## **Boiler Optimization and MATS Work Practices Requirements**

McIlvaine Hot Topics September 27<sup>th</sup>, 2013





# **Mercury and Air Toxics Standard (MATS)**

- Requires all plants to reduce mercury and increase efficiency to mitigate unmeasurable air toxics
  - Requires an efficiency evaluation and tune-up every 3 years starting in 2015
- Complies with a universal consent decree
  - EPA, almost all generators, states and environmental groups are parties
- Generators are investing in mercury mitigation and efficiency
- Using a neural network relaxes timing of efficiency evaluation
  - Neural combustion optimization is only technology that enables plants to defer the evaluation to 2016 and to every four years thereafter
- Substantial business driver for NeuCo
  - NeuCo is seeing 2014 budgets established to include neural networks
  - Will drive universal adoption of combustion optimization in US coal generation



- 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 from every 3 years to every 4 years.
- These provisions provide further evidence that the US EPA recognizes the value of optimization with respect to regulatory objectives relating to emissions and efficiency



- Clearly demonstrate "optimization of NOx and CO"
- Defer initial boiler tune-up by one full year
  - Learn how EPA enforces rule for those not employing neural optimization
  - Better plan for initial tune-up and associated repairs
  - Avoid or defer outage associated with tune-up
- Simplify emissions performance measurement protocol
  - Single before vs. after average as opposed to hourly measurements
  - Reduce sensitive data available to state and federal regulatory agencies
- Reduce subsequent tune-ups from every 3 to every 4 years
- Better meet emissions, efficiency, and availability objectives
- Provide upgrade path for integrated boiler optimization



## Additional EPA Mandates and Enforcement Mechanisms

- Clean Air Act of 1970 and Clean Air Act Amendments of 1990
  - National Ambient Air Quality Standards, PM 2.5, Regional Haze
  - CO<sub>2</sub> for plants triggering New Source Review
  - And now CO<sub>2</sub> standards for existing power plants
- Enforcement Mechanisms
  - New Source Review
  - Internal administrative / judicial process
  - Prescriptive standards (BART/BACT)
  - Regional / market based approaches (CAIR, CSAPR)



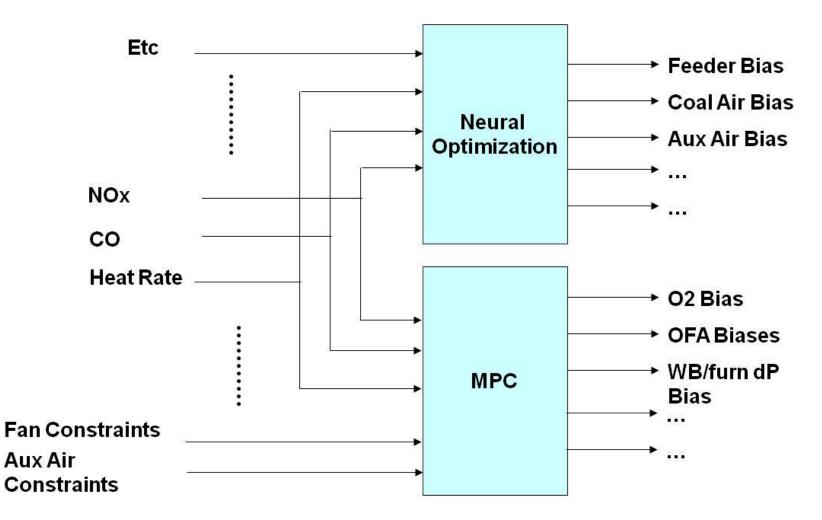
# **CombustionOpt**<sup>®</sup>

- 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)

🔶 🔸 🔹	- 🔏 - 🛸	😂 •			Unit	3: Con	nbustic	onOpt H	ome			11/21/2008 01:	32 PM (1 day)	_
Optimization A	derts									Optimization	Bench	marks		
🔒 🖓 🔍 🕻	Issue		A	Actual	Target III	- NO	x Svngs (	Fuel Svngs (_	Relative Impa		Br	enefits (month	I)	
	C'Opt MVs P	artially Enable	d 0	.7	1		8,720	58,334		Objectives	linite	Achieved (vs. Baseline)	Achievable (vs. Actual	
										Fuel	BtukWh	É LÉ	198.69	-
										Fuel		224,112.09	150,094.01	-
														_
										NOx	Ib/MBtu	0.01	0.01	
										NOx	\$	24,283.09	14,448.01	
- Bumer - O2 Bia	- Tilt A (66.528) — Is (-0.5)	- Bumer Tilt B (	61.558)			— N0x (( — RHT_E		RHT_A (1006) Stack C 0 (14.20	0)	Setpoints (Deviations)				
— 02 Bia	85 (0.5)	- Burner Titt B ( : :07:40 13:		\$54:2	12:49:0		B (998.656)	StackCO (14.20			percent a unitless	7.81	-0.36 0.39 0.03	
- 02 Bia 12:21:00 1	ss (0.5) 12:44:20 13:	07:40 13:	31:00 13			- RHT_E	B (998.656) 40 13:16:2	StackC0 (14.20 0 13:30:00 11/21/20	13:43:40 08 01:23:06 PM	(Deviations) O2 Split Sum of Fdr Big	percent a unitless	7.81	0.39	
- 02 Bia 12:21:00 1 MV Name	ss (4.5) 12:44:20 13: Pre-Move	:07:40 13: Post-Move	31:00 13		Objectives	- RHT_E	8 (998.656) 40 13:16:2 Predicted	Stack C0 (14.20 0 13:30:00 11/21/20 Target	13:43:40	(Deviations) O2 Split Sum of Fdr Big	percent a unitless	7.81	0.39	
	ss (0.5) 12:44:20 13:	07:40 13:	31:00 13			- RHT_E	B (998.656) 40 13:16:2	StackC0 (14.20 0 13:30:00 11/21/20	13:43:40 08 01:23:06 PM	(Deviations) O2 Split Sum of Fdr Bie Sum of Aux Bi	percent a unitless	7.81	0.39	
- 02 8ia 12:21:00 1 MV Name UD/DPR AA SEL	I2:44:20 13: Pte-Move 3:496	07:40 13: Post-Move 3.371	31:00 13		Objectives RH Spray Flo	- RHT_E	8 (998.656) 40 13:16:2 Predicted 57.87	stackC0 (14.20 0 13:30:00 11/21/20 Target < 25 (kb/h	13:43:40 08 01:23:06 PM	(Deviations) O2 Splt Sum of Far Bit Sum of Aux Bit	percent a unitless ii unitless	7.81	0.39	
- 02 Bia 12:21:00 1 MV Name UDOPR AA SEL UDOPR AB SEL UDOPR BC SEL	12:44:20 13: Pre-Move 3:496 -4.186 1.059 2:233	07:40 13: Post-Move 3.371 -4.061 0.996 2.296	31:00 13		Objectives RH Spray Flo Mill 3F dP (in Mill 3C dP (in Mill 3E dP (in	- RHT_E Actual 53,93 8,82 7,92 7,48	40 13:16:2 Predicted 57.87 8.82 7.92 7.48	Stack C0 (14.20 0 13:30:00 11/21/20 Target < 7.5 (inH < 7.5 (inH < 7.5 (inH	13:43:40 08 01:23:06 PM	(Deviations) O2 Splt Sum of Fdr Bit Sum of Aux Bit Limits (%Violations)	percent a unitiess ic unitiess	7.81	0.39	
- 02 Bia 12.21:00 1 MV Name UDOPR AA SEL UDOPR AB SEL UDOPR CO SEL UDOPR DE SEL	12:44:20 13: Pre-Move 3:496 -4.186 1.059 2:233 -0.857	07:40 13: Post-Move 3.371 -4.061 0.996 2.296 -0.859	31:00 13		Objectives RH Spray Flo Mill 3F dP (in Mill 3C dP (in Mill 3E dP (in Sum of Fdr Bi	- RHT_E Actual 53.93 8.82 7.92 7.48 0.02	40 13:16:2 Predicted 57.87 8.82 7.92 7.48 0.01	Stack C0 (14.20 0 13:30:00 11/21/20 Target < 25 (klb/h < 7.5 (nH < 7.5 (nH < 7.5 (nH 0	13:43:40 08 01:23:06 PM	(Deviations) O2 Split Sum of Fdr Bit Sum of Aux Bit (%Violations) Opacity	percent a unitiess ic unitiess	7.81 -0.01	-33.53	
- 02 Bia 12:21:00 1 MV Name UX:0PR AA SEL UX:0PR AB SEL UX:0PR CD SEL UX:0PR CD SEL UX:0PR CD SEL	ES (0.5) 12:44:20 13: Pre-Move 3:496 -4.186 1.059 2:233 -0.857 -2.374	07:40 13: Post-Move 3.371 -4.061 0.996 2.296 -0.859 -2.499	31:00 13		Objectives RH Spray Flo Mill 3F dP (in Mill 3C dP (in Mill 3E dP (in Sum of Fdr Bi IDF 3A Amps	- RHT_E Actual 55.93 8.82 7.92 7.48 0.02 431.8	40 13:16:2 Predicted 57.87 8.82 7.92 7.48 0.01 430.5	stack C 0 (14.20 0 13:30:00 11/21/20 C 25 (kb/h < 7.5 (nH < 7.5 (nH < 7.5 (nH < 7.5 (nH < 445 (A)	13:43:40 08 01:23:06 PM	(Deviations) O2 Split Sum of Fdr Bit Sum of Aux Bit (%Violations) Opacity O2 1, 2	percent a unitless ic unitless percent percent	7.81 -0.01	0.39 0.03 -33.53 4.7	
- 02 Bia 12:21:00 1 MV Name AUDOPR AA SEL AUDOPR AB SEL AUDOPR DE SEL AUDOPR DE SEL AUDOPR EF SEL	12:44:20 13: Pre-Move 3:496 -4:186 1:059 2:233 -0:857 -2:374 0:552	07:40 13: 3.371 -4.061 0.996 2.296 -0.859 -2.499 0.777	31:00 13		Objectives RH Spray Flo Mill 3F dP (in Mill 3G dP (in Mill 3E dP (in Sum of Fdt Bi IDF 3A Amps Sum of Aux B	- RHT_E Actual 55,93 8,82 7,92 7,48 0,02 431,8 0,02	40 13:16:2 Predicted 57.87 8.82 7.92 7.48 0.01 430.5 0.02	Stack C0 (14 20 0 13:30:00 11/21/20 <b>Target</b> < 25 (Ikb/h < 7.5 (imH < 7.5 (imH 0 < 445 (A) 0	13:43:40 08 01:23:06 PM	(Deviations) O2 Split Sum of Fdr Bit Sum of Aux Bit (%Violations) Opacity	percent a unitiess ic unitiess	7.81 -0.01	-33.53	
12:21:00 1 12:21:00 1 MV Name AUXOPR AA SEL AUXOPR BC SEL AUXOPR CD SEL AUXOPR CD SEL AUXOPR FF SEL FEEDER A SEL BI	12.44.20 13. Pre-Move 3.496 4.186 1.059 2.233 0.857 -2.374 0.652 -8	Post-Move 3.371 -4.061 0.996 2.296 -0.859 -2.499 0.777 -8	31:00 13		Objectives RH Spray Flo Mill 3F dP (in Mill 3C dP (in Mill 3E dP (in Sum of Fdr Bi IDF 3A Amps Sum of Aux B O2 Split (perc	- RHT_E Actual 59.93 59.93 8.82 7.92 7.48 0.02 431.8 0.02 431.02	8 (998,855) 40 13:16:2 Predicted 57,87 8.82 7,92 7,48 0.01 430.5 0.02 -0.22	Stack C0 (14 20 0 13:30:00 11/21/20 11/21/20 < 25 (kb/r) < 7.5 (mH < 7.5 (mH 0 < 445 (A) 0 0	13:43:40 08 01:23:06 PM	(Deviations) O2 Split Sum of Fdr Bit Sum of Aux Bit (%Violations) Opacity O2 1, 2	percent a unitless ic unitless percent percent	7.81 -0.01 t -4.27 t -3.81 t 0	0.39 0.03 -33.53 4.7	
- 02 Bia 12:21:00 1 MV Name AUDOPR AA SEL AUDOPR AB SEL AUDOPR DE SEL AUDOPR DE SEL AUDOPR EF SEL	ss (0.5) 12.44-20 13 Pre-Move 3.496 4.186 1.059 2.237 0.655 8 1.226	07:40 13: 3.371 -4.061 0.996 2.296 -0.859 -2.499 0.777	31:00 13		Objectives RH Spray Flo Mill 3F dP (in Mill 3G dP (in Mill 3E dP (in Sum of Fdt Bi IDF 3A Amps Sum of Aux B	- RHT_E Actual 55,93 8,82 7,92 7,48 0,02 431,8 0,02	40 13:16:2 Predicted 57.87 8.82 7.92 7.48 0.01 430.5 0.02	Stack C0 (14 20 0 13:30:00 11/21/20 <b>Target</b> < 25 (Ikb/h < 7.5 (imH < 7.5 (imH 0 < 445 (A) 0	13:43:40 08 01:23:06 PM	(Deviations) O2 Split Sum of Fdr Bit Sum of Aux Bit (%Violations) Opacity O2 1, 2 O2 3, 4	percent a unitiess is unitiess percent percent	-0.01 -0.01 t -4.27 t -3.81 t 0 9.63	0.39 0.03 -33.53 4.7 0	



# **Combining Neural with MPC**





#### **Typical CombustionOpt Benefits**

- NOx reductions of 10-15%
- Boiler efficiency increase of 0.5-0.75%
- CO controlled to desired limit
- Better ramping and load-following performance
- Reduced opacity excursions
- Avoided tail-chasing behavior
- Better adherence to fan and mill amp limits
- Improved situational awareness and process insight



### **CombustionOpt at DTE Belle River**

- B&W opposed wall-fired, balanced draft boiler built in 1984
- Normal full load of 645 gross MW, Max load with over-fire of 685 gross MW (turbine limited)
- Designed for and burns 100% PRB (Decker, Spring Creek, Wyoming)
- Pulverized coal from 8 B&W MPS-89 pulverizers, 7 operate during normal operation
- 5 burners per mill, 40 total
- Originally 4 burner levels per wall, burners replaced with LNB and redistributed into 3 levels
- Top level of burners replaced with OFA ports (1/3 and 2/3 control dampers in each port)
- 6 single-point extractive type O2 probes at economizer exit



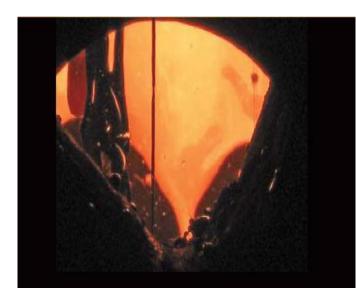


## **Unit 2 Performance Test Results**

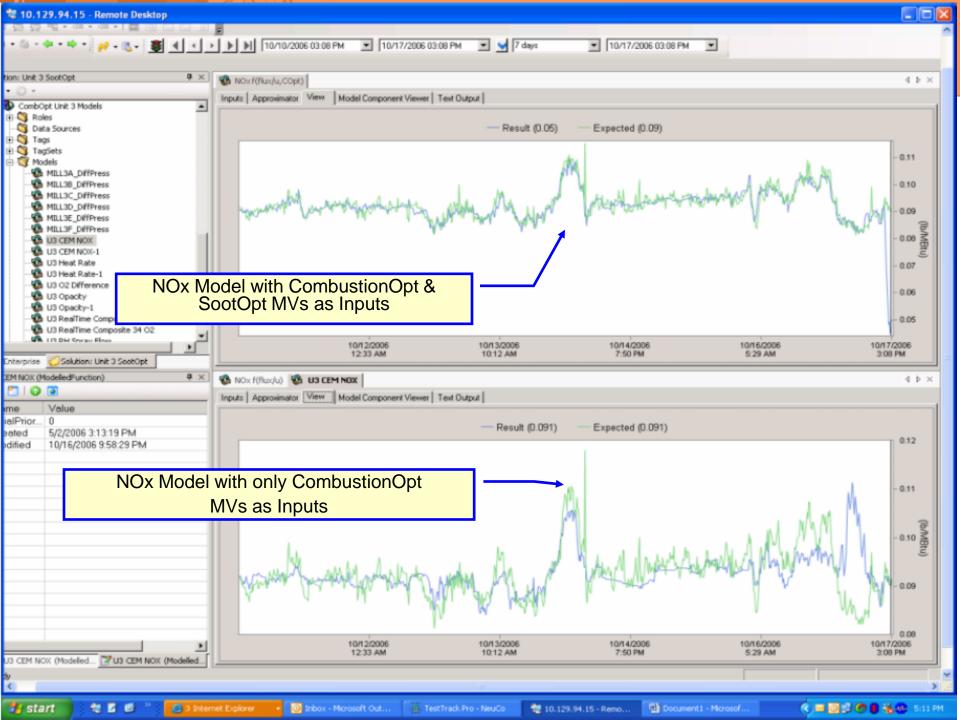
				Manua	al Tuning	Neuco	Tuning
	Baseline Heat Rate Test 07/27/10	Manual Tuning Heat Rate Test 07/28/10	Neuco Tuning Heat Rate Test 07/30/10	Manual Tuning Change (Absolute)	Manual Tuning Change (Relative, %)	Neuco Tuning Change (Absolute)	Neuco Tuning Change (Relative, %)
Gross Load, MW	647.954	647.948	645.058	-0.006	0.00%	-2.896	-0.45%
Net Load, MW	606.641	608.604	607.743	1.964	0.32%	1.102	0.18%
Auxiliary Power, MW	41.313	39.343	37.315	-1.970	-4.77%	-3.998	-9.68%
Raw Net Unit Heat Rate (Heatloss), BTU/kWhr		10402	10331	-115	-1.10%	-186.0	-1.77%
Corrected Net Unit Heat Rate (Heatloss), BTU/kWhr		10286	10224	-108	-1.0%	-169.184	-1.63%
Net Unit Heat Rate (Input/Output), BTU/kWhr		10362	Not Avail.	-131	-1.25%	Not Avail.	Not Avail.
Corrected Net Unit Heat Rate (Input/Output), BTU/kWhr		10358	Not Avail.	-100	-0.96%	Not Avail.	Not Avail.
NOx, Ib/MBTU	0.2513	0.2025	0.2010	-0.0488	-19.43%	-0.050	-20.02%
CO, PPM	88	78	157	-10	-11.18%	68.200	77.18%
CO2 Intensity, Tons CO2/MWhr		1.047	1.043	-0.02	-2.06%	-0.03	-2.43%
Total Boiler Air Flow, klb/hr		5926	5483	-387	-6.13%	-830	-13.14%
Average Excess O2, %		3.23%	2.45%	-1.15%	-26.31%	-0.019	-44.18%
Excess Air, %		20.75%	15.12%	9.75%	-31.97%	-15.38%	-50.43%



- 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









- 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

🗧 - 🔶 🔕 🚮	- 🍅 💊 -		Unit	2: Soot	Opt Ho	me			5/7/2	2009 08:28:00	AM (6 hours)	
ptimization Alerts								Op	timization Ben	chmarks		
🎦 🙄 🔍 🚫 Issue/	Action		Actua	al Target	III	-		•	Average Steam	Temperatures, So	ot Opt On vs. Off	
🐴 💱 🔍 A Some	blowers in the L_PrimarySH	Zone are below	v their 1	0	Low				Soot Opt Or		Opt Off, SH	
🐴 🎱 🔍 A Some	blowers in the L_PlatenSH 3	Zone are below	their 2	0	Low				SootOpt Or		Opt Off, RH Opt Off, Tilts	
🐴 🎱 🔍 A Some	blowers in the R_PlatenSH	Zone are below	their 2	0	Low					, APHGIT 📒 Soot		
🔂 🎱 🔍 A Some	blowers in the L_AirHeater 2	Zone are below	their 2	0	Low							٦
👌 🎱 🔍 🗛 Some	blowers in the L_Economize	er1 Zone are bel	ow th 2	0	Low						1. 11	
👌 🎱 🔍 A Some	blowers in the R_Economize	er1 Zone are bel	low th 2	0	Low						lin hi	1
👌 🏹 🔍 🗛 Some	blowers in the R_Economize	er2 Zone are bel	low th 1	0	Low			-				
ptimization Analysis												
ast Transition: 5/7/2009	8:28:14 AM 3:27:13 AM, Goal: L_RHT U;	p, Zone: L_Rehe	eat, Device: L1	_	Blower Sel <novarial< th=""><th></th><th>•</th><th></th><th>60</th><th>0<mil <799,="" a<="" th=""><th>800 <m <="" th=""><th>000</th></m></th></mil></th></novarial<>		•		60	0 <mil <799,="" a<="" th=""><th>800 <m <="" th=""><th>000</th></m></th></mil>	800 <m <="" th=""><th>000</th></m>	000
ast Transition: 5/7/2009	3:27:13 AM, Goal: L_RHT U			Blower Selec	<no th="" varial<=""><th>ole&gt;: NA</th><th>1</th><th></th><th></th><th></th><th></th><th>000</th></no>	ole>: NA	1					000
ast Transition: 5/7/2009 ( Zone Selection:	3:27:13 AM, Goal: L_RHT U; Zone	Eligible	Applicab	_	<no variat<br="">stion: Eligible</no>		Rank		Average Heat	Rate and NOx, Soo	tOpt On vs. Off	
.ast Transition: 5/7/2009 : Zone Selection: àoal _Nose TS	3:27:13 AM, Goal: L_RHT Up Zone L_Nose	Eligible	Applicab	Blower Select Blower L8_277	<no varial<br="">stion: Eligible</no>	ole>: NA	1		Average Heat	Rate and NOx, Soo GrossMW Soo C	tOpt On vs. Off	
.ast Transition: 5/7/2009 : Zone Selection: âoal _Nose TS }_Nose TS	3:27:13 AM, Goai: L_RHT Uj Zone L_Nose R_Nose	Eligible	Applicab	Blower Selec Blower	<no varial<br="">ction: Eligible</no>	ole>: NA	1		Average Heat Soo Opt On, Soot Opt On, Soot Opt On,	Rate and NOx, Soo GrossMW Soo NOx Soot NHR Soot	tOpt On vs. Off Opt Off, GrossMi Opt Off, NOx Opt Off, NHR	
Lest Evaluation: 5/7/2009 Lest Transition: 5/7/2009 Zone Selection: Soal _Nose TS _Nose TS _Nose TS _RHT Up _RHT Up	3:27:13 AM, Goal: L_RHT Up Zone L_Nose	Eligible X X	Applicab	Blower Select Blower L8_277 L9_278	<no varial<br="">stion: Eligible</no>	ole>: NA	1		Average Heat Soo Opt On, SootOpt On, SootOpt On, SootOpt On,	Rate and NOx, Soo GrossMW Soo NOx Soot NHR Soot	tOpt On vs. Off Opt Off, GrossMi Opt Off, NOx Opt Off, NHR Opt Off, CO	N
.ast Transition: 5/7/2009 : Zone Selection: Nose TS 3_Nose TS Rose TS RHT Up	327:13 AM, Goai: L_RHT Uj Zone L_Nose R_Nose L_Reheat	Eligible X X	Applicab	Blower Select Blower L8_277 L9_278 L10_279	<no varial<br="">stion: Eligible X X</no>	ole>: NA	1		Average Heat Soo Opt On, SootOpt On, SootOpt On, SootOpt On,	Rate and NOx, Soo GrossMW Soot NOx Soot NHR Soot CO Soot Opacity Soot	tOpt On vs. Off Opt Off, GrossMi Opt Off, NOx Opt Off, NHR Opt Off, CO	N
Last Transition: 5/7/2009 ( Zane Selection: _Nose TS _Nose TS _Rhose TS _RHT Up	3.27:13 AM, Goak L_RHT U;        Zone        L_Nose        R_Nose        L_Reheat        L_Economizer1	Eligible X X X	Applicab	Blower Select Blower L8_277 L9_278 L10_279 L12_281	<no varial<br="">stion: Eligible X X X</no>	ole>: NA	1		Average Heat Soo Opt On, SootOpt On, SootOpt On, Soo Opt On, SootOpt On,	Rate and NOx, Soo GrossMW Soot NOx Soot NHR Soot CO Soot Opacity Soot	tOpt On vs. Off Opt Off, GrossMi Opt Off, NOx Opt Off, NHR Opt Off, CO Opt Off, Opacity	N
.ast Transition: 5/7/2009 / Zone Selection: .Nose TS 	227.13 AM, Goat L_RHT Uj Zone L_Nose R_Nose L_Reheat L_Economizer1 L_Reheat	Eligible X X V X	Applicab ✓ ✓ ✓ ✓ ✓ ✓	Blower Select Blower L8_277 L9_278 L10_279 L12_281	<no varial<br="">stion: Eligible X X X</no>	ole>: NA	1		Average Heat Soo Opt On, SootOpt On, SootOpt On, Soo Opt On, SootOpt On,	Rate and NOx, Soo GrossMW Soot NOx Soot NHR Soot CO Soot Opacity Soot	tOpt On vs. Off Opt Off, GrossMi Opt Off, NOx Opt Off, NHR Opt Off, CO Opt Off, Opacity	N

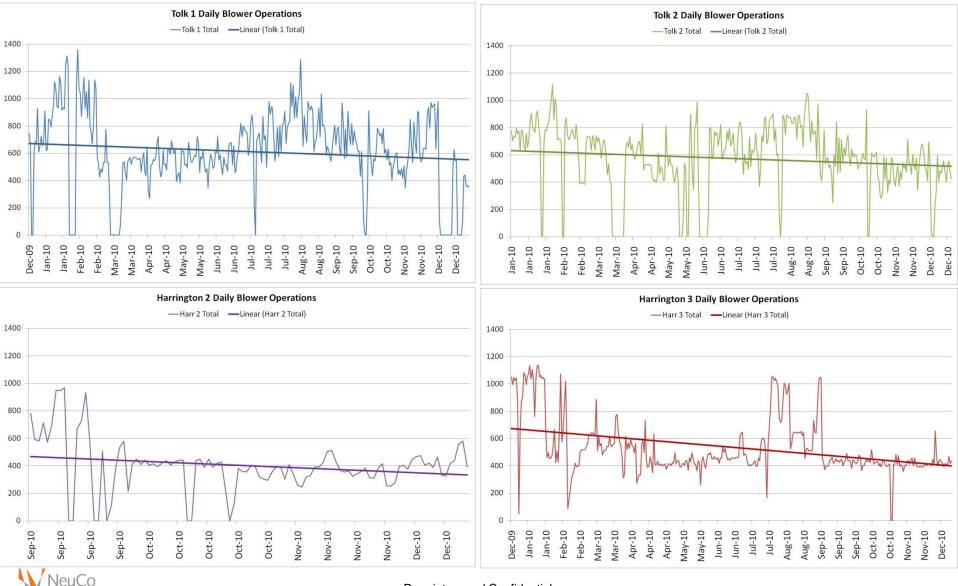


# **Typical SootOpt Benefits**

- Reduced and more tightly controlled APH inlet temps
- Improved SH and RH steam temperature control
- Reduced attemperation sprays
- Heat rate reduction of 0.75-1.00%
- Incremental NOx reduction of 2.5-5%
- Avoided opacity excursions
- Reduced blowing of 10-35%
- Avoided thermal stress from blowing clean surfaces
- Fewer tube-leak failures
- Improved situation awareness and process insight

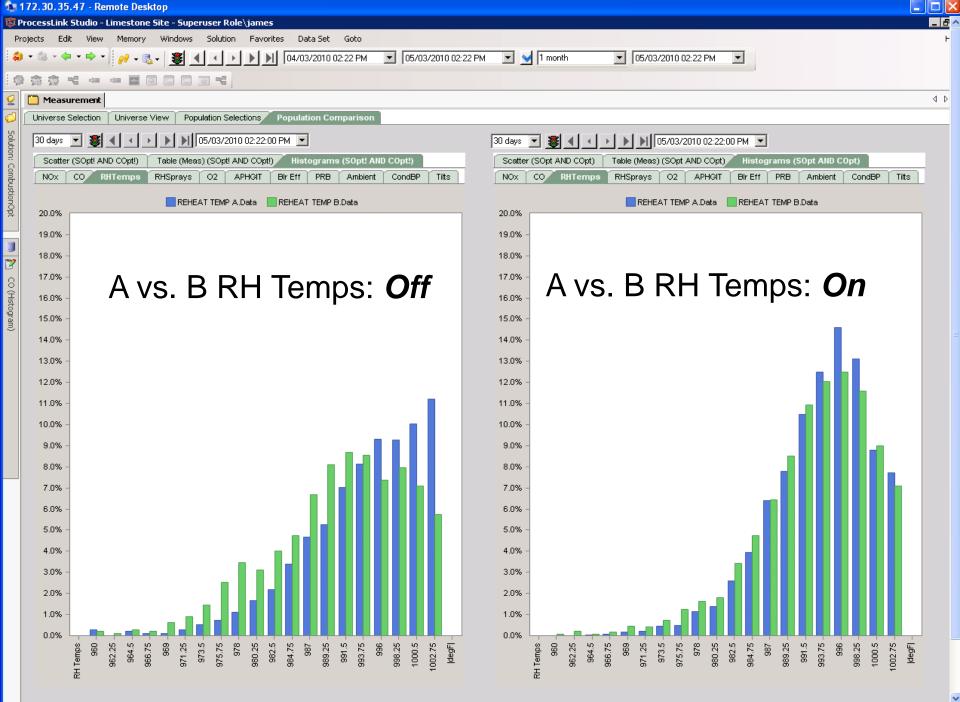


## **Blower Count Trends**

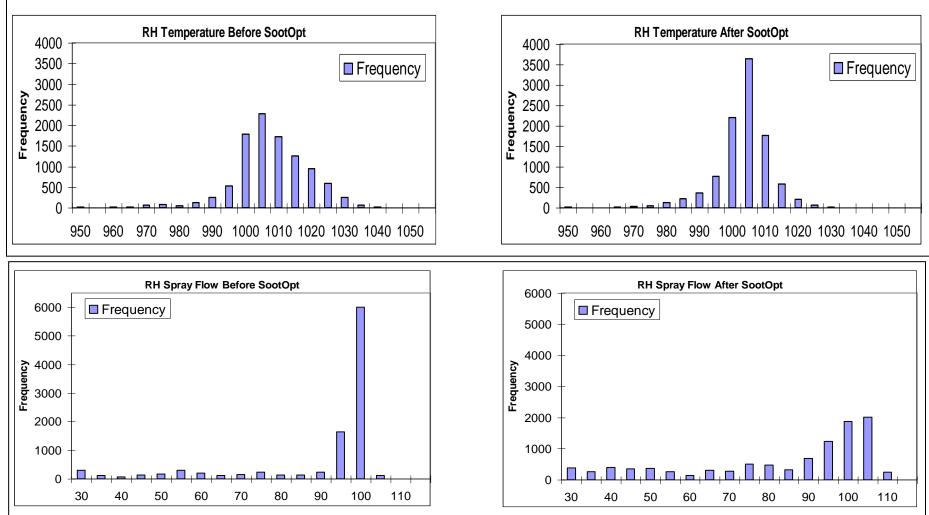


Proprietary and Confidential

The Optimization Standard™



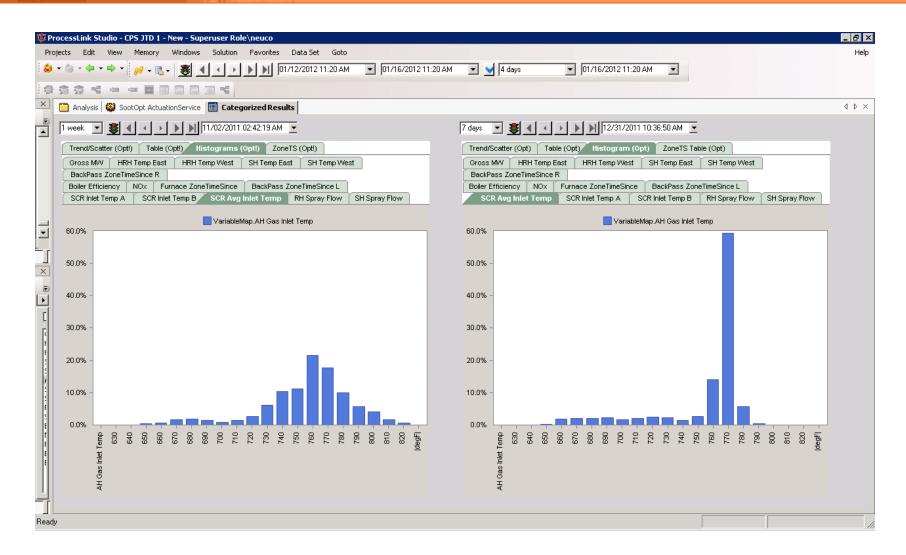
#### RH Temps & Sprays – SootOpt Before vs. After





Proprietary and Confidential

#### Typical Gas Inlet Temps SootOpt Off vs. On





Proprietary and Confidential

### **BoilerOpt Availability Mechanisms**

- Reduced Boiler Tube Leak Outages
  - Less unnecessary cleaning (SootOpt)
  - Avoided thermal stress (SootOpt & CombustionOpt)
- Avoided Slagging/Fouling De-Rates & Outages
  - Pro-active cleaning for vulnerable surfaces (SootOpt)
  - Improved stoichiometry control (CombustionOpt)
  - Tighter control of gas path temperatures (SootOpt & CombustionOpt)
  - Reduced ammonium bi-sulfate air heater pluggage (SootOpt & CombustionOpt)
- Improved Situational Awareness
  - Overtaxed mills and fans (CombustionOpt)
  - Malfunctioning sootblowers (SootOpt)



Insufficient media (SootOpt)

### **BoilerOpt Efficiency Mechanisms**

- Boiler Efficiency
  - Reduced O2 (CombustionOpt)
  - More balanced fuel and air distribution (CombustionOpt)
  - Improved heat transfer (SootOpt)
  - Better gas temperature control (SootOpt)
    - APH gas inlet temps
    - Economizer inlet and exit temps
    - Furnace exit gas temperature (FEGT)
- Additional Heat Rate Components
  - Better superheat steam temperature control (SootOpt)
  - Better reheat steam temperature control (SootOpt)
  - Reduced attemperation sprays (SootOpt)



#### **BoilerOpt Emissions Mechanisms**

#### NOx

- More balanced fuel-air distribution (CombustionOpt)
- Reduced overall O2 (CombustionOpt)
- More balanced temperature profile (SootOpt)

#### CO

- Explicitly controlling to desired limit (CombustionOpt)
- Fewer pockets of oxygen-deficient combustion (CombustionOpt)

### Opacity

- Proactive cleaning to avoid ash accumulation (SootOpt)
- Not cleaning specified zones when opacity trending high (SootOpt)
- More balanced fuel-air distribution (CombustionOpt)
- Preemptively increasing O<sub>2</sub> to manage excursions (CombustionOpt)

## • CO<sub>2</sub>

- Improved boiler efficiency (CombustionOpt)
- Tighter steam and gas temperature control (SootOpt)
- Reduced unnecessary attemperation sprays (CombustionOpt and SootOpt)



# **Questions?**

#### Peter Spinney spinney@neuco.net

