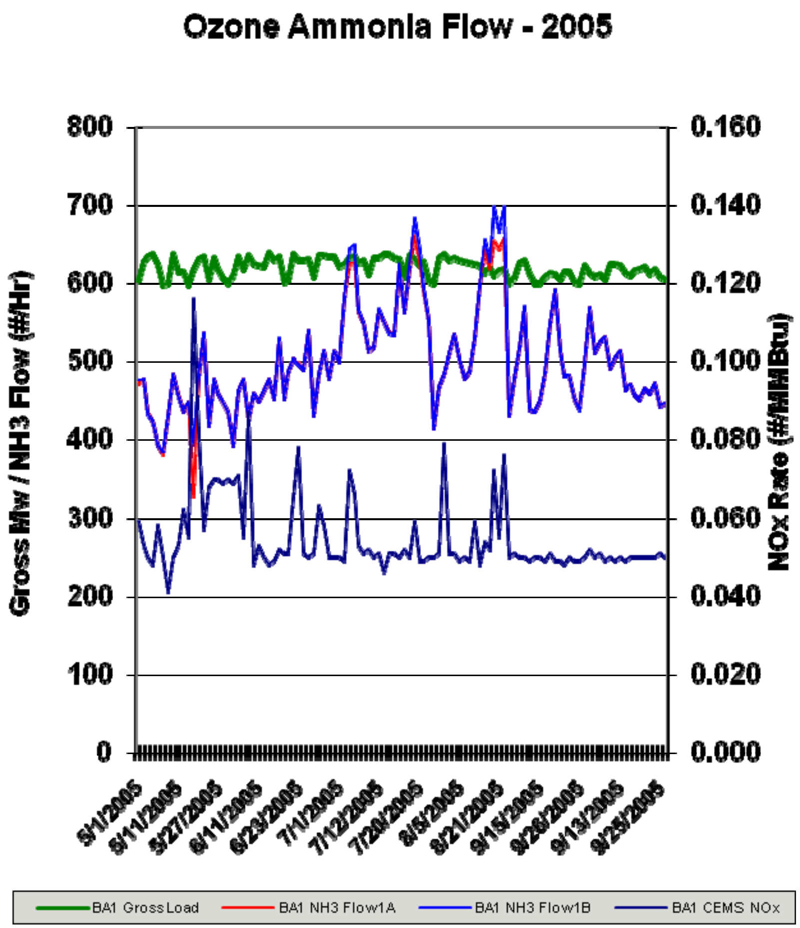
Impact on NH3

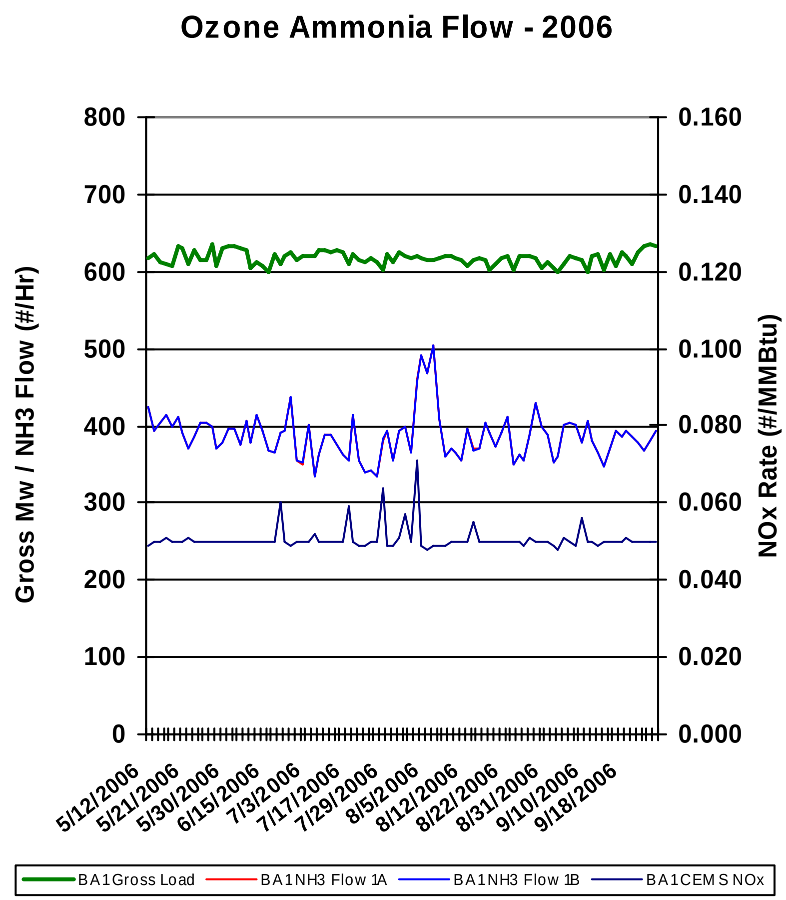


WITHOUT Optimization, 400-600 klb/hr NH3 flow needed to meet NOx target

WITH Optimization, 300-400 klb/hr NH3 flow needed to meet NOx target

Baldwin 1 – Full Load Comparison





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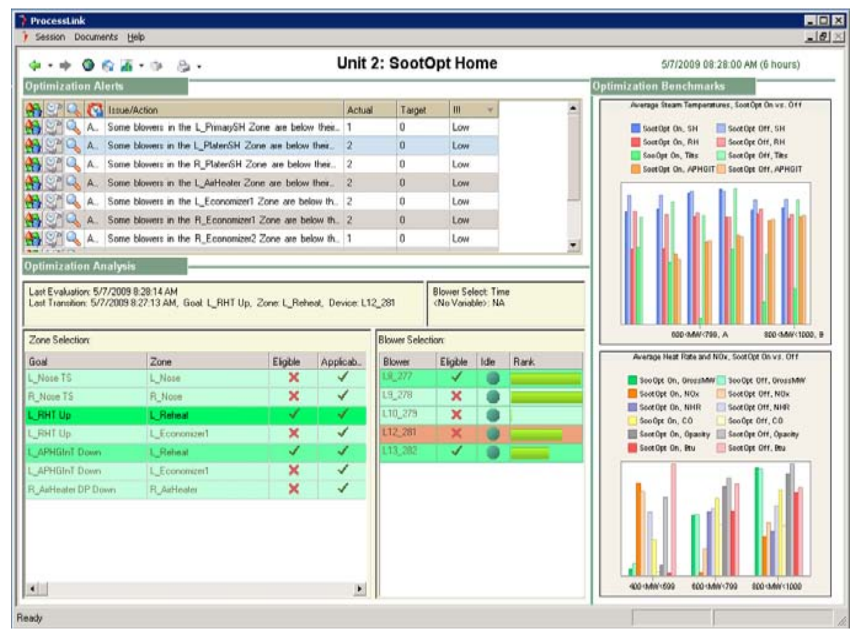
SootOpt®

- 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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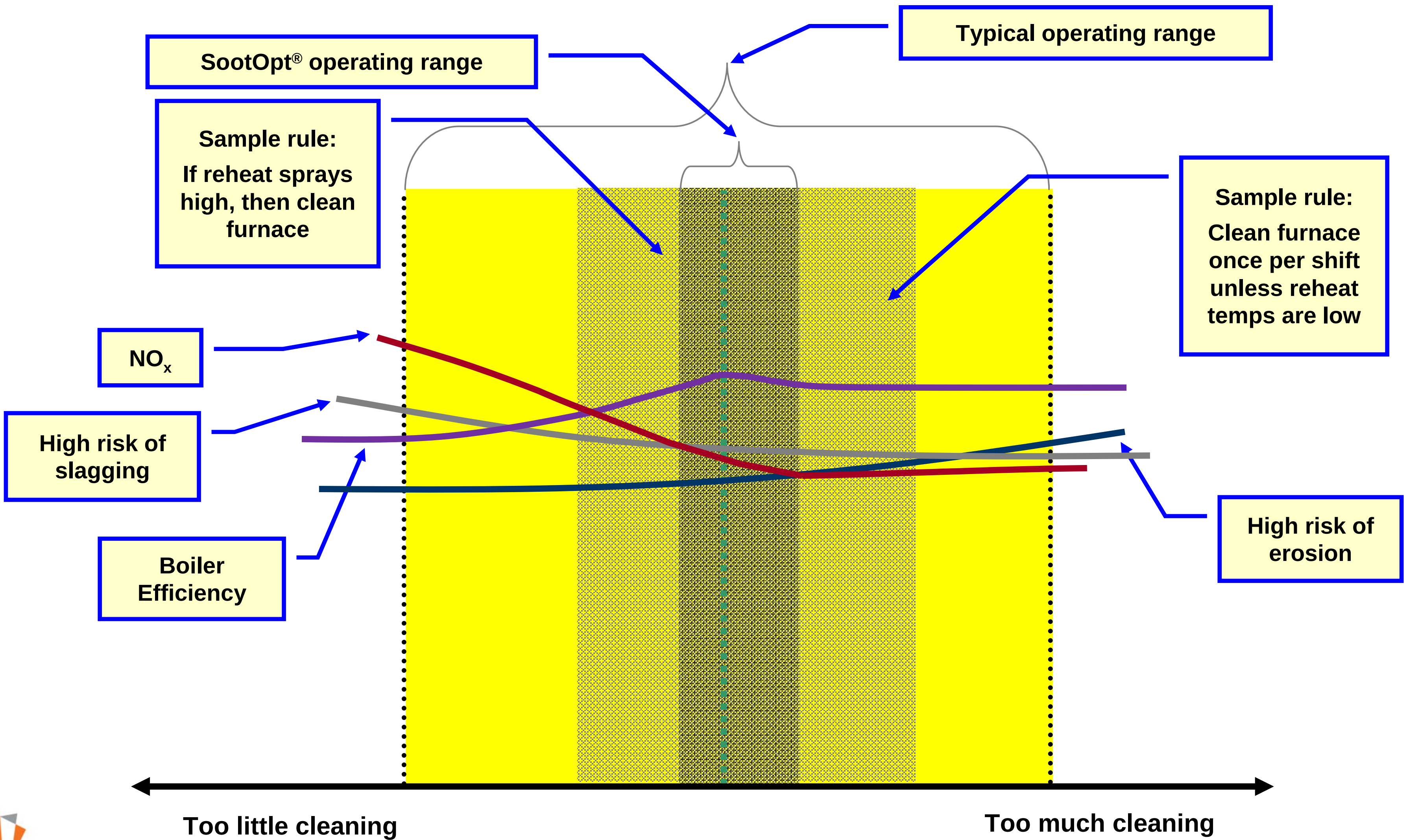
Sootblowing Optimization



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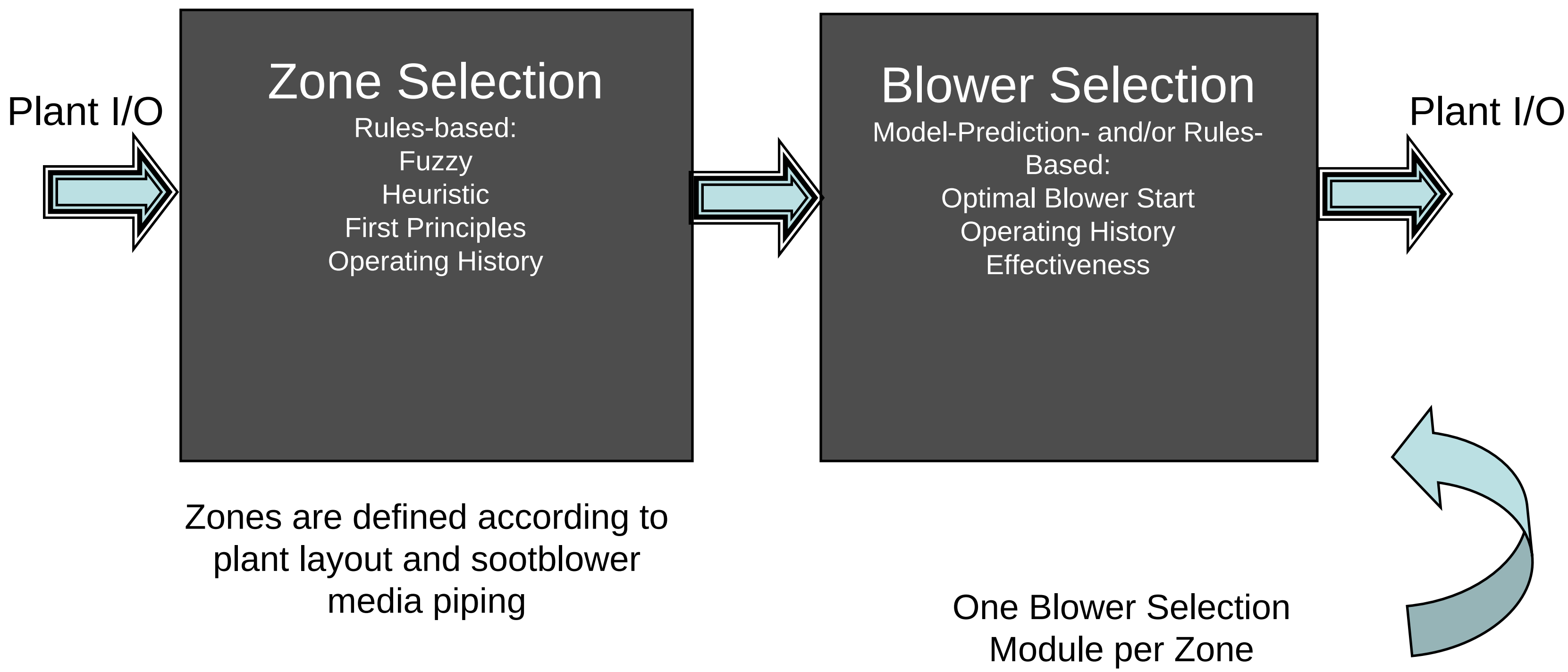
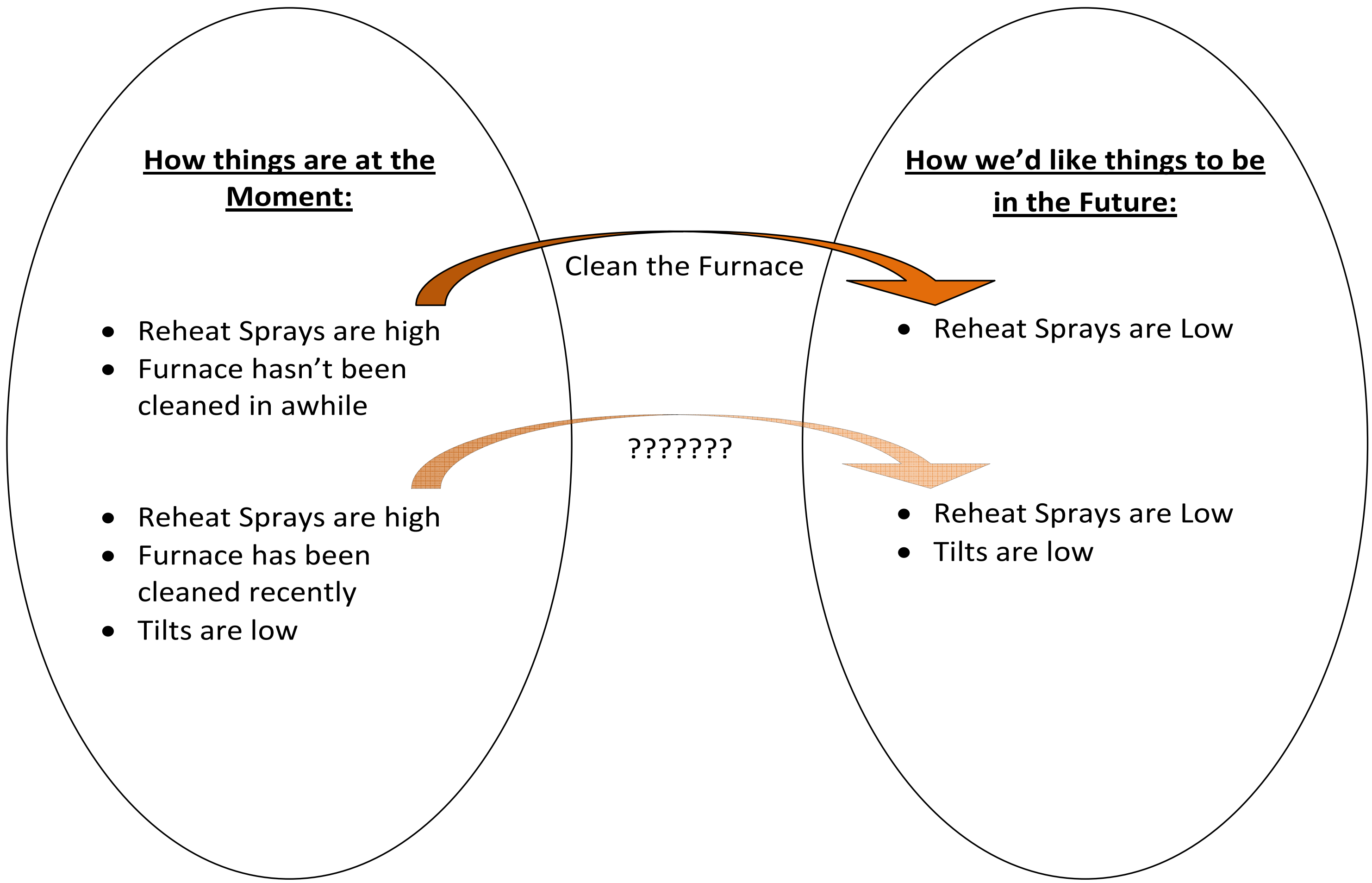
What SootOpt Does

- Improves heat rate
  - by improving heat transfer and heat transfer distribution
  - Be improving steam temperature control
  - by reducing use of attemperation spray and sootblowing media (steam, water, air)
- Improves availability
  - Reduced blowing reduces tube erosion and thermal fatigue
- Improves NOx control
  - through improved heat transfer, reduction of “hot spots”, and reduced firing intensity
- Reduces opacity violations
  - by using opacity data in decision-making
- Reduces operator workload and improves shift-to-shift consistency

Overview: How SootOpt Works



Rules Development



- Expert Rules model the effect of actions – opportunistically (*when we know them)*
- And can be described in regular sentences

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Blower Selection

- Once a Zone is Selected
- Two methods are available for blower selection
  - Greatest time-since last operation
    - Recognizes blower actuations by SootOpt or otherwise
    - Can be used alone
    - Blowers over their Maximum Allowable Idle Time trumps Predictive Neural Selection
  - Predictive (“neural”)
    - Used with Time-Since
    - Neural models are used to predict the effect of operating each blower in the zone
    - The blower with the predicted best effect is chosen

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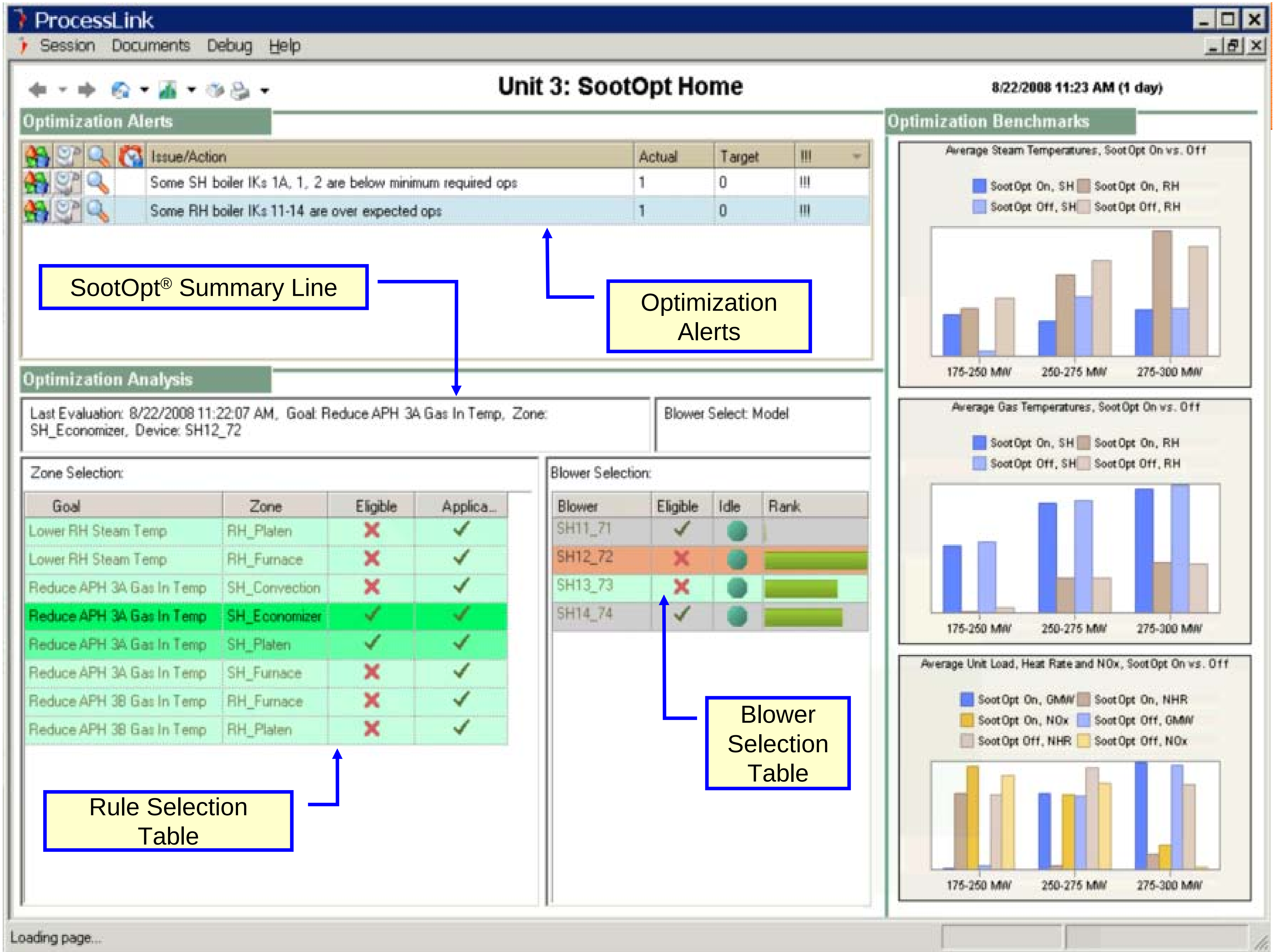
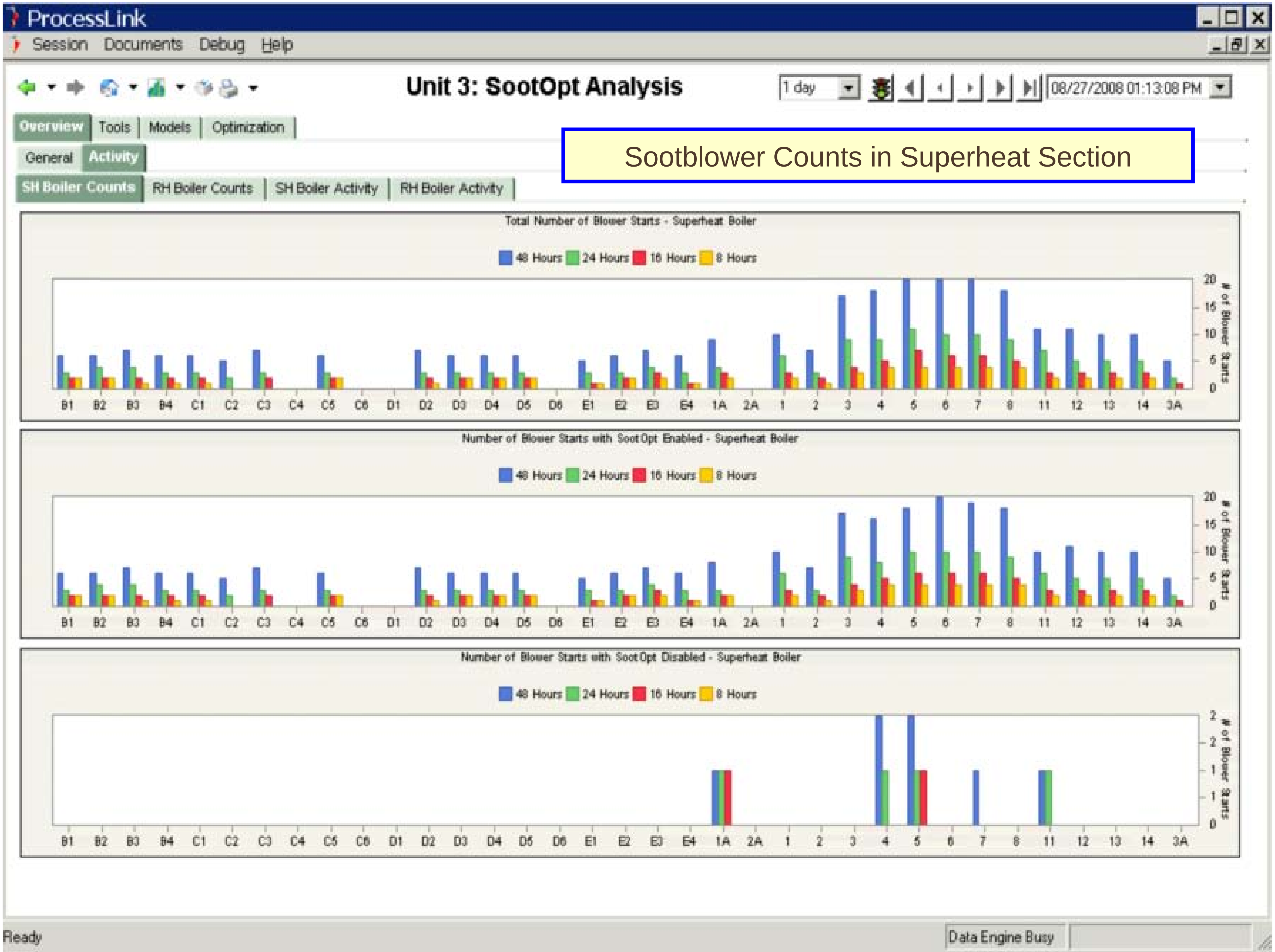

ProcessLink
Session Documents Debug Help
Unit 3: SootOpt Home
8/22/2008 11:23 AM (1 day)
Optimization Alerts
Issue/Action | Actual | Target | !!!
Some SH boiler IKs 1A, 1, 2 are below minimum required ops | 1 | 0 | !!!
Some RH boiler IKs 11-14 are over expected ops | 1 | 0 | !!!
SootOpt® Summary Line
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
Blower Selection:
Blower | Eligible | Idle | Rank
SH11_71
SH12_72
SH13_73
SH14_74
Rule Selection Table
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...

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


ProcessLink
Session Documents Debug Help
Unit 3: SootOpt Analysis
1 day
08/27/2008 01:13:08 PM
Overview Tools Models Optimization
General Activity
SH Boiler Counts RH Boiler Counts SH Boiler Activity RH Boiler Activity
Sootblower Counts in Superheat Section
Total Number of Blower Starts - Superheat Boiler
48 Hours 24 Hours 16 Hours 8 Hours
# of Blower Starts
B1 B2 B3 B4 C1 C2 C3 C4 C5 C6 D1 D2 D3 D4 D5 D6 E1 E2 E3 E4 1A 2A 1 2 3 4 5 6 7 8 11 12 13 14 3A
Number of Blower Starts with SootOpt Enabled - Superheat Boiler
48 Hours 24 Hours 16 Hours 8 Hours
# of Blower Starts
B1 B2 B3 B4 C1 C2 C3 C4 C5 C6 D1 D2 D3 D4 D5 D6 E1 E2 E3 E4 1A 2A 1 2 3 4 5 6 7 8 11 12 13 14 3A
Number of Blower Starts with SootOpt Disabled - Superheat Boiler
48 Hours 24 Hours 16 Hours 8 Hours
# of Blower Starts
B1 B2 B3 B4 C1 C2 C3 C4 C5 C6 D1 D2 D3 D4 D5 D6 E1 E2 E3 E4 1A 2A 1 2 3 4 5 6 7 8 11 12 13 14 3A
Ready
Data Engine Busy

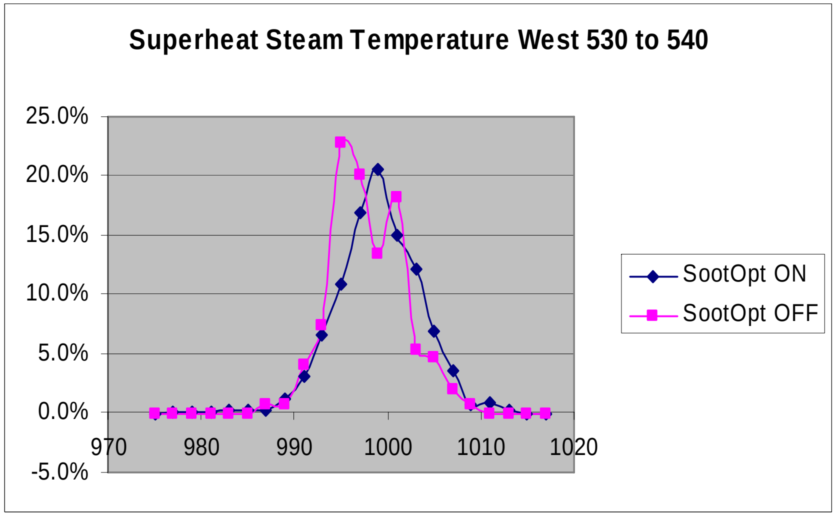
SootOpt at Xcel Energy Tolk U1 & U2

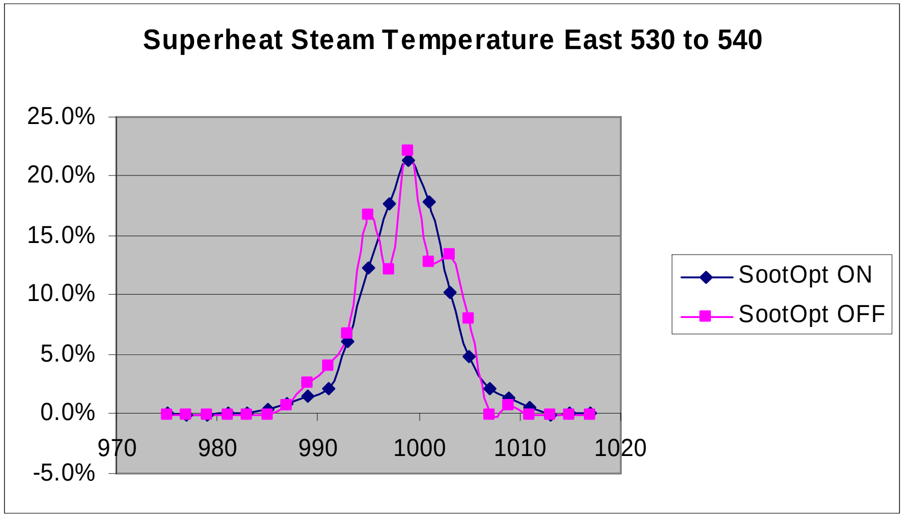
- U2 Completed April ’09
- U1 Completed July ’09
- Both units already had ISB
- Objectives
  - Further NOx reduction
  - Better balancing of Sootblowing Operations
  - More consistent Sootblowing Operation
  - Lower APH gas inlet temps

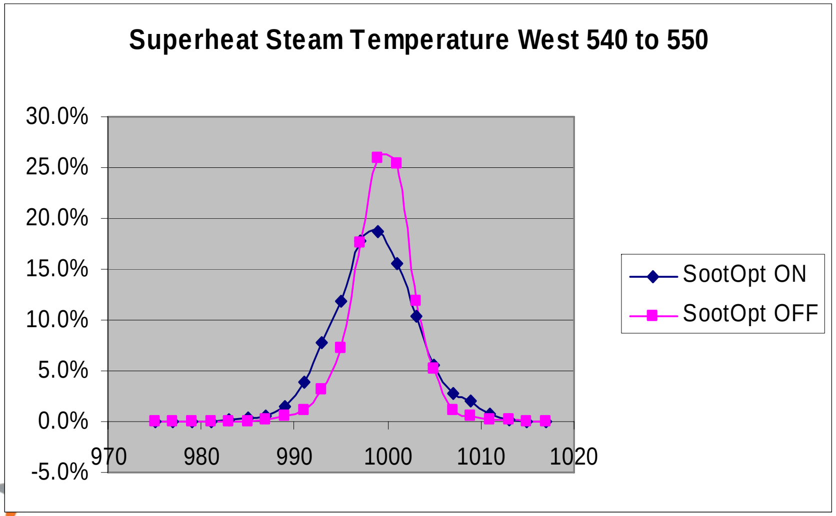
Initial Benefits: SootOpt at Tolk U1 & U2

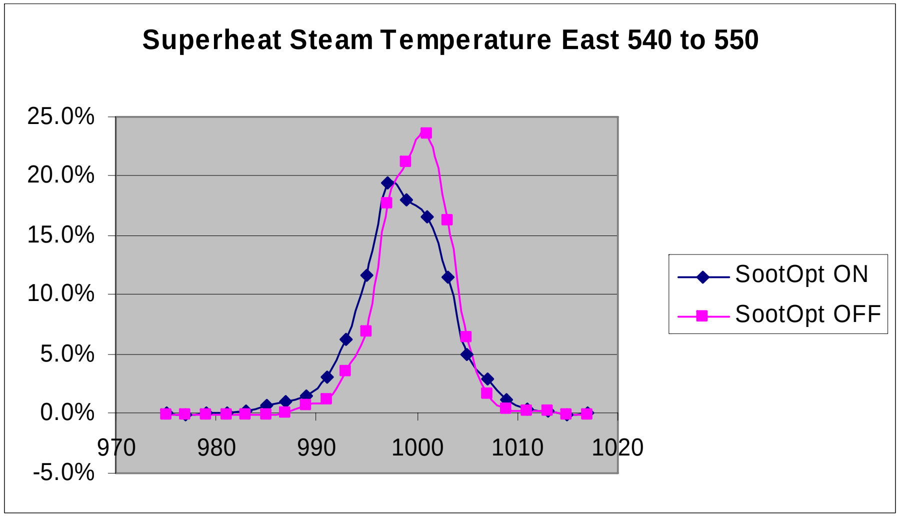
- Operators have one less thing to worry about
  - Takes the right actions, consistently
- SH & RH temps better balanced
- Superheat sprays significantly reduced
- APH gas inlet temps significantly reduced
- Tighter control of burner tilts
- Boiler Efficiency increased (resulting in further NOx reductions)
- Helps address problems associated with changing load profile
- Better balancing furnace-to-steam circuits

Superheat Steam Temperatures Tolk U2









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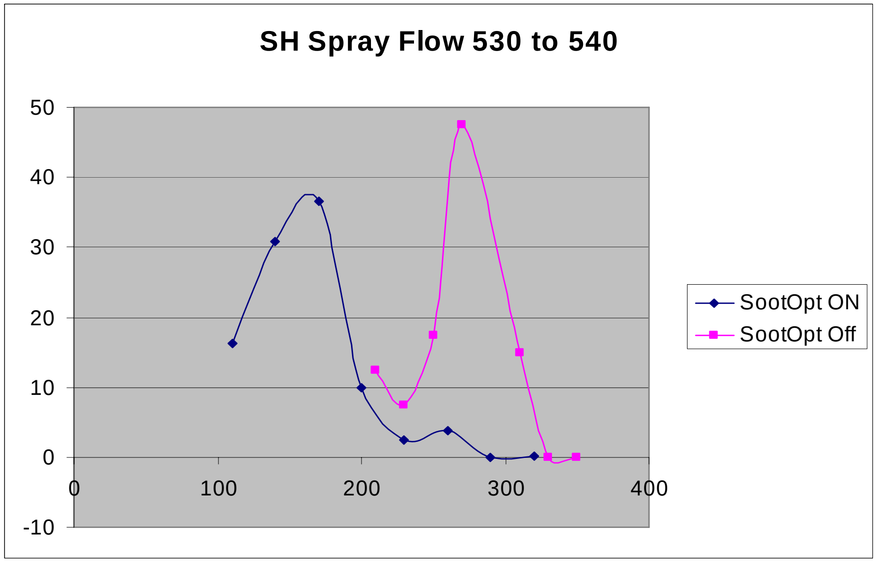
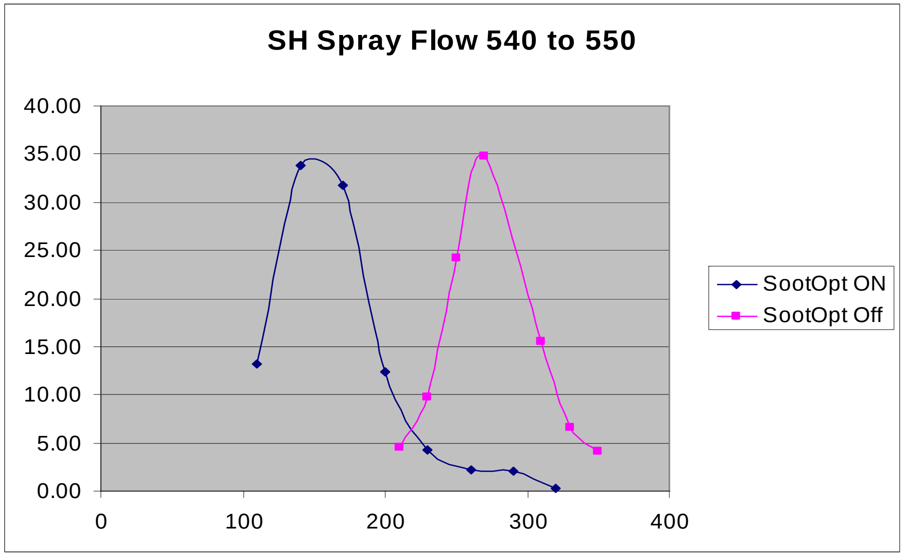
Tolk Unit 2 Superheat Spray Flows





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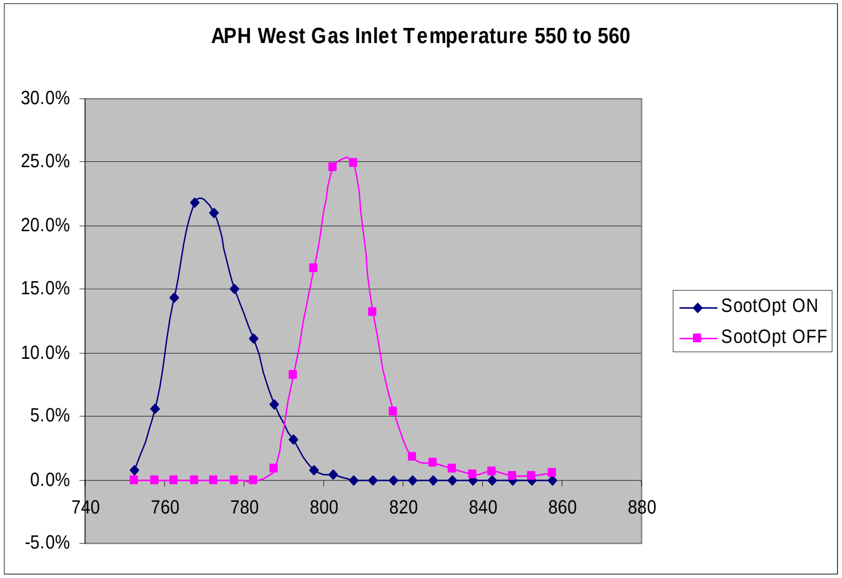
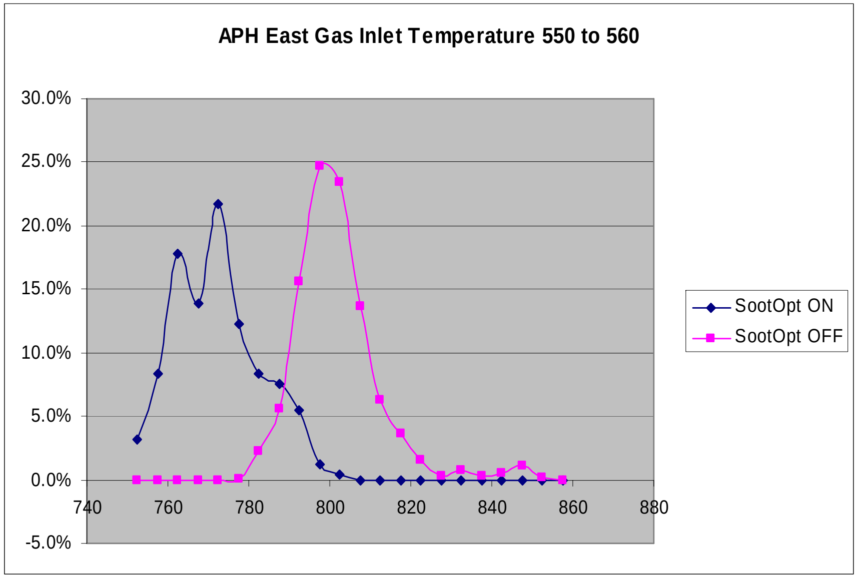
APH Gas Inlet Temperatures Tolk U2 (550-560 MW)





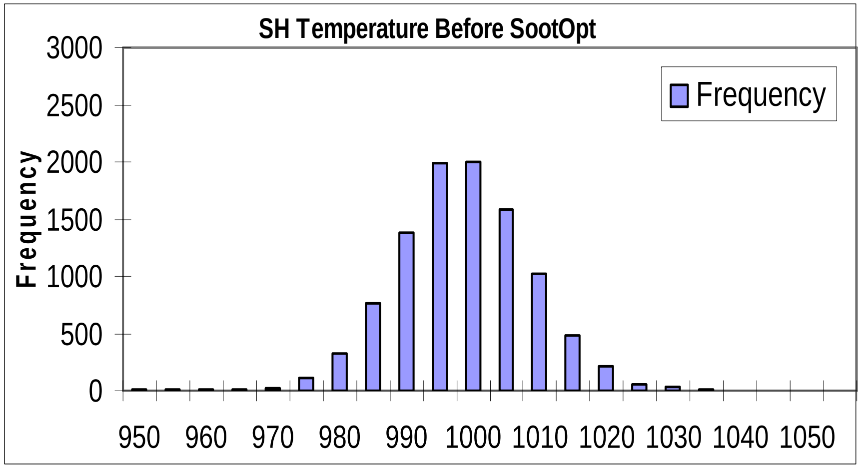
~ 30° F Reduction in Average Temperatures

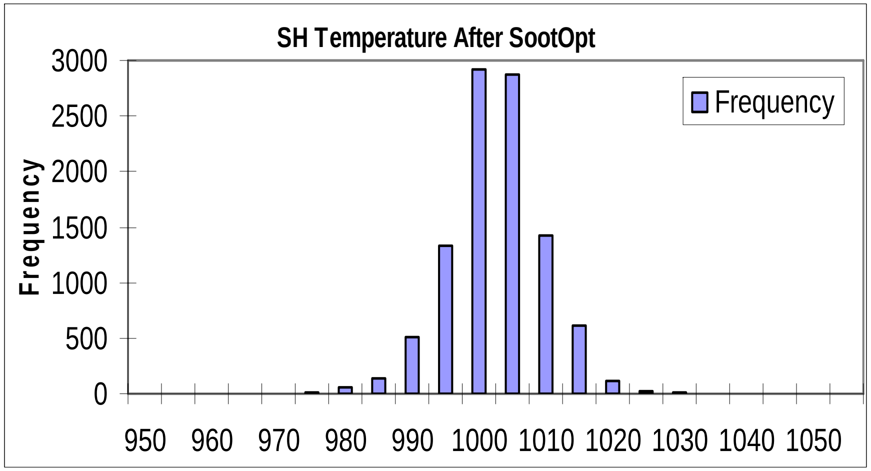
Meramec Unit 3 Results

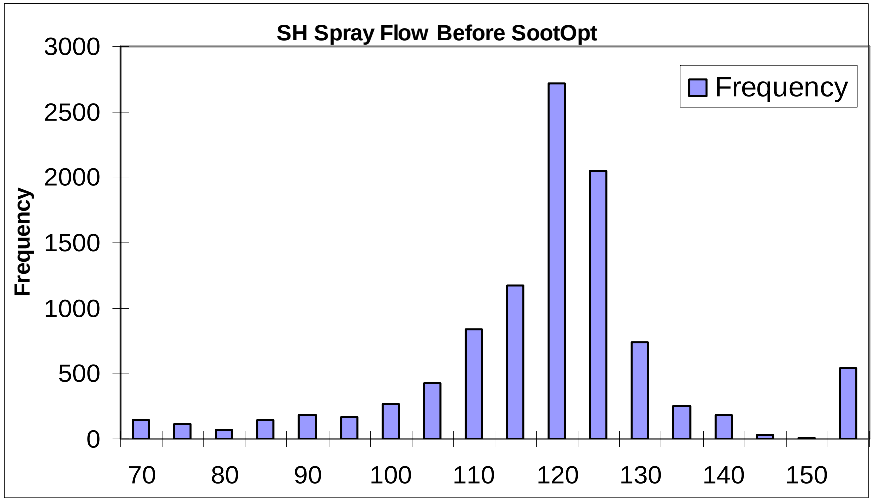
U3 Individual Sootblower Counts – Long Lances

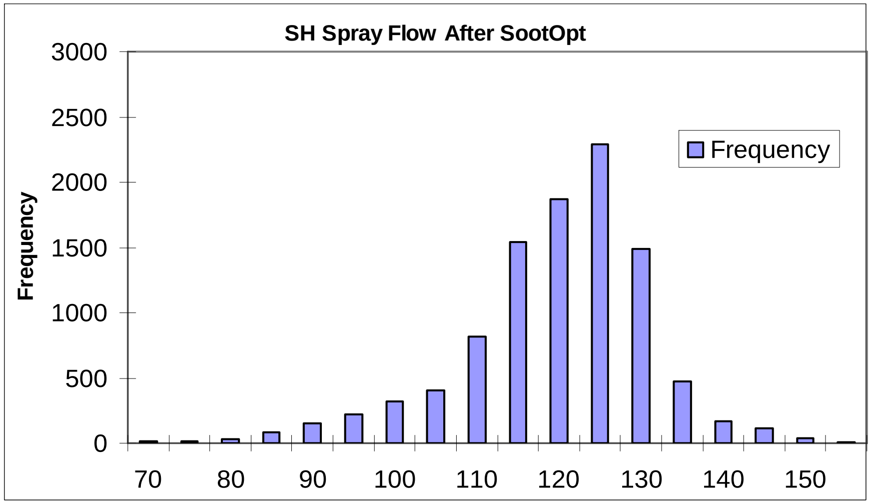
	Before SootOpt Totals (3/25/08 to 4/07/08)	After SootOpt Totals (8/9/08 to 8/22/08)	% Change
SH-LL's			
LL_1	300	116	-61.3
LL_1A	256	134	-47.7
LL_2	300	134	-55.3
RH-LL's			
LL_1	369	253	-31.4
LL_1A	309	221	-28.5
LL_2	377	255	-32.4

U3 SH Temps & Sprays – SootOpt Before vs. After

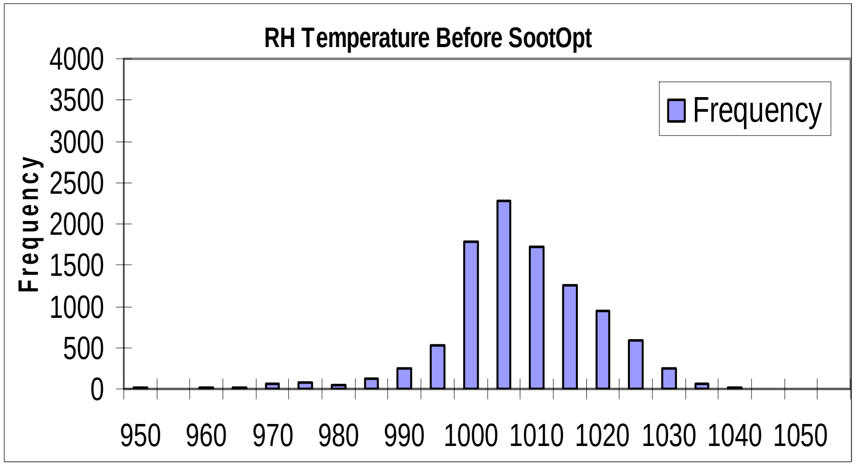


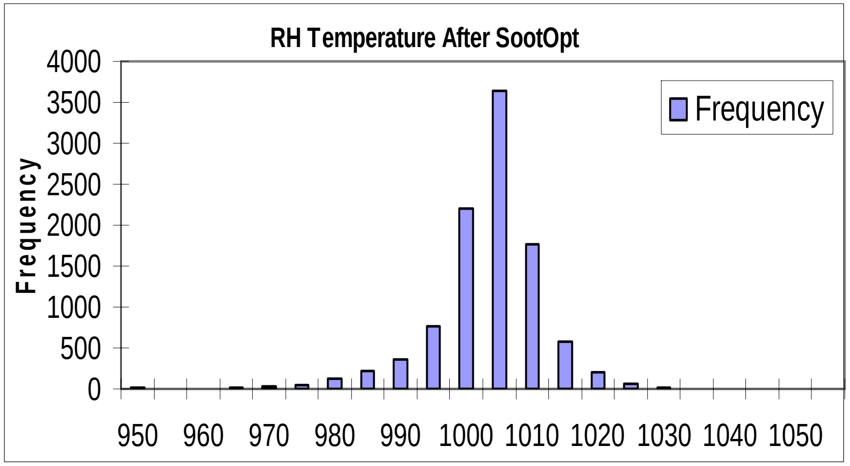


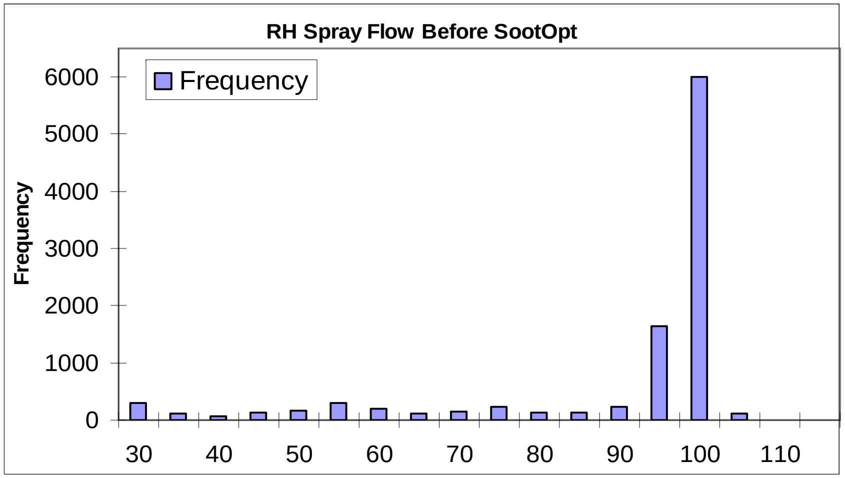


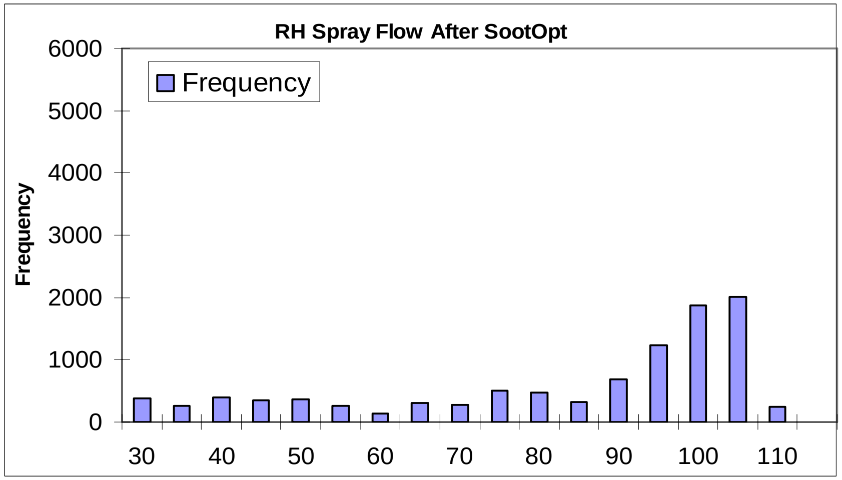


U3 RH Temps & Sprays – SootOpt Before vs. After









U3 APH Temps - SootOpt Before vs. After

Air Preheater 3A Gas Inlet Temperature Frequency Distribution and Percentage Change

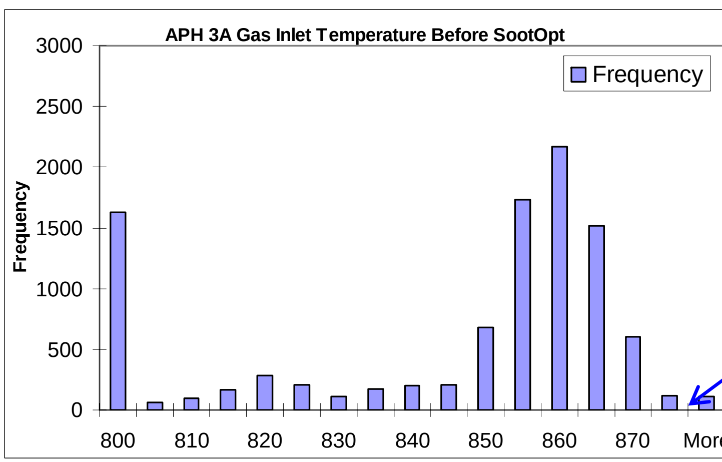
APH 3A Temp Ranges (DegF)	Before SootOpt Frequency	After SootOpt Frequency	% Change
800	1631	2685	-64.62
805	62	81	-30.65
810	99	48	51.52
815	167	66	60.48
820	281	58	79.36
825	205	50	75.61
830	109	67	38.53
835	173	49	71.68
840	198	81	59.09
845	206	427	-107.28
850	676	1213	-79.44
855	1732	2267	-30.89
860	2167	1674	22.75
865	1515	946	37.56
870	605	240	60.33
875	116	69	40.52
More	108	29	73.15

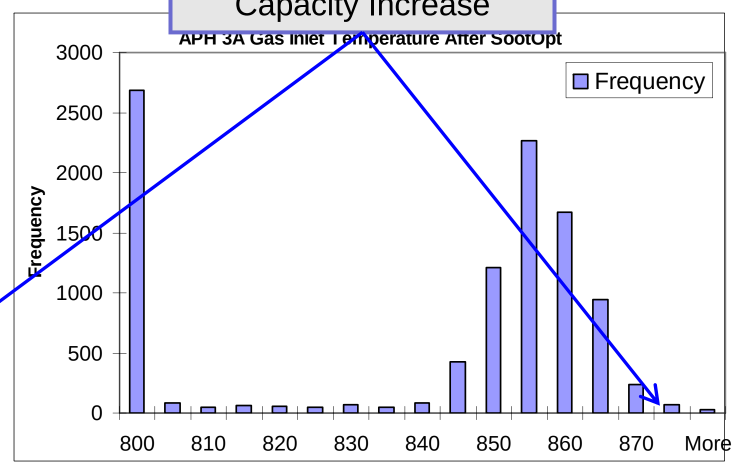
Notes

Positive % Change = decrease in occurrence frequency

Negative % Change = increase in occurrence frequency

Better Control Over APH Inlet Temps is Providing 25 MW Capacity Increase





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U3 Meramec SootOpt Benefits Summary

- Narrowed superheat and reheat steam temperature variability and moved closer to setpoint
- Simultaneously reduced attemperation sprays
- Reduced manually blowing of three lances in less than half
- No erosion-related tube leaks in at least *seven months*, relative to history of every 2-8 weeks
- Improved the operators' effectiveness:
  - Before, operators had to manually manage sootblowing
  - Now they operators spend very little time managing sootblowing
  - *"We just put in SootOpt and let it fly"*—Ameren Meramec Engineer

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Meramec Unit 4 Results

Unit 4 Sootblower Actuation Counts (Average Daily Runs Pre & Post SootOpt)

Negative % Change = Decrease in number of sootblower actuations

Positive % Change = Increase in number of sootblower actuations

Blower	Pre SootOpt	Post SootOpt	% Change
LL 1L	6.4	4.6	-28.6
LL 2L	3.6	3.6	0.9
LL 3L	5.0	3.4	-32.4
LL 4L	5.7	4.4	-22.3
LL 5L	6.0	5.4	-10.7
LL 6L	3.3	3.5	5.6
LL 6AL	6.4	5.9	- 8.5
LL 7L	3.4	3.6	6.4
LL 8L	6.1	4.3	-29.6
LL 9L	5.7	4.6	-19.6
LL 10L	5.7	4.6	-19.9
LL 11L	6.3	5.4	-14.0
LL 12L	6.2	4.6	-26.0
LL 13L	6.1	5.4	-12.0
LL 14L	6.1	4.6	-24.8
LL 15L	6.6	7.8	17.1*
LL 16L	6.6	5.1	-22.6
LL 17L	6.4	7.9	22.6*
LL 18L	6.3	5.2	-17.6
LL AH1	2.9	4.6	55.0**
LL 1R	6.3	5.0	-20.9
LL 2R	3.4	2.4	-31.4
LL 3R	3.4	2.3	-33.7
LL 4R	6.3	3.2	-48.3
			-12.7

* Note: the actuation frequency of long lances 15 and 17 were increased per feedback from plant operations personnel

** Air preheater blower starts increased to respond to higher air preheater differential pressure since air preheater sootblower outage event

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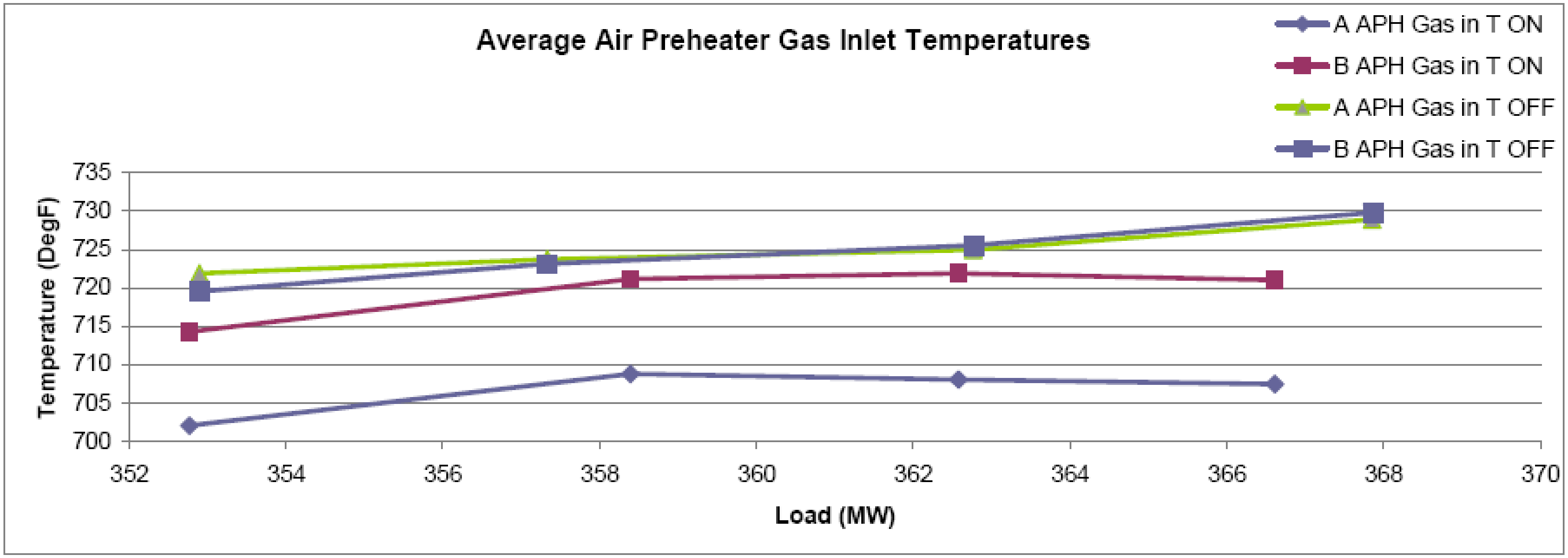
U4 Air Preheater Gas Inlet Temperatures



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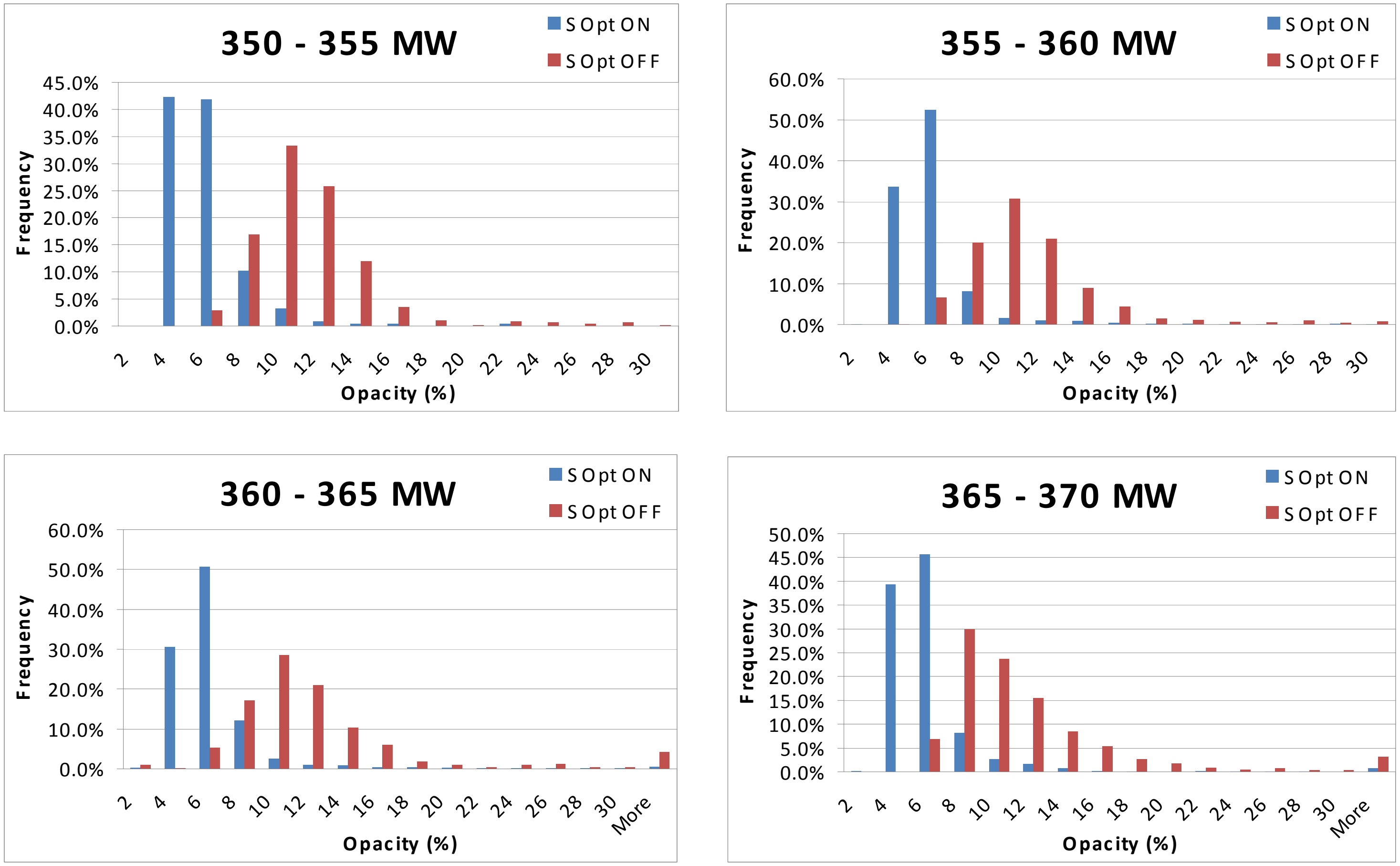
Unit 4 – Opacity

- Opacity levels with SootOpt were lower by over 50%
- Opacity excursions (> 20%) dropped notably with SootOpt

Opacity Frequency Distribution



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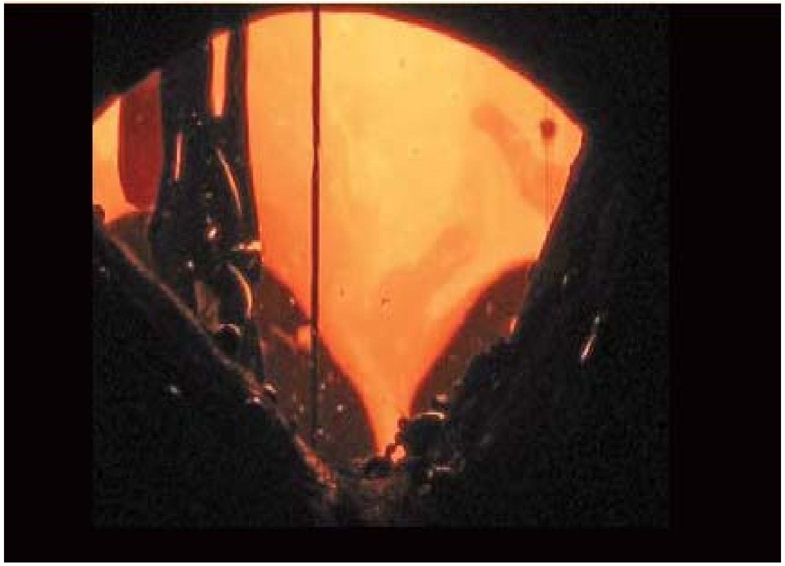
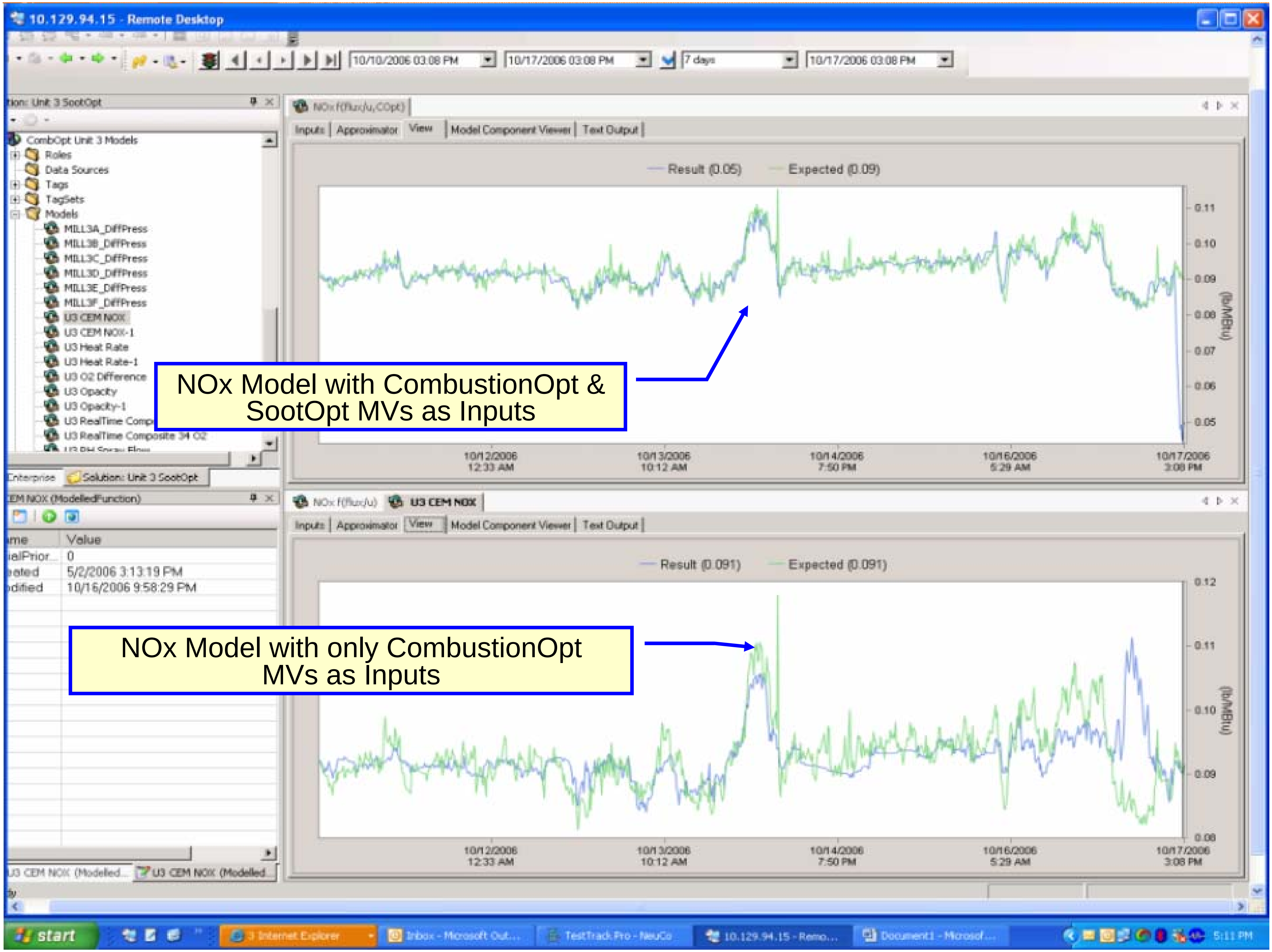
Unit 4 SootOpt Results Summary

- Total blower starts reduced by more than 12% -- higher reductions for many of the blowers
- Reheat steam temperature variations minimized
- Reduced delta between east and west side reheat steam temperatures
  - Deviation between east and west reheat temperature narrowed from an average of 25.4 degF without SootOpt to an average of 8 degF with SootOpt
- Air pre-heater gas inlet temperatures lowered by an average of 18.3 degF and 4.9 degF for the A and B sides respectively
- Reduced NOx levels – ranging from +0.5% to -2.6% depending on load
- Opacity levels lowered by more than 50%
- Utilization remains high -- enabled more than 95% of time

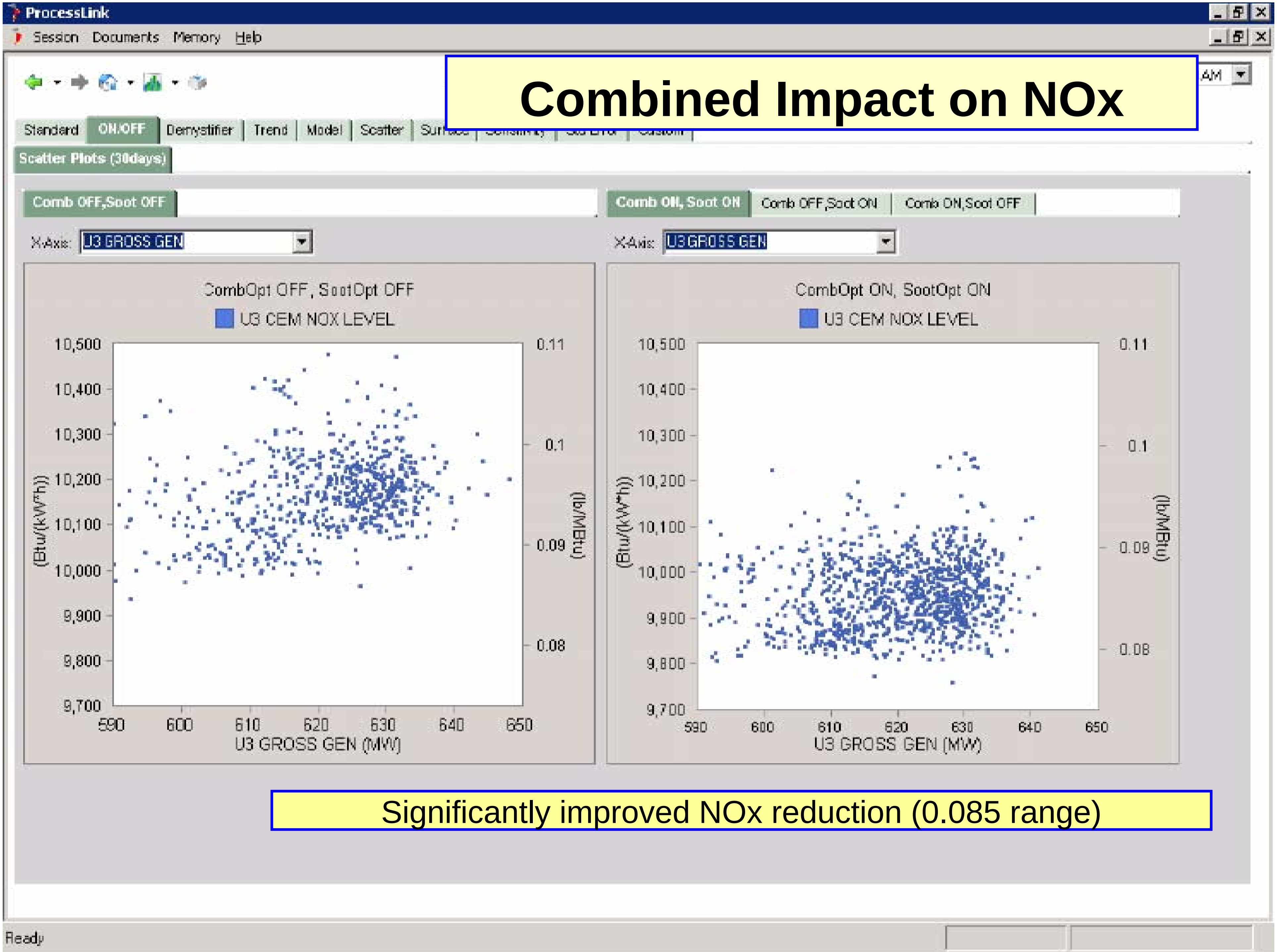
Comprehensive Boiler Optimization

- 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



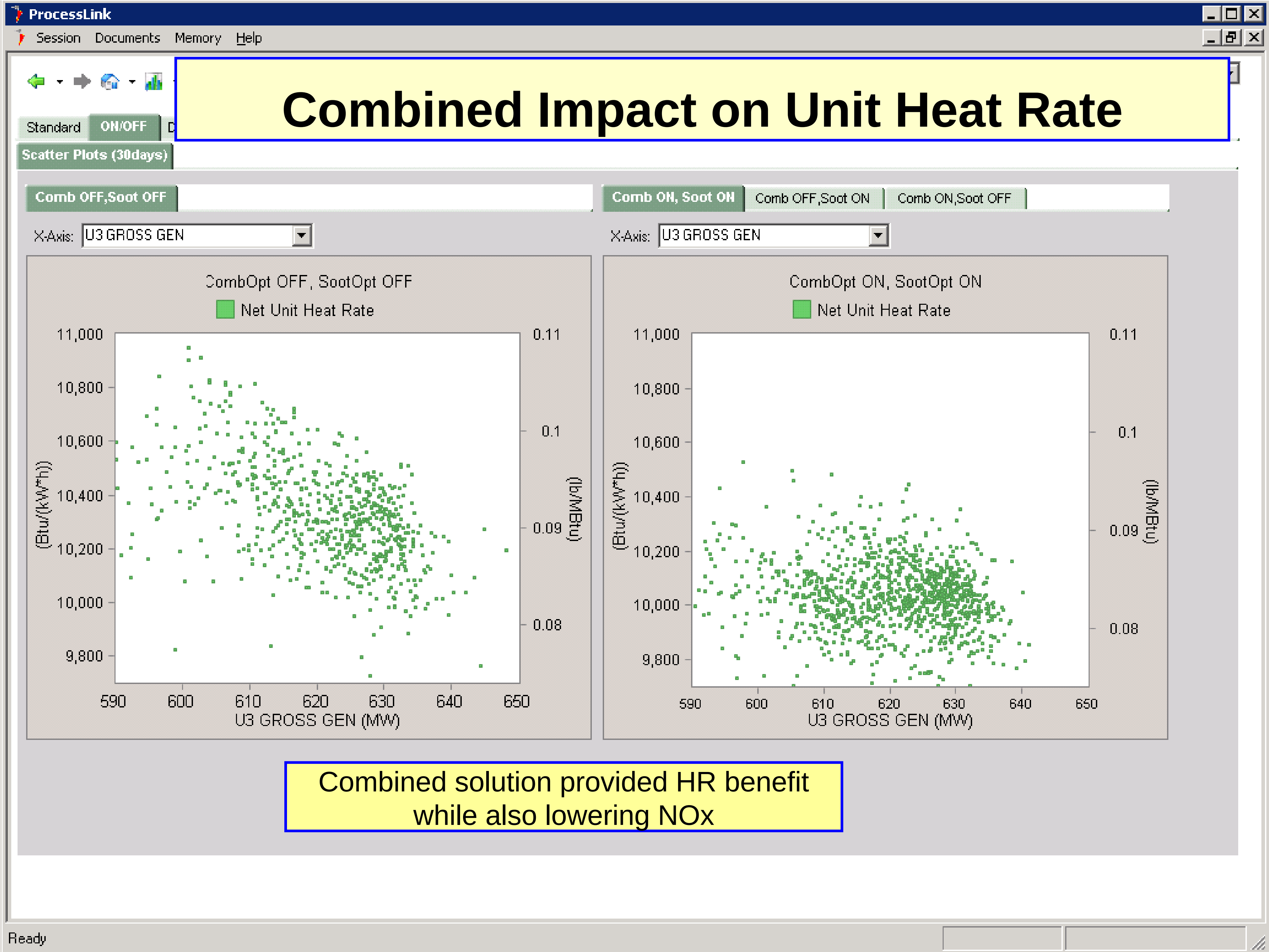

10.129.94.15 - Remote Desktop
NOx f(flux/u,COpt)
Inputs
Approximator
View
Model Component Viewer
Text Output
Result (0.05)
Expected (0.09)
NOx Model with CombustionOpt & SootOpt MVs as Inputs
CombOpt Unit 3 Models
Roles
Data Sources
Tags
TagSets
Models
MILL3A_DiffPress
MILL3B_DiffPress
MILL3C_DiffPress
MILL3D_DiffPress
MILL3E_DiffPress
MILL3F_DiffPress
U3 CEM NOX
U3 CEM NOX-1
U3 Heat Rate
U3 Heat Rate-1
U3 O2 Difference
U3 Opacity
U3 Opacity-1
Solution: Unit 3 SootOpt
NOx f(flux/u)
U3 CEM NOX
Result (0.091)
Expected (0.091)
NOx Model with only CombustionOpt MVs as Inputs
10/12/2006 12:33 AM
10/13/2006 10:12 AM
10/14/2006 7:50 PM
10/16/2006 5:29 AM
10/17/2006 3:08 PM
(lb/MBtu)
5/2/2006 3:13:19 PM
10/16/2006 9:58:29 PM
start

Combined Impact on NOx



Significantly improved NOx reduction (0.085 range)

Combined Impact on Unit Heat Rate



Combined solution provided HR benefit while also lowering NOx

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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Contact Information

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