# Boiler Optimization and MATS Work Practices Requirements

*McIlvaine Hot Topics*

*July 10th, 2013*

NeuCo
The Optimization Standard™

ProcessLink®

# Mercury and Air Toxics Standard (MATS)

- Requires all plants to reduce mercury and increase efficiency to mitigate unmeasurable air toxics
  - Requires an efficiency evaluation 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

# 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 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

# Benefits of Neural Network Optimization for MATS Work Practices Requirements

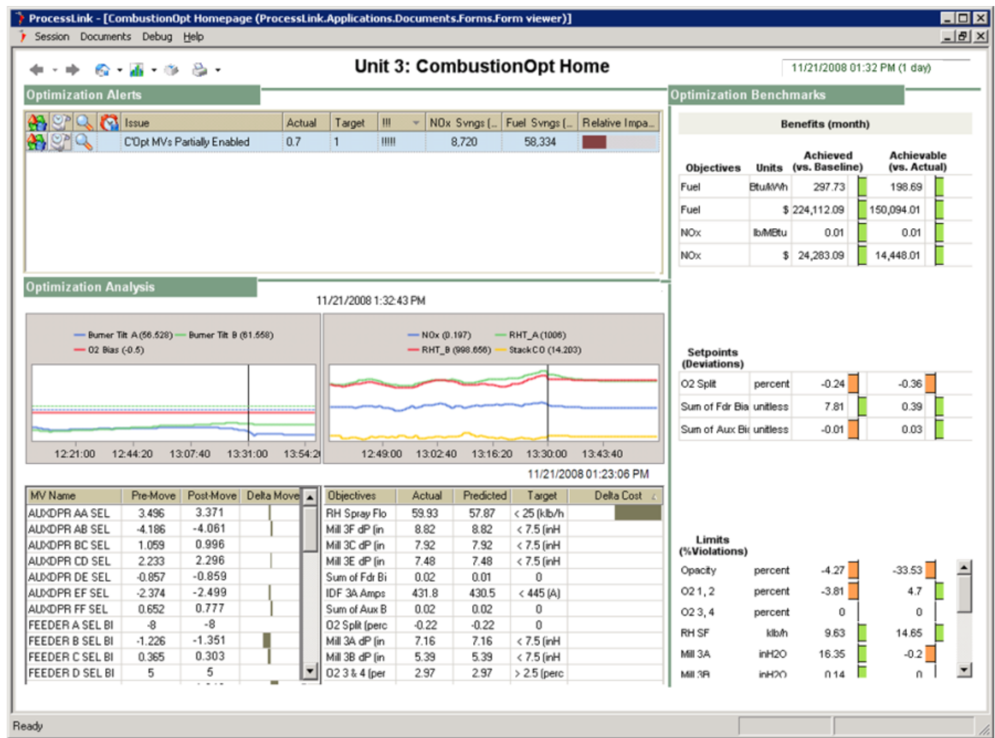
- Clearly demonstrate "optimization of NOx and CO"
- Defer initial boiler tune-up by one full year
  - Learn how EPA enforces rule for those not employing neural optimization
  - Better plan for initial tune-up and associated repairs
  - Avoid or defer outage associated with tune-up
- Simplify emissions 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, Regional Haze
  - $CO_2$ for plants triggering New Source Review
  - And now $CO_2$ 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®

- 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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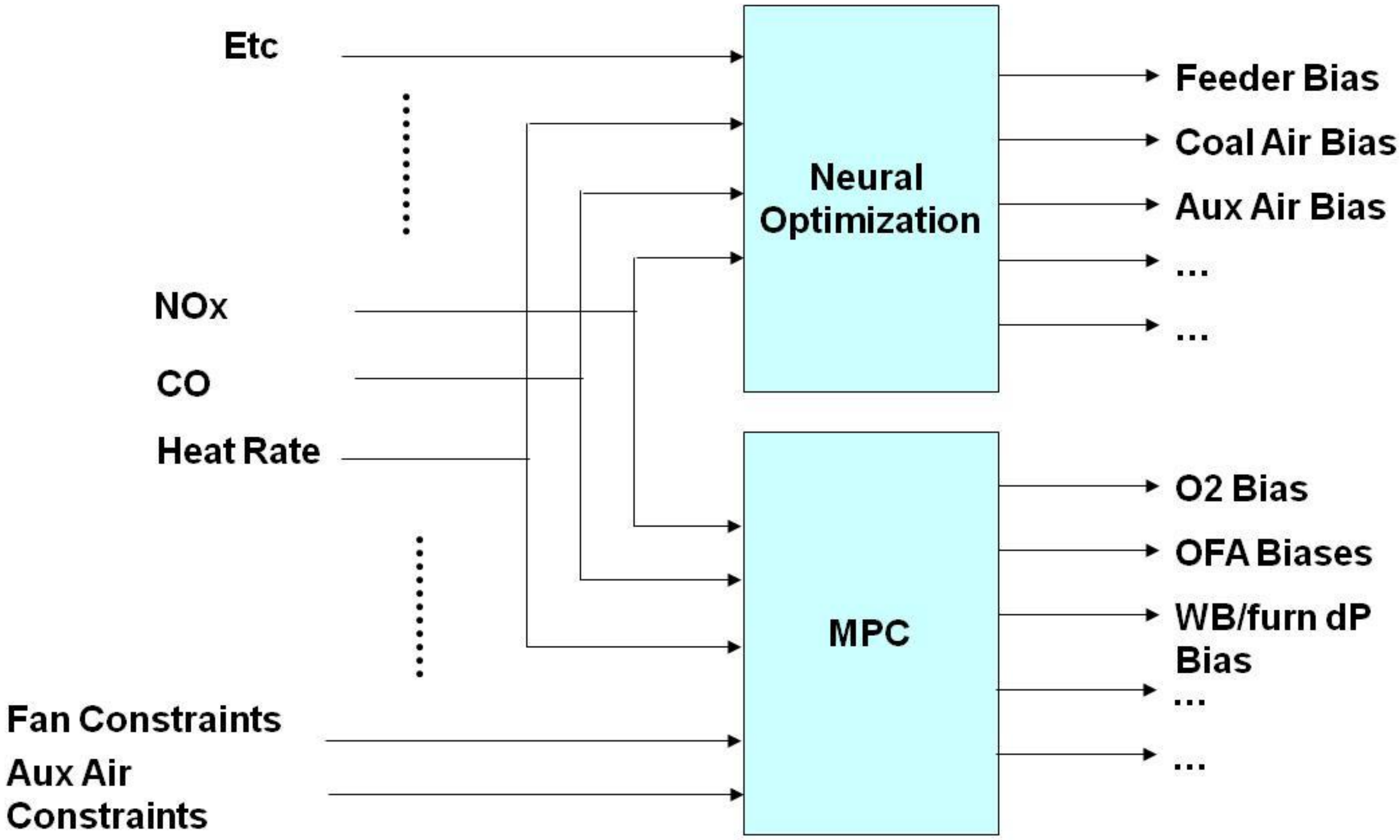
# Combining Neural with MPC

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# 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

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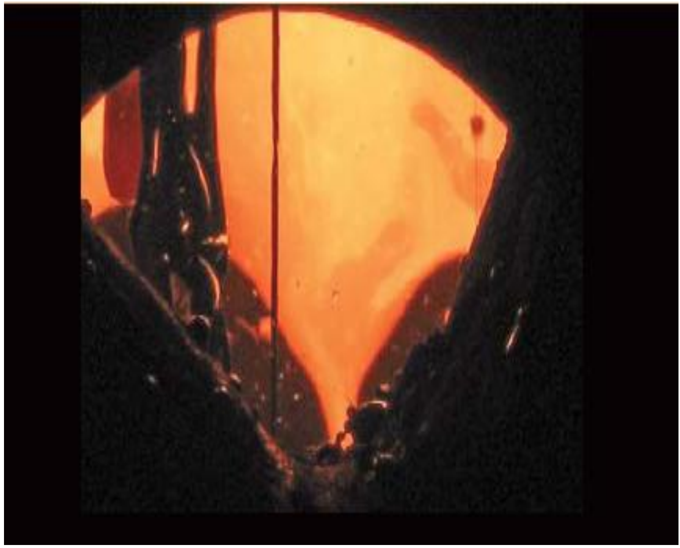
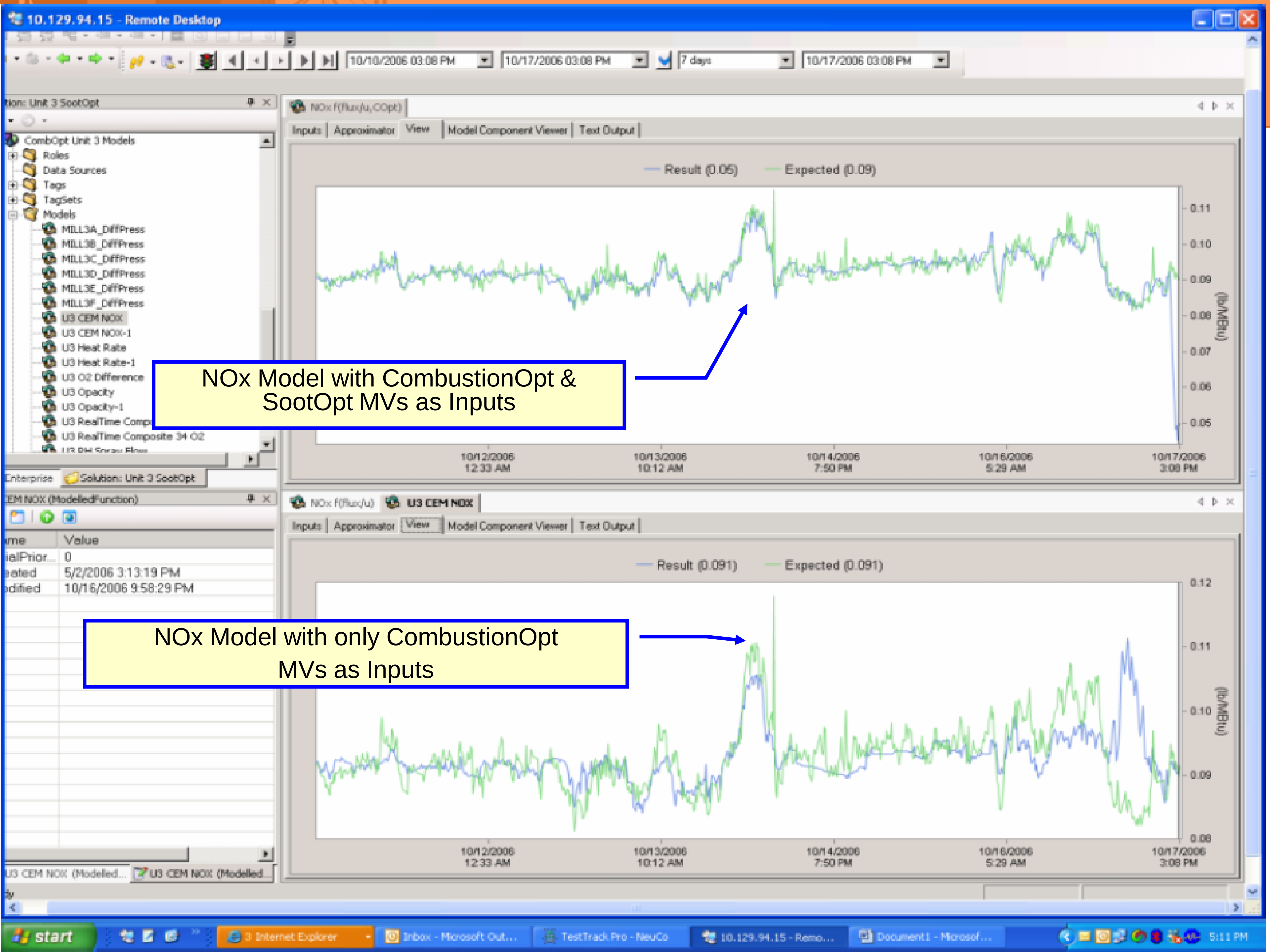
# Unit 2 Performance Test Results

| | | | | Manual 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** | 10517 | 10402 | 10331 | -115 | -1.10% | -186.0 | -1.77% |
| **Corrected Net Unit Heat Rate (Heatloss), BTU/kWhr** | 10393 | 10286 | 10224 | **-108** | **-1.0%** | **-169.184** | **-1.63%** |
| **Net Unit Heat Rate (Input/Output), BTU/kWhr** | 10493 | 10362 | Not Avail. | -131 | -1.25% | Not Avail. | Not Avail. |
| **Corrected Net Unit Heat Rate (Input/Output), BTU/kWhr** | 10458 | 10358 | Not Avail. | -100 | -0.96% | Not Avail. | Not Avail. |
| **NOx, lb/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** | 1.069 | 1.047 | 1.043 | **-0.02** | **-2.06%** | **-0.03** | **-2.43%** |
| **Total Boiler Air Flow, klb/hr** | 6313 | 5926 | 5483 | -387 | -6.13% | -830 | -13.14% |
| **Average Excess O2, %** | 4.39% | 3.23% | 2.45% | -1.15% | -26.31% | -0.019 | -44.18% |
| **Excess Air, %** | 30.50% | 20.75% | 15.12% | **9.75%** | **-31.97%** | **-15.38%** | **-50.43%** |

# 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

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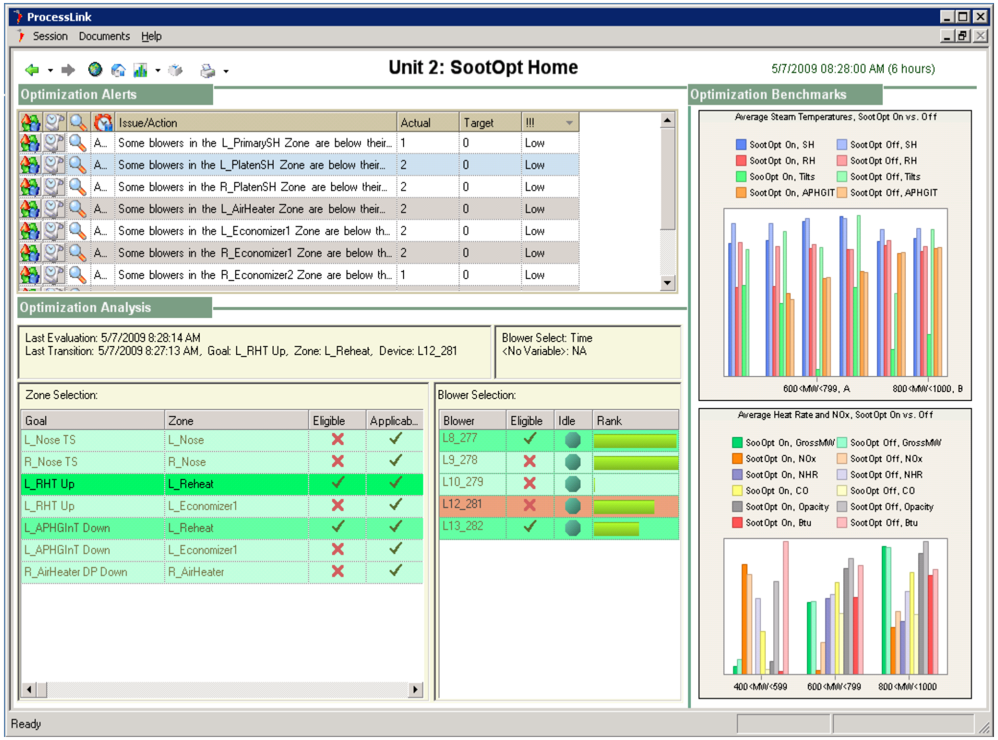
# SootOpt ®

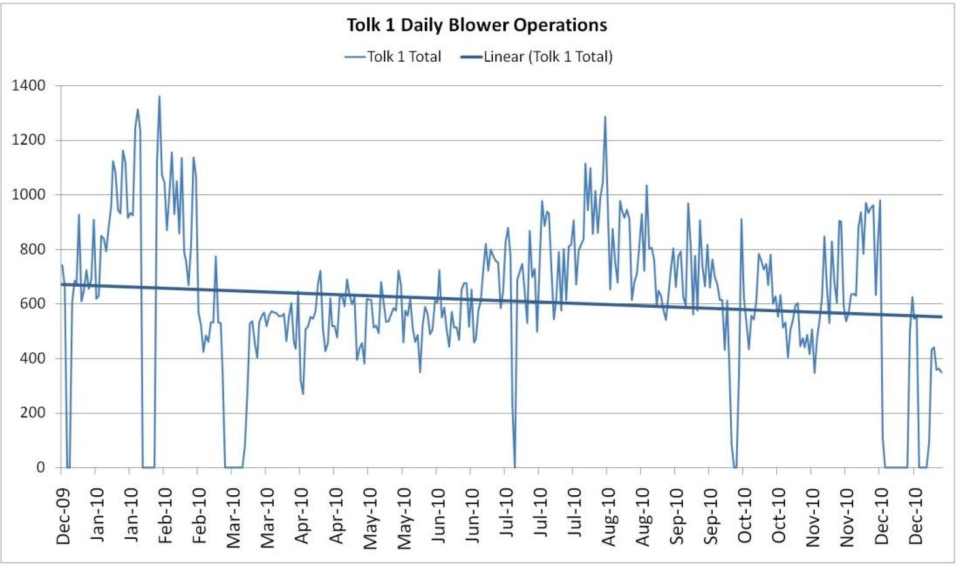
- Provides real-time closed-loop optimization of soot cleaning equipment
- Using:
  - Expert Rules
  - Neural Networks
- To Improve:
  - Sootblowing consistency
  - Unnecessary sootblowing
  - Steam temps
  - Sprays
  - Leverage on heat rate

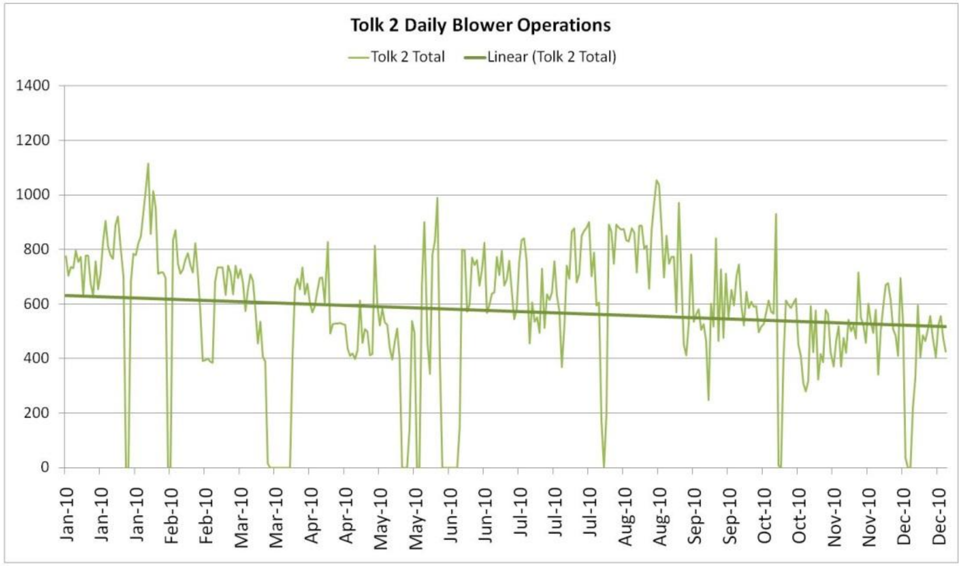


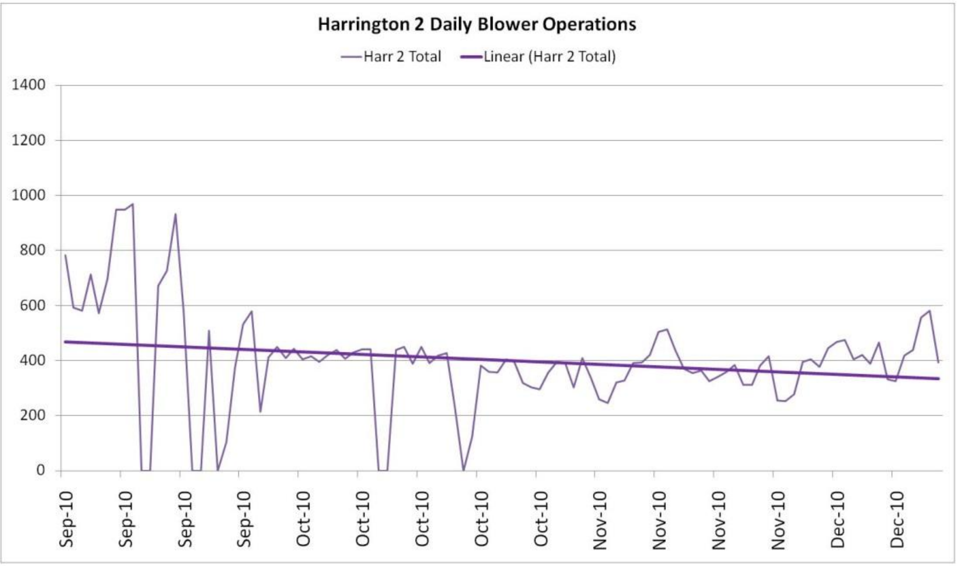
# Typical SootOpt Benefits

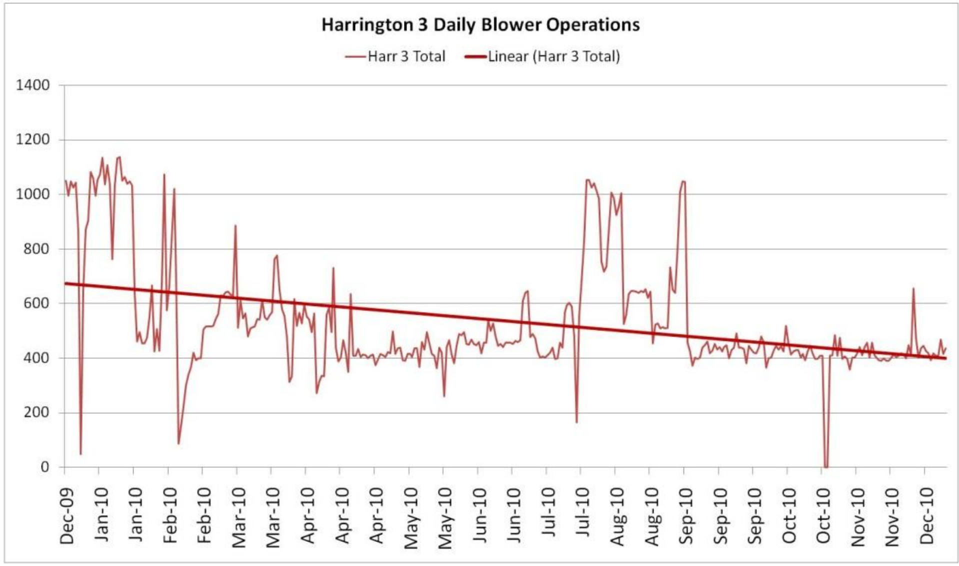
- Reduced and more tightly controlled APH inlet temps
- Improved SH and RH steam temperature control
- Reduced attemperation sprays
- Heat rate reduction of 0.75-1.00%
- Incremental NOx reduction of 2.5-5%
- Avoided opacity excursions
- Reduced blowing of 10-35%
- Avoided thermal stress from blowing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

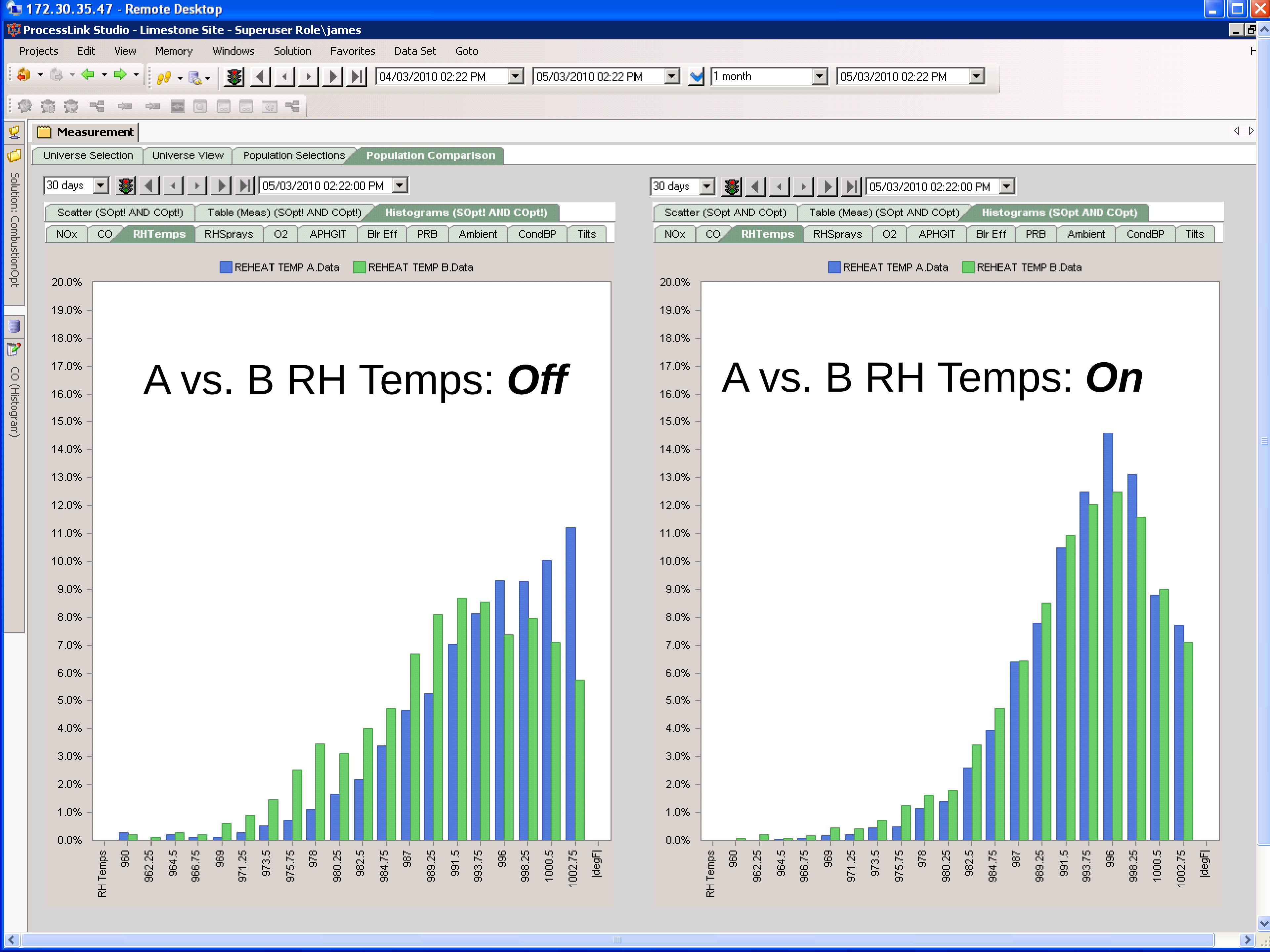
# Blower Count Trends

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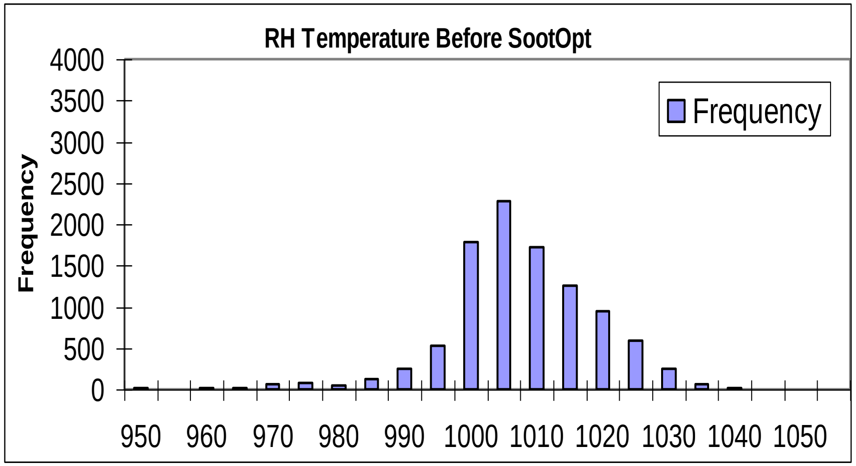
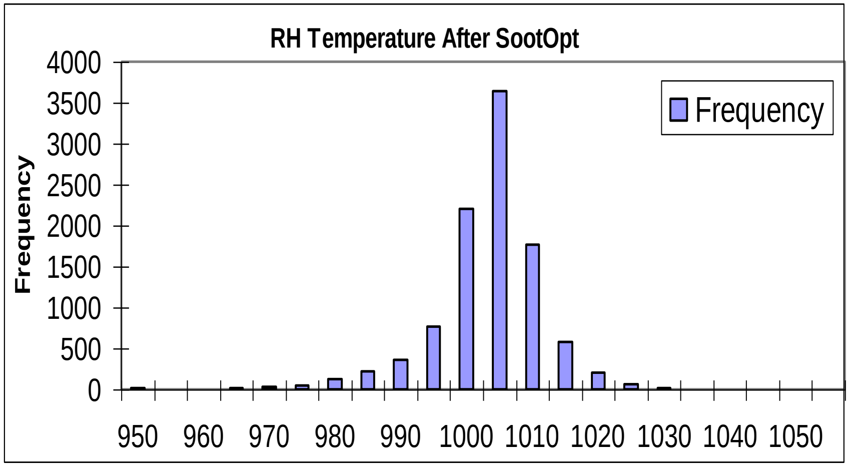
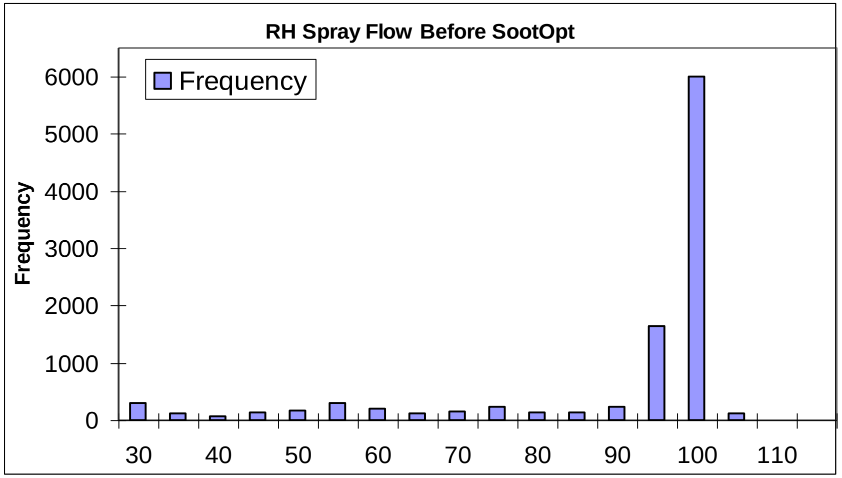
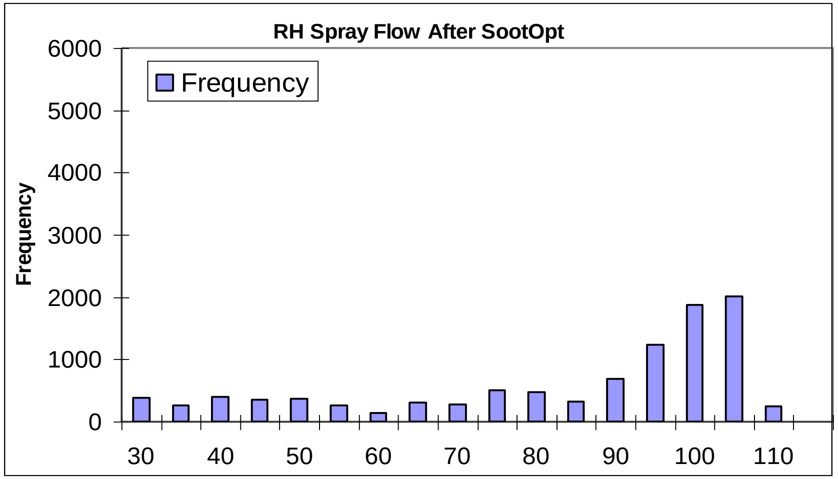
# RH Temps & Sprays – SootOpt Before vs. After

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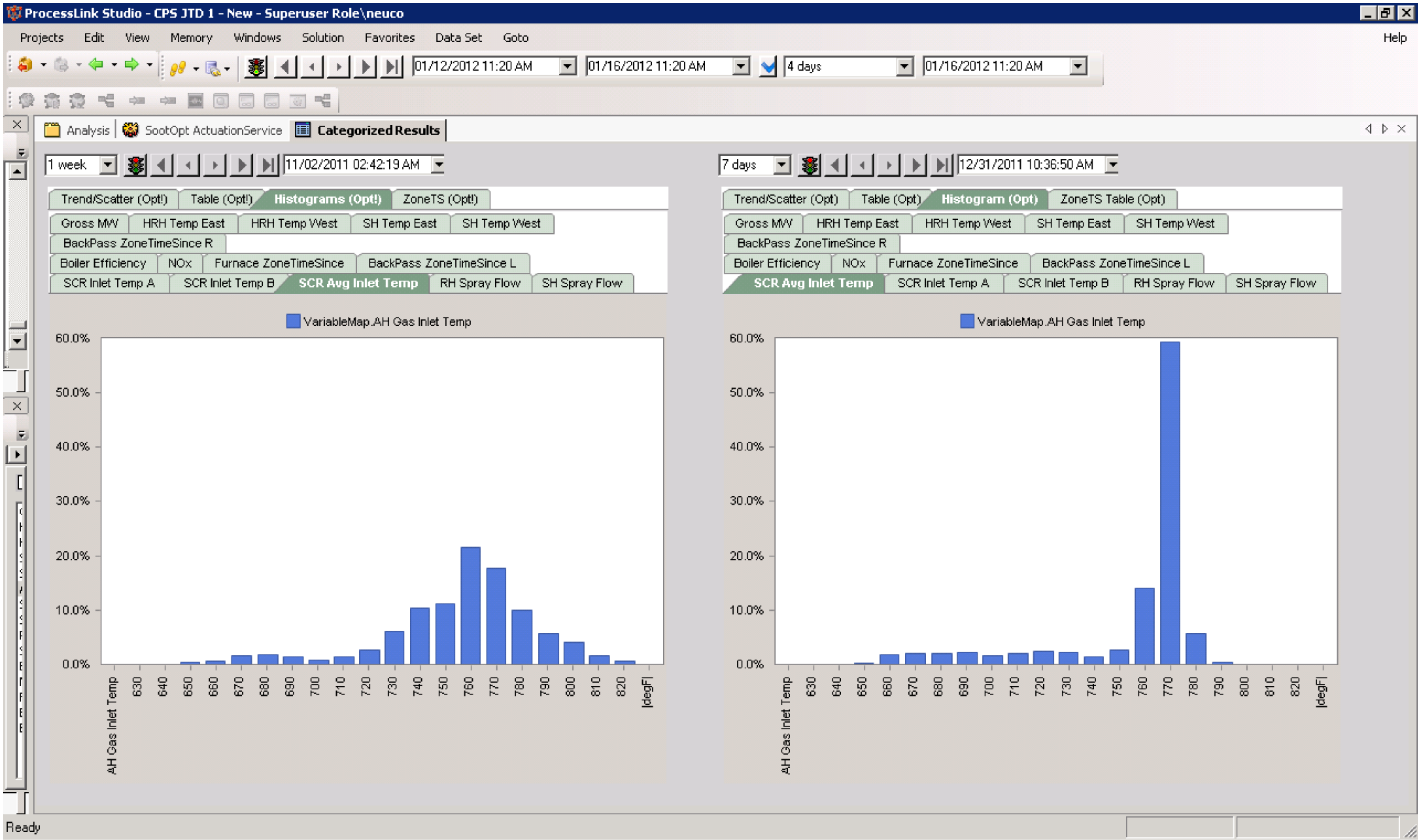
# Typical Gas Inlet Temps SootOpt Off vs. On

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# 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 $O_2$ to manage excursions (CombustionOpt)
- $CO_2$
  - Improved boiler efficiency (CombustionOpt)
  - Tighter steam and gas temperature control (SootOpt)
  - Reduced unnecessary attemperation sprays (CombustionOpt and SootOpt)

# Questions?

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