



GAS-SIDE OPTIMIZATION OF FOSSIL-FIRED POWER GENERATION

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MCILVAINE HOT TOPICS

WEDNESDAY, NOVEMBER 8, 2017

THE POWER INDUSTRY IS CHANGING

Generational Turnover in Equipment and Staff

30% of the electric utility workforce is projected to retire within the next 5 years

But large uncertainties in emissions regulation

Impact of Renewables & Changing Costs, Demand & Regulations

Renewable energy predicted to become the world's largest source of electricity within 15 years

Coal based power expected to contribute over 30% of the world's electricity through 2025 ¹

Variable fuel prices & quality affect operating margins

Units designed for baseload now cycling continuously

Growing pressure to reduce emissions affect operations



¹ U.S. Energy Information Association (EIA), 2016

MAJOR FOSSIL-STEAM-FIRED BOILER DESIGNS

- Pulverized Coal
 - Wall-fired
 - Tangentially Fired
 - Turbo
- Circulating Fluidized Bed (CFB)
 - Pressurized
 - Atmospheric
 - Bubbling
- Stoker
- Integrated Gasified Coal Combined Cycle

OPPORTUNITIES FOR EFFICIENCY & EMISSIONS PERFORMANCE

- Boiler
 - Thermal performance monitoring
 - Boiler tuning
 - Combustion optimization
 - Boiler cleanliness optimization
- Air Quality Control Systems (AQCS)
 - SCR tuning
 - SCR/SNCR optimization
 - FGD optimization
 - Hg optimization
- Turbine
 - Thermal performance monitoring
 - Sliding pressure throttle control
- Balance of Plant
 - Cooling tower, condenser, outlet water temperature, etc.

COAL QUALITY IS IMPORTANT

- Heat content, sulfur, hardness, grind-ability and other chemical constituents have big implication .
- Major classifications based on heat content: in descending order:
 - Anthracite
 - Bituminous
 - Subbituminous
 - Lignite
 - Peat
- Powder River Basin (PRB) coal in US a major emissions compliance strategy
- Boilers burning off-design fuels have challenges and opportunities
- Large wave of conversions from coal to natural gas in early phase
- Outcome will be affected by both regulation and natural gas proces

BOILER OPTIMIZATION

- Applies AI optimization in a real-time closed-loop application
 - ✓ Integrates fuel / air and sootblowing management
 - ✓ The same brain operates 24 X 7 X 365
 - ✓ Integrates directly into plant control
 - ✓ Provides analytics on premise and to remote users
 - ✓ Deploys integrated optimization – MPC, neural networks, heuristics, first principals – to best address complex, real world problems in closed loop

TYPICAL BOILER OPTIMIZATION BENEFITS

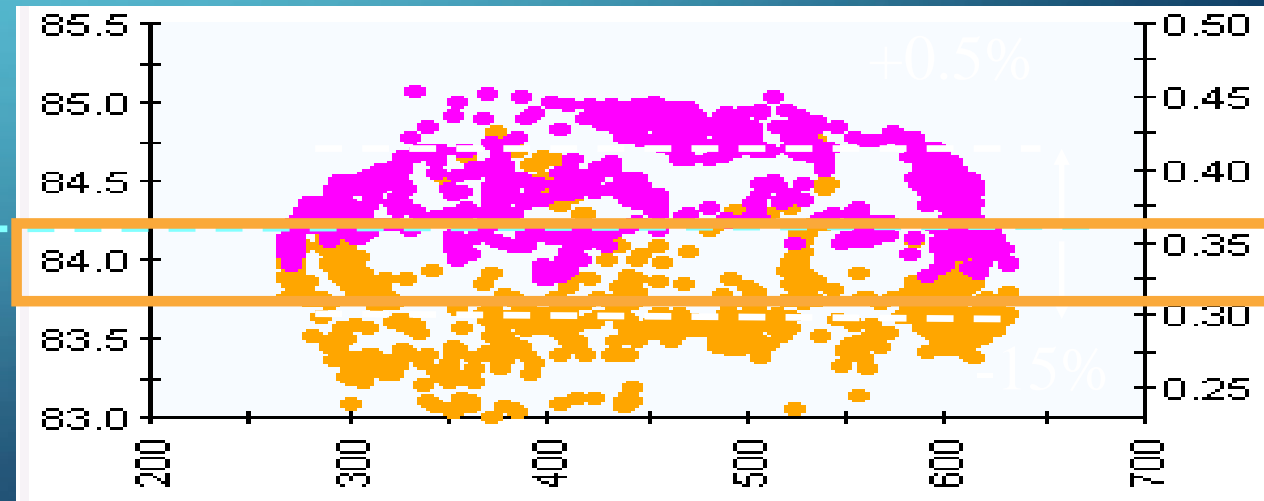
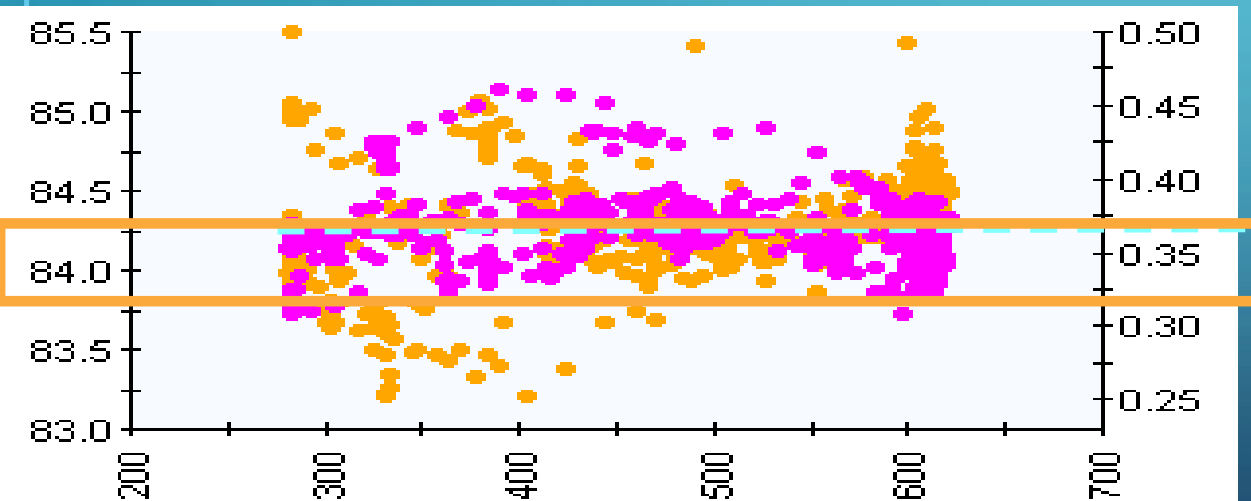
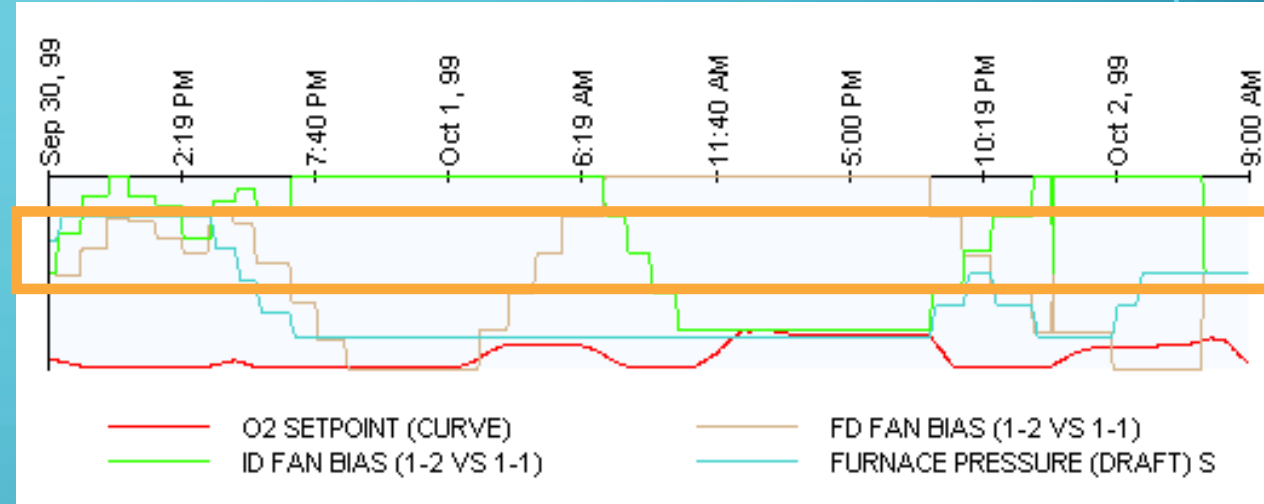
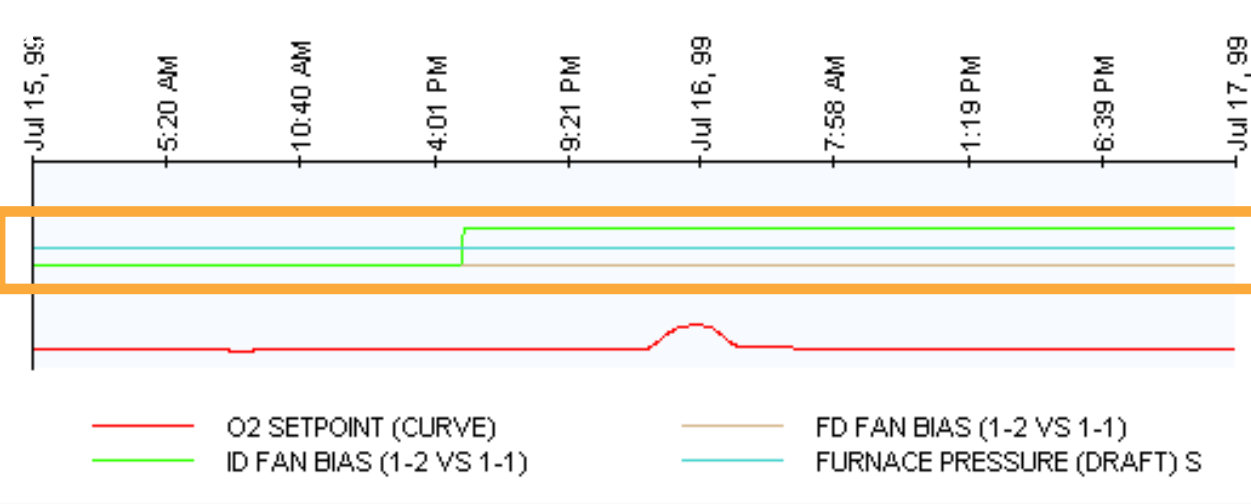
400 MW UNIT FIRING PRB W/80% CAPACITY FACTOR

Benefit Type	Plant Y Unit 1
Availability (W/Avoided MATS Lost Revenue)	\$811,286
Fuel Savings	\$567,148
NOx Reduction Value	\$26,254
Avoided MATS Inspection/Tuning/Testing Costs	\$86,667
<i>Total Availability, Fuel, Nox & MATS Benefits</i>	<i>\$1,491,355</i>
Potential CO2 Benefits	\$357,500
<i>Total Potential Benefits</i>	<i>\$1,848,855</i>

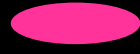
TYPICAL COMBUSTIONOPT BENEFITS

- NO_x 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

IMPACT ON OPERATIONS & PERFORMANCE



Boiler Efficiency



NOx

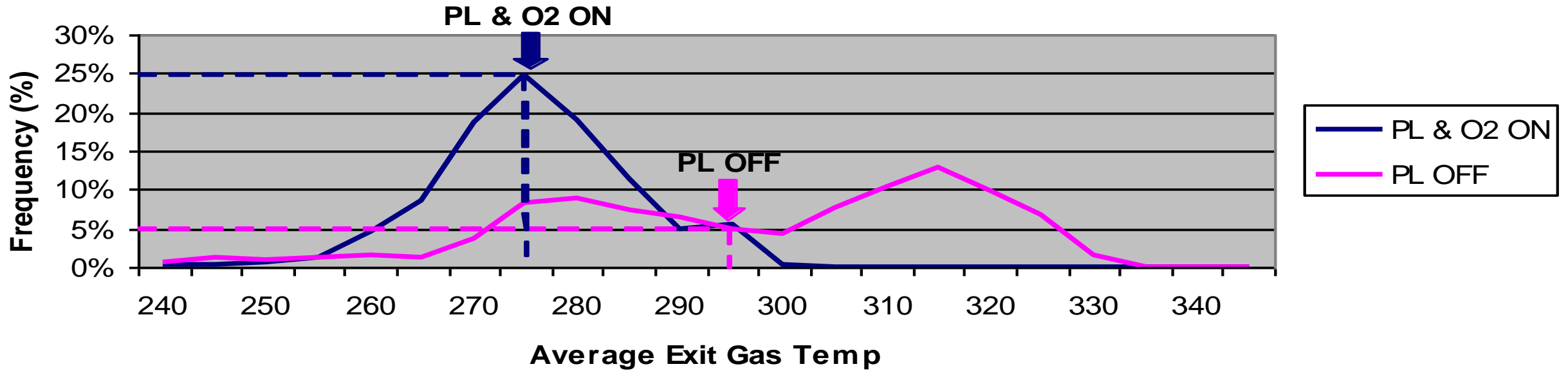


SAME UNIT 1 FIVE YEARS LATER (1/1/05)



EXIT GAS TEMPERATURE IMPACT

Average Exit Gas Temp



Soot Blower Control System HMI

FoxView AW2002:AW2002 - soot_blwr

File Config Disp Das Trends Lab Tech tune Ash sootb Op_Trends Tech_Trends SftMnt Applic Help

System Process 04-14-09 09:28 AM

Prev Disp Main Menu Change Env FoxSelect LMCC Gen Master Sta Power Turb Master Blr Master Burners SH Temps RH Temps Drum Level Soot Blwr Cems Trend Aux Air Comb Opt Silence Horns

Soot Opt Master

Disable Enable

Soot Opt Permissives

Watch Dog Timer OK
All Sequences Stopped

SEQ #	STATUS
SEQ 1	STOPPED
SEQ 2	STOPPED
SEQ 3	STOPPED
SEQ 4	STOPPED
SEQ 5	STOPPED
SEQ 6	STOPPED
SEQ 7	STOPPED
SEQ 8	STOPPED

NUMBER OF IR BLOWERS 3

Sootblowers

S/B Air Avail SBOPT Request Start Permits Legend Logs Disp Alarm Enable

RIGHT

1.12 amps

SBOPT Blwr Rqstd IK02 Last Rqstd IK15

1.12 amps

-0.00 amps

REAR

LOCK OUT LOCK OUT NOTES UNLOCK START

SEQUENCE STATUS

SootOpt

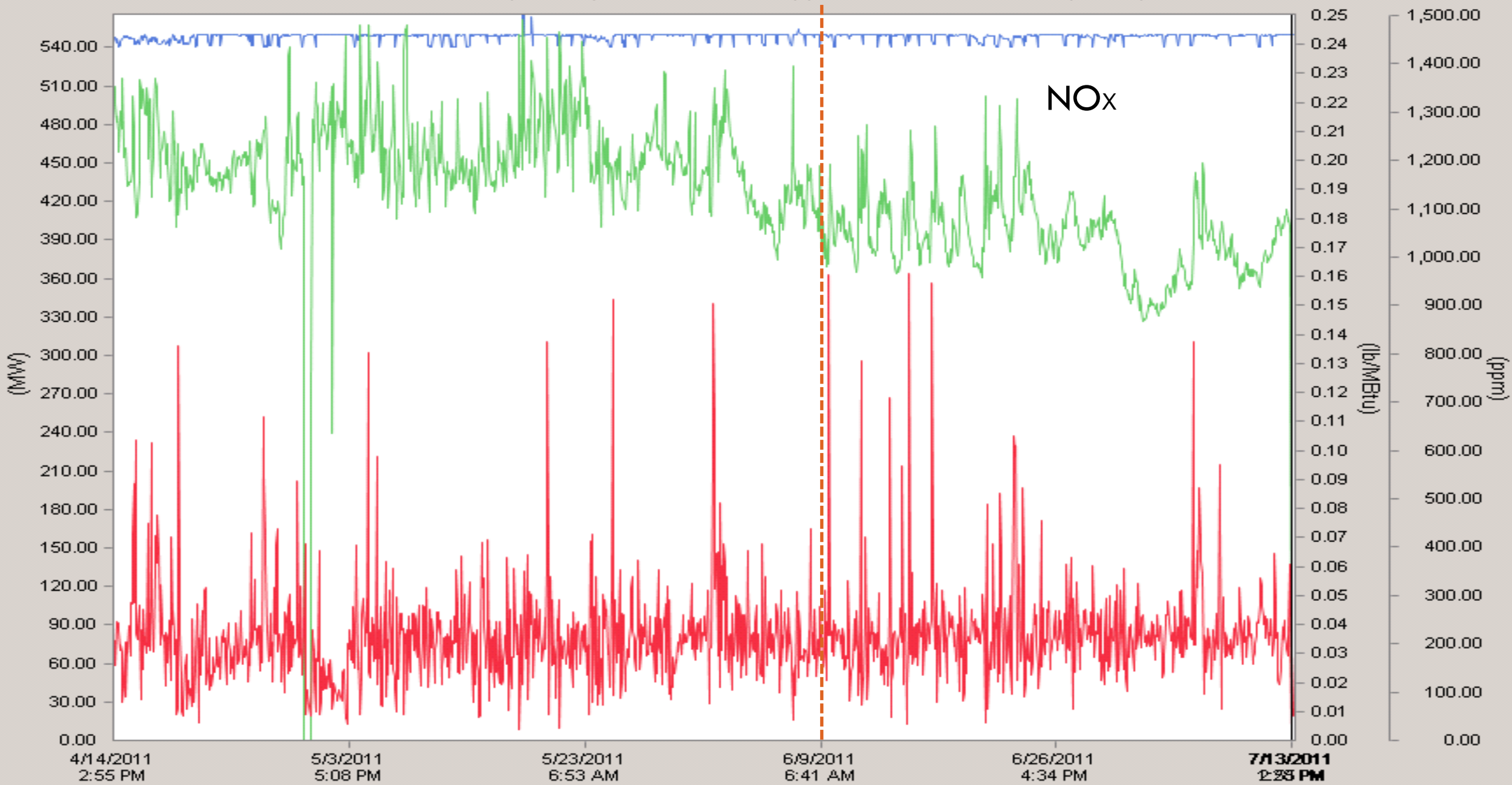
P1 P2 P3 P4 P5 P6 P7 P8

/opt/sootb/soot_blwr.fdf

T2_Eng Overlay:0

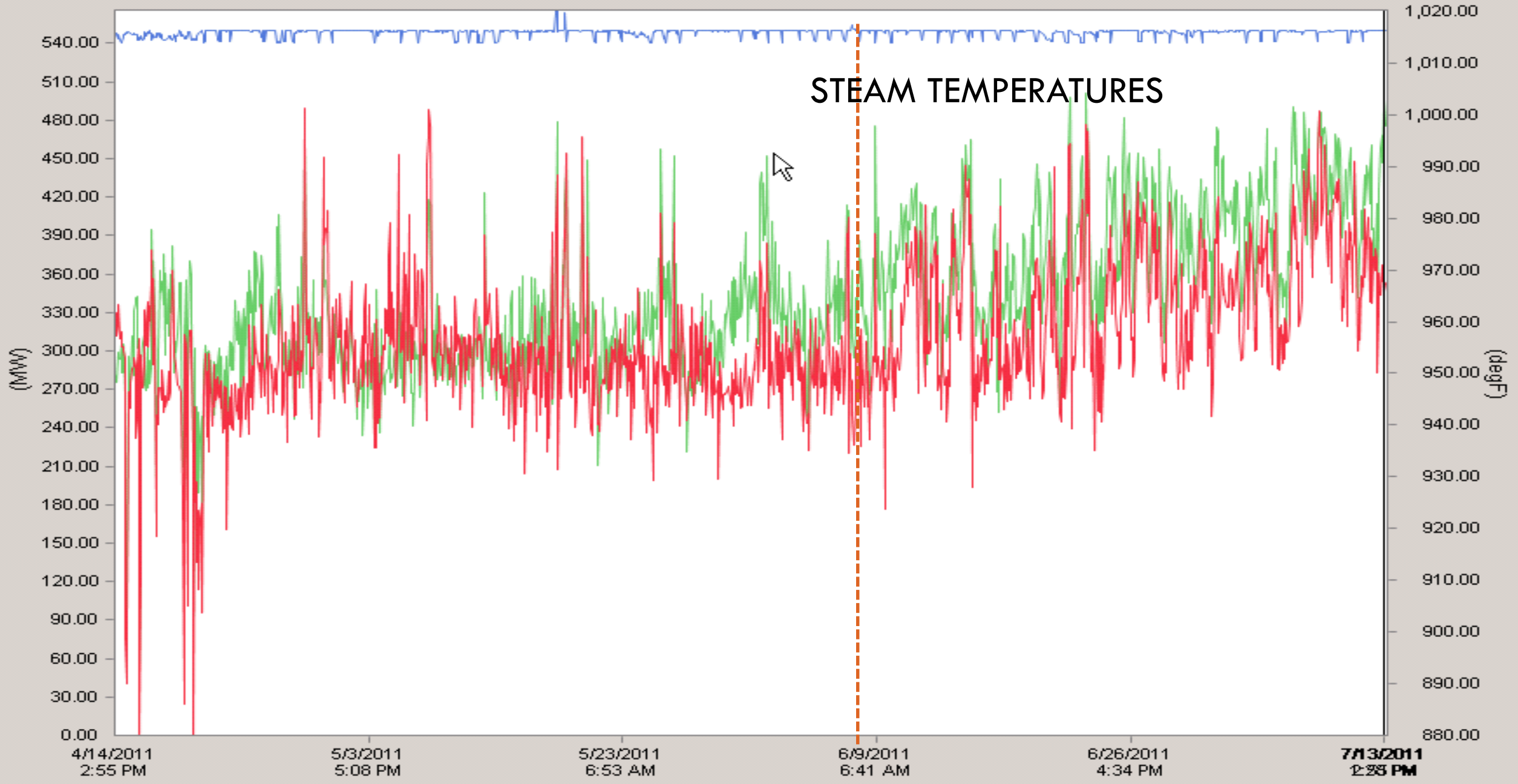
Trend Talk2

— Gross MW A (549.992) — STACK NO_x (0) — STACK CO (51.305)



Trend Talk2

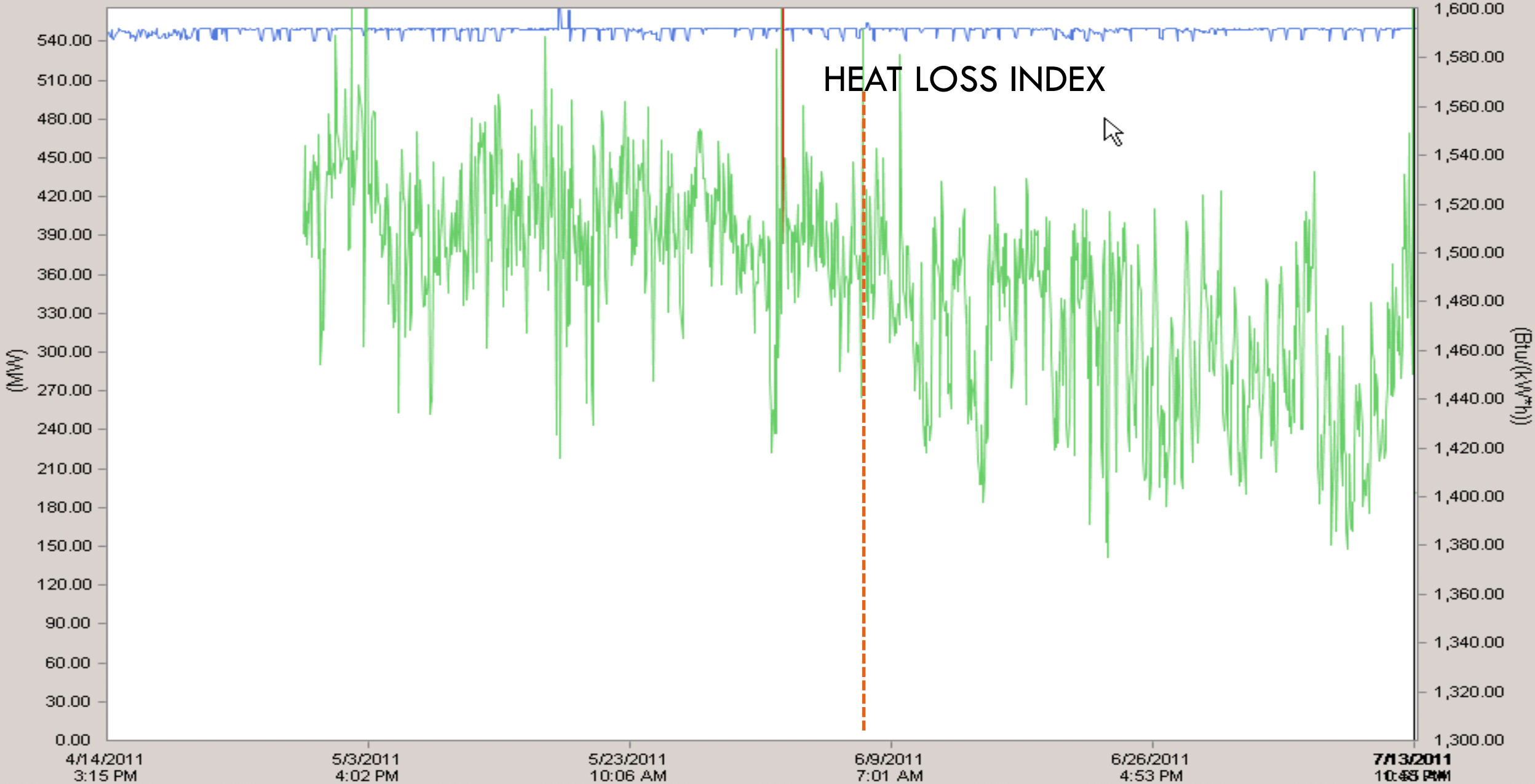
Gross MW A (549.992) RH Temp East (997.976) RH Temp West (967.615)



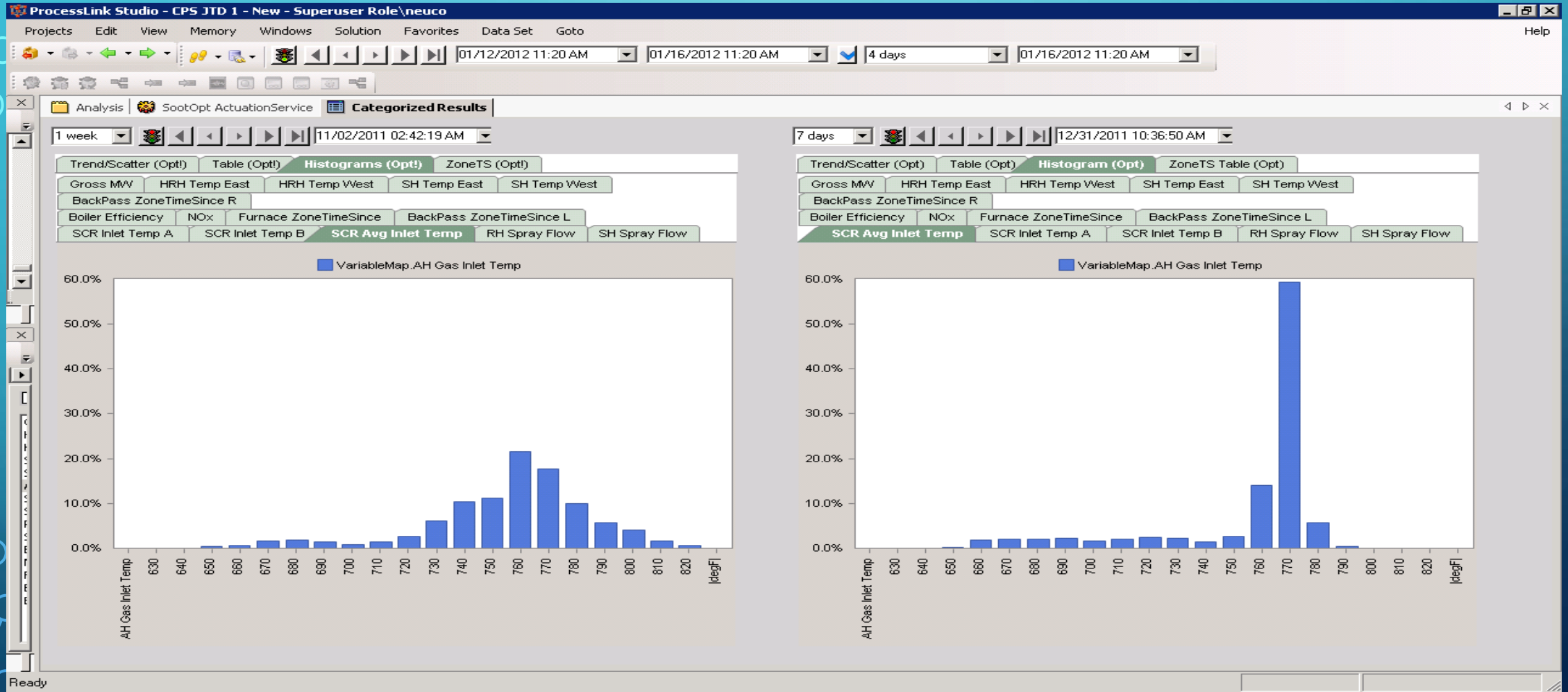
Trend TolK2

Gross MW A (550.043)

Advanced Heat Loss Index.Advanced_NeuCo_Index (1401.861)



TYPICAL GAS INLET TEMPS SOOTOPT OFF VS. ON

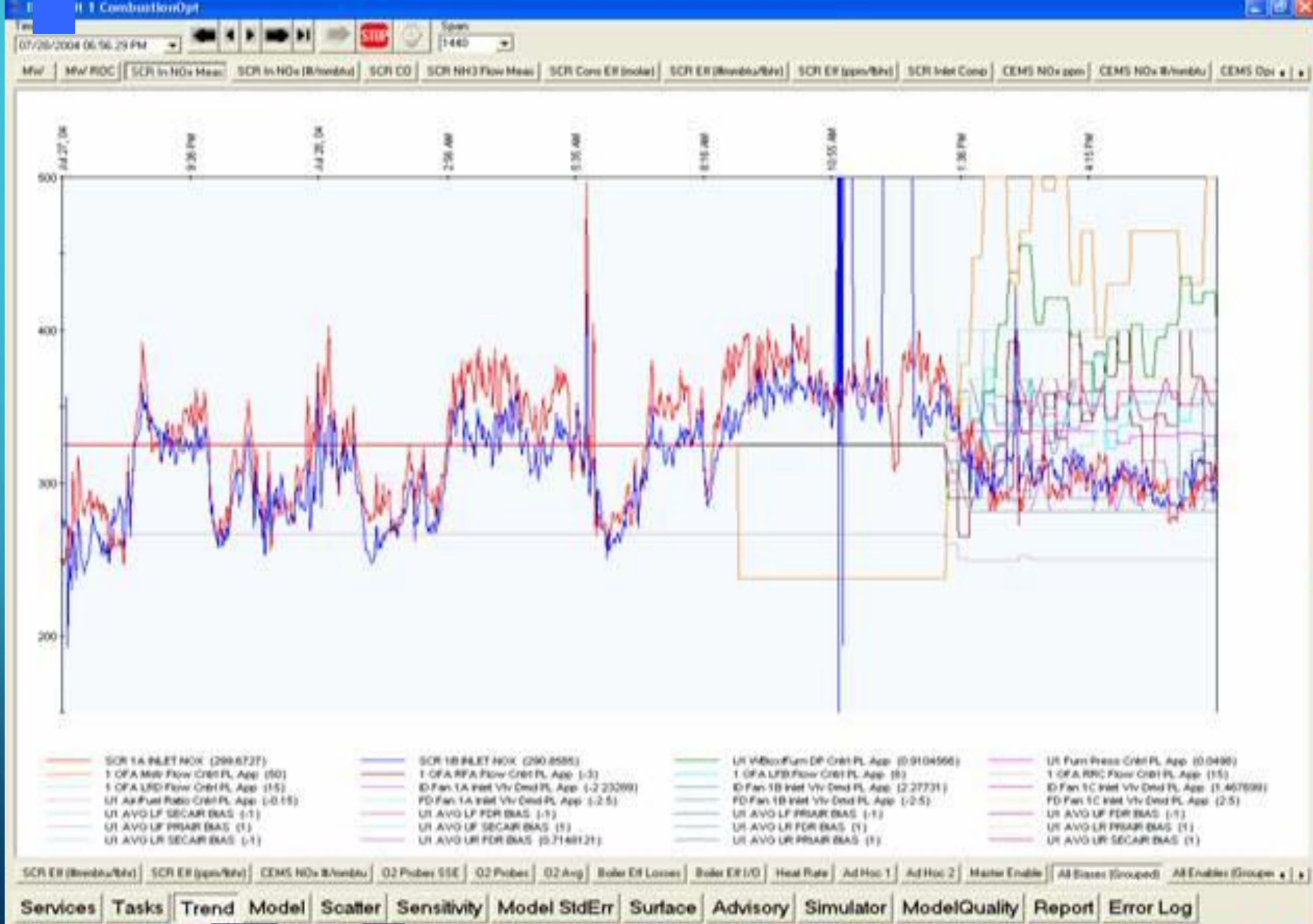


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SCR/SNCR SYSTEMS & OPTIMIZATION

- 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





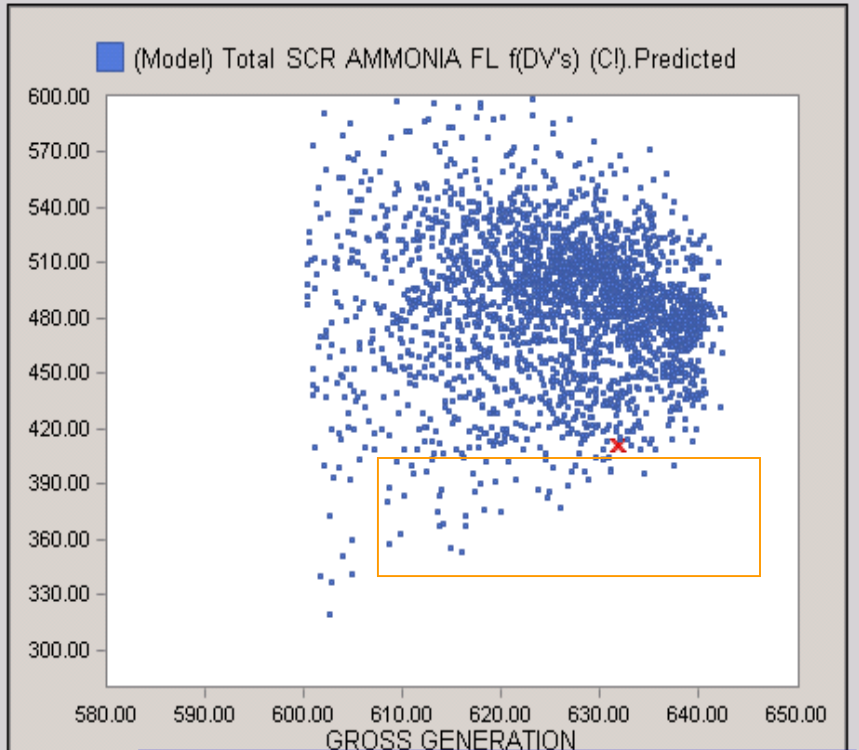
Impact on NH₃ Usage

imes
ion Favorites Data Set Help
02/01/2008 04:43 PM 02/08/2008 04:43 PM 7 days 02/08/2008 04:43 PM

Benchmarking (U1) Benchmarking (U2) Benchmarking (U3)

365 days 02/08/2008 04:43:39 PM
Scatter Means (Table) Model Means (Table) Model Scatter
Scatter (C!)

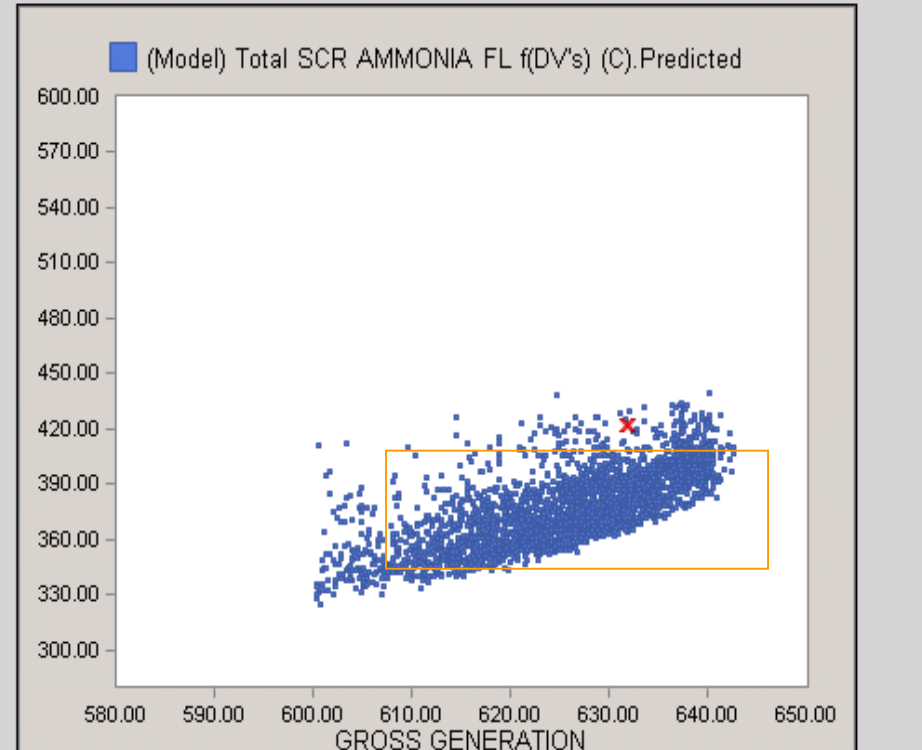
Primary: NH3 f(DVs) (Overlay: empty X-Axis: GROSS GENERATIO



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

365 days 02/08/2008 04:43:39 PM
Scatter Means (Table) Model Means (Table) Model Scatter
Scatter (C)

Primary: NH3 f(DVs) (Overlay: empty X-Axis: GROSS GENERATIO



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

DCS SCREEN EXAMPLE

OIS33: 8

PRCLINK FUEL UNIT AIR/GAS STEAM WATER ELEC ASH/BGHSE MISC TRENDS TURBINE Utilities ULTRAMAX Operations Displays

FRIDAY OCT 06, 2000 10:42:21 U1 PROCESSLINK OVR & COMMON 4 6 8 12 16 17 21 24 25 27 28 30 65 99 S A

ProcessLink Status

	MASTER	SEC AIR	OUTLET TEMP	BNR 1	BNR 2	BNR 3
PULV A	OFF	OFF	OFF	OFF	OFF	OFF
PULV B	OFF	OFF	OFF	OFF	OFF	OFF
PULV C	OFF	OFF	OFF	OFF	OFF	OFF
PULV D	OFF	OFF	OFF	OFF	OFF	OFF
PULV E	OFF	OFF	OFF	OFF	OFF	OFF
PULV F	OFF	OFF	OFF	OFF	OFF	OFF
PULV G	OFF	OFF	OFF	OFF	OFF	OFF

ProcessLink™

M MASTER ENABLE

ON

NOx 0.3 #/MBTU
 CO 330.2 PPM
 OXYGEN 2.2%
 OPACITY 1.9%
 UNIT MW 226.6 MW
 THROT PRS 1873. PSIG
 SH TEMP 1010. DEG F
 RH TEMP 1005. DEG F
 FUEL FLOW 94.8%
 AIR FLOW 94.4%
 FURN PRS -0.6 IN H2O
 EXIT TEMP **H 2122. DEG F**
 BGHSE DP A **H 8.6 INWC**
 BGHSE DP B 6.4 INWC

PL COMMUNICATIONS

A O2 SETPOINT BIAS

OFF

PV 2.16% SP 2.00%

ACT 0.00% OP 0.00%

B FD FANS BIAS

OFF

AOUT 62.9% BOUT 63.9%

ACT 0.6% OP 0.6%

C ID FANS BIAS

OFF

AOUT 77.5% BOUT 76.9%

ACT -0.0% OP -0.0%

NEUC01 CLR PULV D PULV A PULV B PULV F PULV E PULV C PULV G

1
K-8
P-1
CON
TUN
SHF

Recycle Bin

Start Composer - [System Archit... Exceed Telnet - 10.51.3.33 OIS33: 8

10:44 PM

Boiler and Back-end Process Causality Chain

