



CLYDE BERGEMANN Power Group

On Load Boiler Cleaning Optimization Technologies

October 11, 2012

Outline

- Review of Best Available On Load Cleaning Optimization Technologies,
  - ➔ SMART Feedback Devices
  - ➔ On load cleaning control integration into different optimization goals for the power boilers
  - ➔ How to select the right feedback technology
  - ➔ System Integration
- Case study on tube life and reliability optimization
- Case study on SCR temperature control
- Case study on Plant Heat Rate Optimization
- Case studies on Fuel FlexibilitySystem Introduction

Clean Energy Solutions

- Part of the Clyde Bergemann Power Group
  - ➔ Privately held
  - ➔ US corporation
- 30 business units worldwide
  - ➔ 17 of which include production facilities
- Over 1,500 employees

- Vision:
  - ➔ # 1 Global Enterprise providing innovative Products and Solutions for Clean Power Generation
- Currently Providing Solutions in Six Fields:
  - ➔ Air Pollution Control
  - ➔ Material Handling
  - ➔ Boiler Efficiency
  - ➔ Air & Gas Handling
  - ➔ Energy Recovery
  - ➔ Firing Solutions

On Load Boiler Optimization

→ **Decision:**

The uppermost goal is to preserve boiler efficiency and availability. Here, an evaluation takes place of all recommended cleaning actions using current process data and stored operating events. The most suitable cleaning strategy will be selected and triggered.

→ **Analysis:**

Software modules as intelligent units continuously analyse and interpret data in real time. They provide recommendations concerning where, how and when to clean. These recommendations are forwarded to the decision level.

→ **Diagnostics:**

Different sensors continuously monitor important process parameters feeding back key data for analysis.

ON LINE DIAGNOSTICS
SMART Feedback Devices

Monitor Boiler Performance

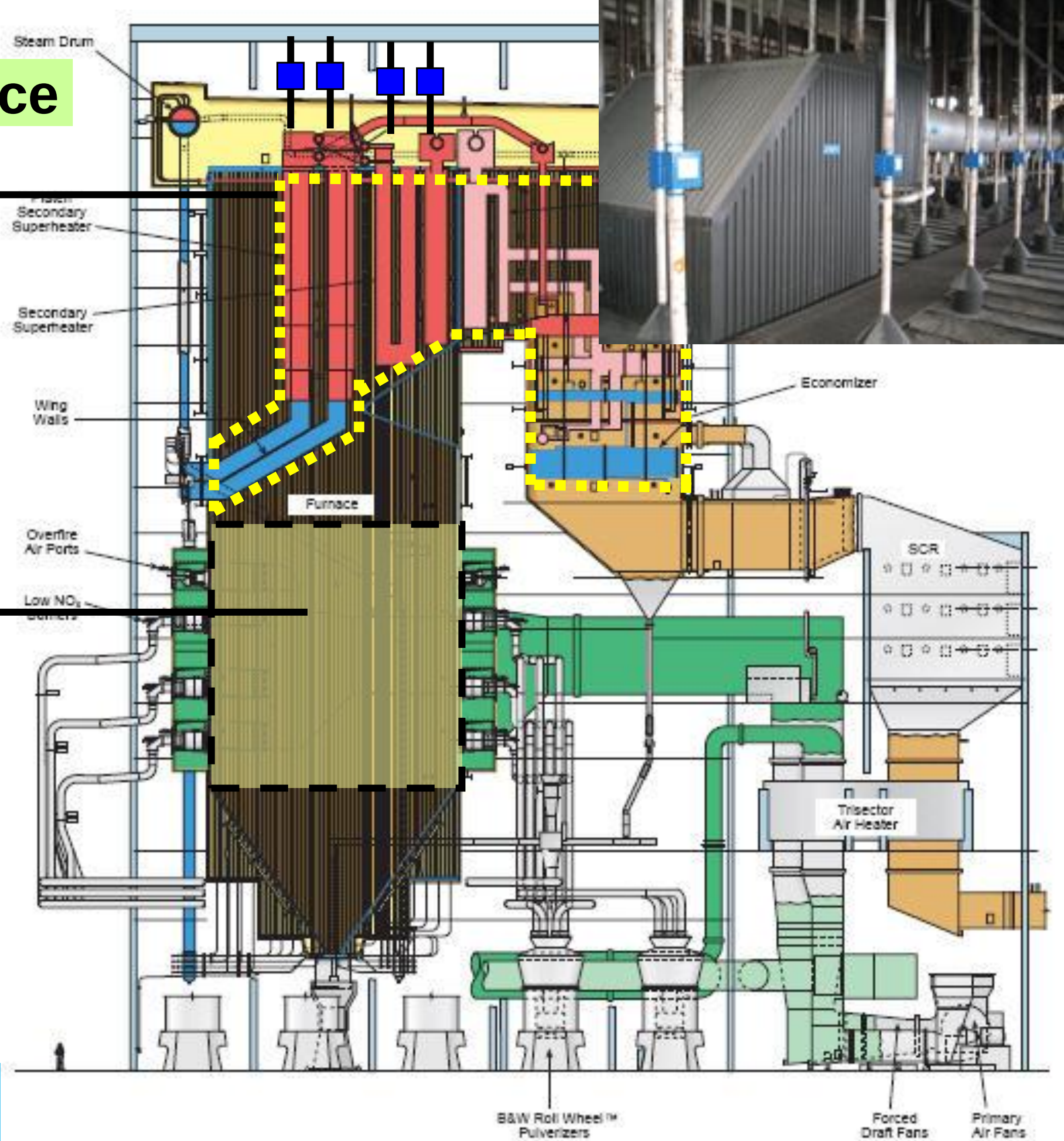
CONVECTION

SMART Gauge

TDM **T**hermo **D**ynamic **M**odel

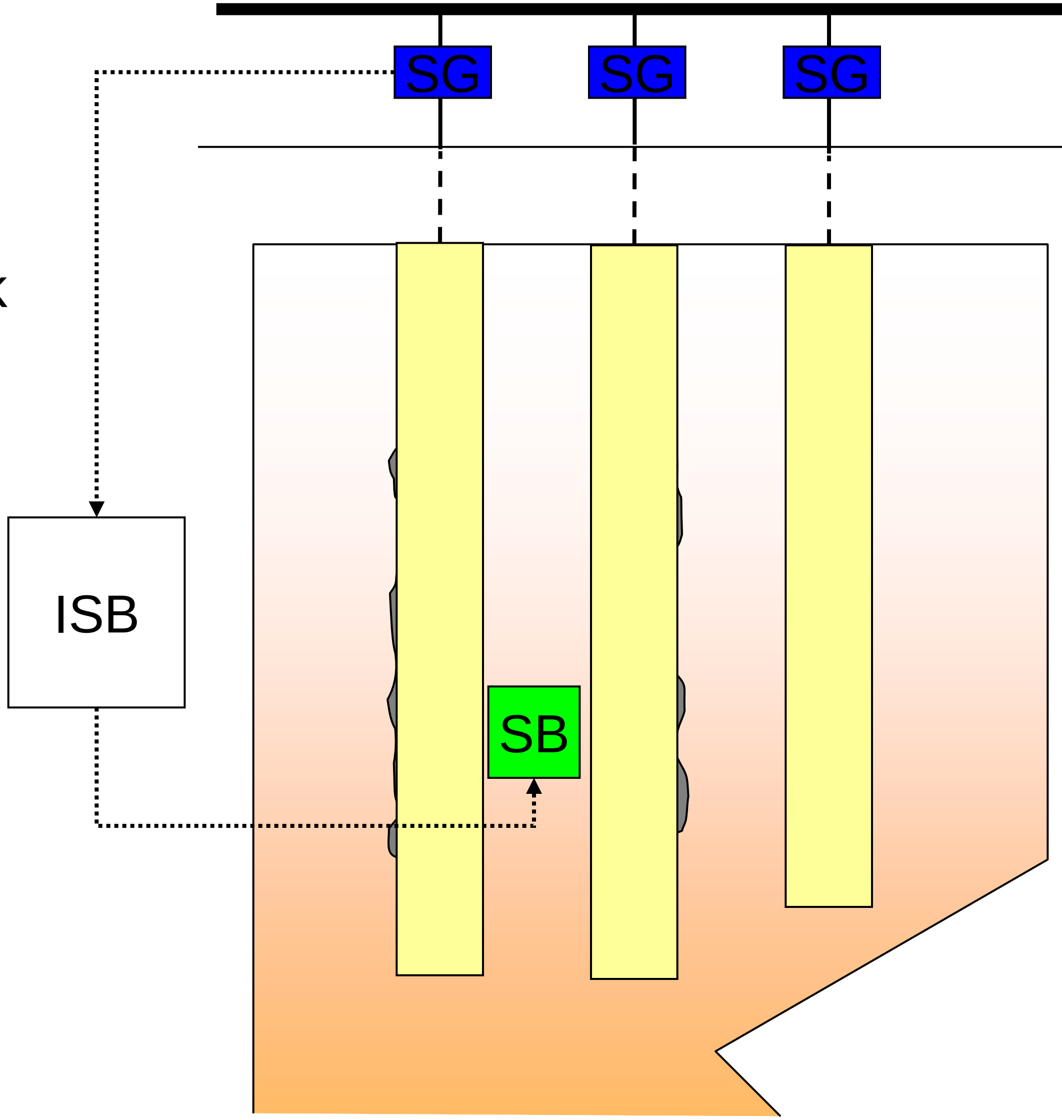
FURNACE

SMART Flux Sensor



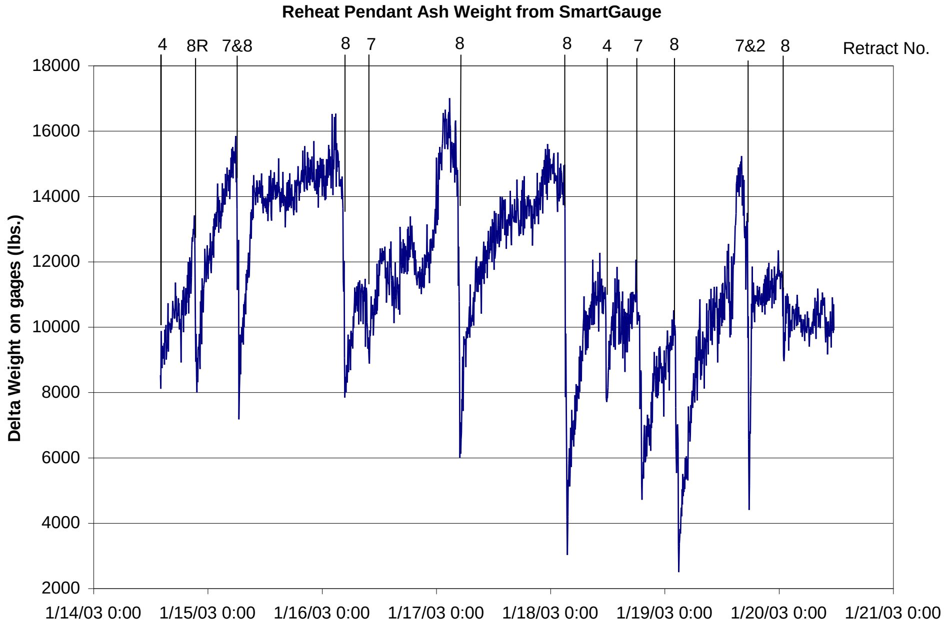
SMART Gauge™ System

- Monitors Weight Accumulation on pendants
- As deposits stick to the tub banks the overall weight of the tube bank increases
- This increase in weight is detected by the Smart Gauges located on the hanger rods
- The strain gauges relay the increase in weight to the ISB system
- The ISB system then operates the correct sootblower to remove the deposit

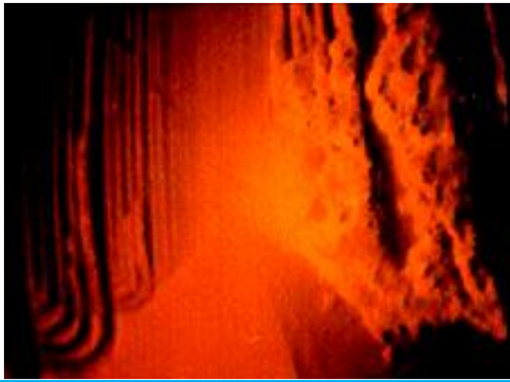


SMART Gauge™ System

- Direct Measurement System
- Strain Gauge Technology
- Installed on Pendant Rods
  - ➔ Measures Weight Gain from Ash Build-up
  - ➔ Detects Clinker Formation



SMART Gauge Install



Thermodynamic Model

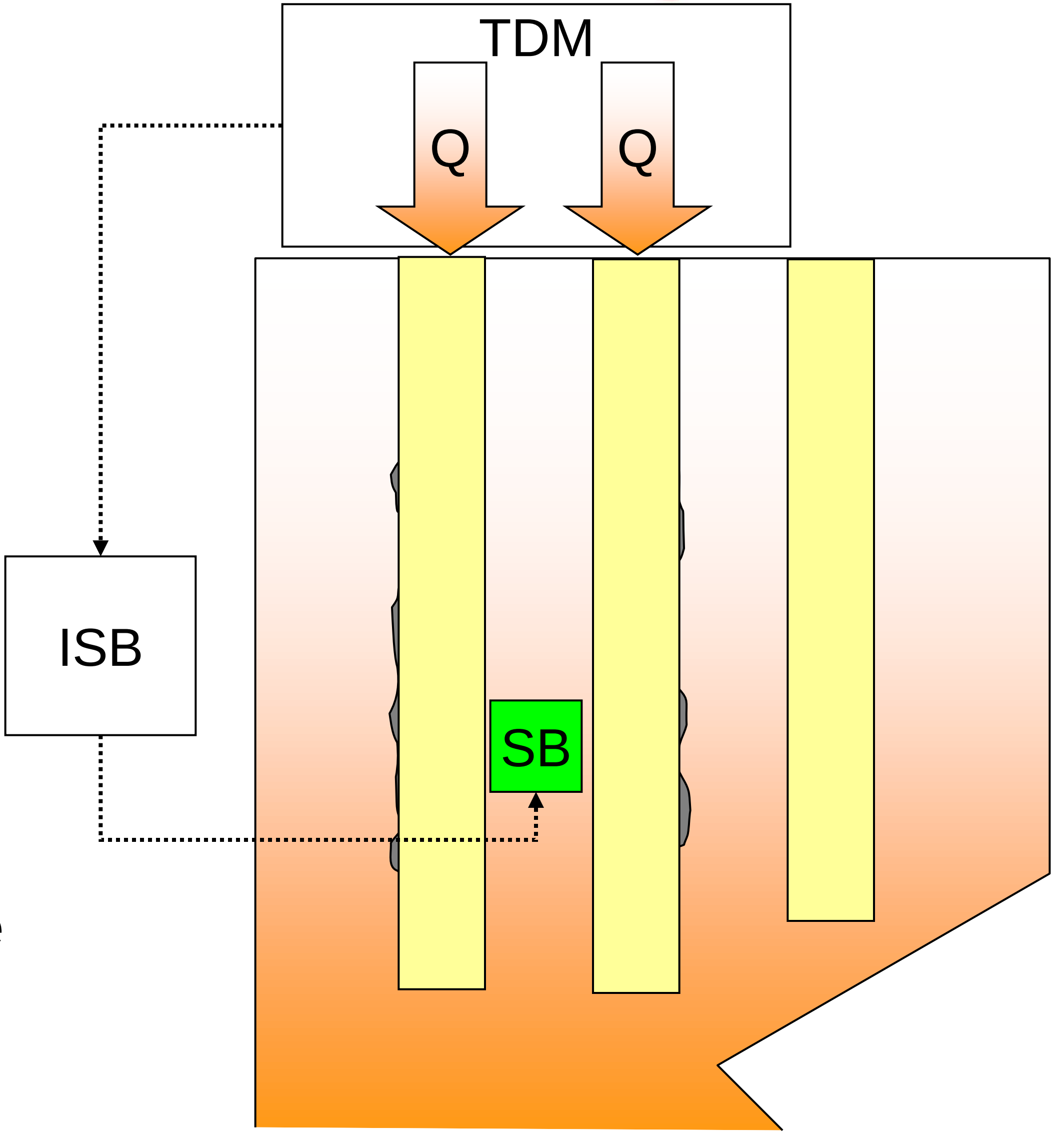
- Objective
  - Calculate heat transfer rates of tube banks in convection pass using real-time boiler process data
- Function
  - Uses real-time data to create a Cleanliness Factor

$$\text{Heat Transfer Efficiency [zone]} = \frac{\text{Heat Transfer Rate in Real-Time}}{\text{Maximum Theoretical Heat Absorption}}$$

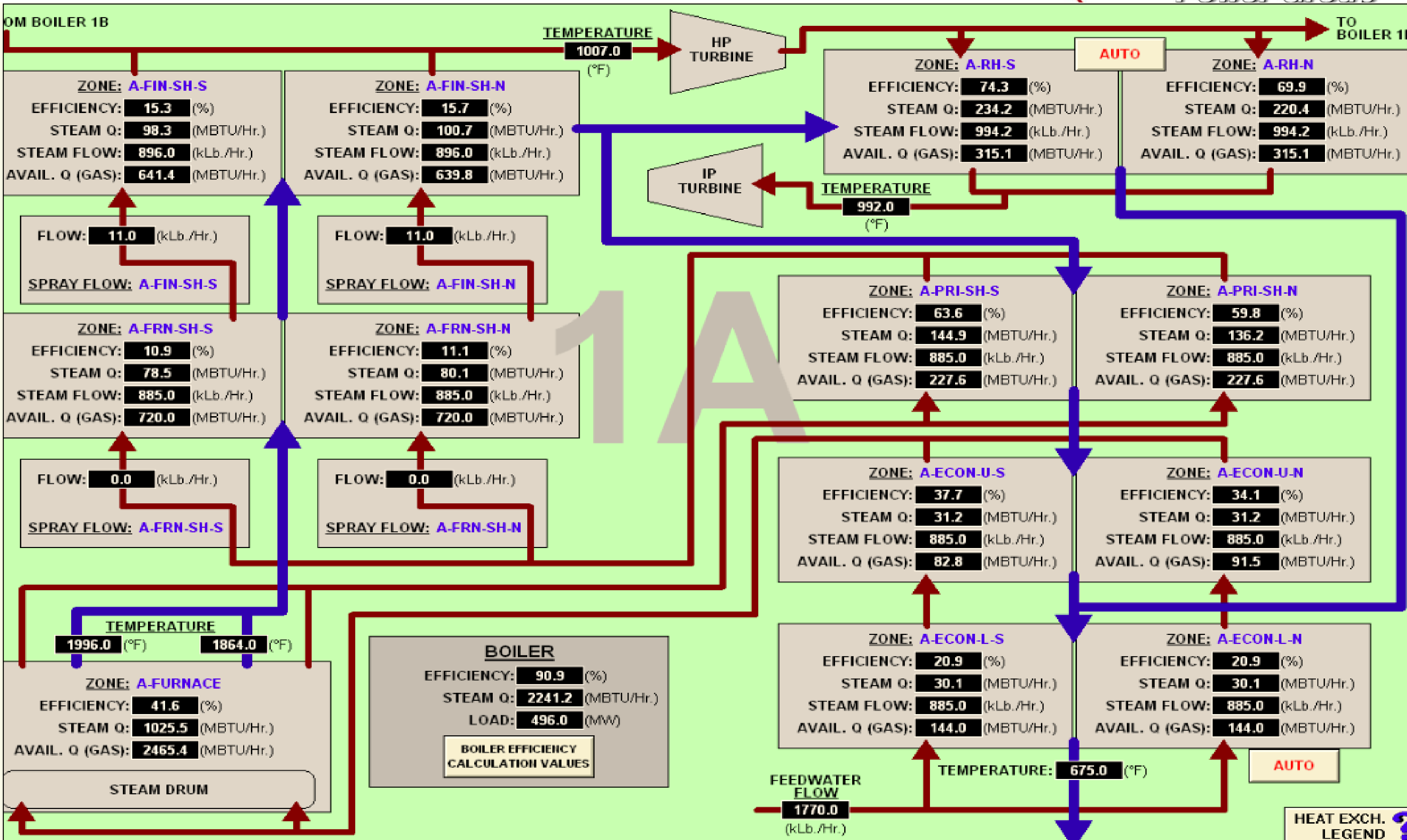
  - Tube banks are cleaned only when HTE is below required rate
  - Prioritizes sootblowers based on effectiveness of previous cleaning event

ThermoDynamic Model

- Monitors Inlet and Exit Temperatures and Flows for each heat exchanger
- As deposits stick to the tub banks the overall heat transferred (Q) to the tube banks decreases
- This decrease in heat transfer is detected by the Thermodynamic model
- The TDM relays the decrease in heat transfer to the ISB system
- The ISB system then operates the correct sootblower to remove the deposit

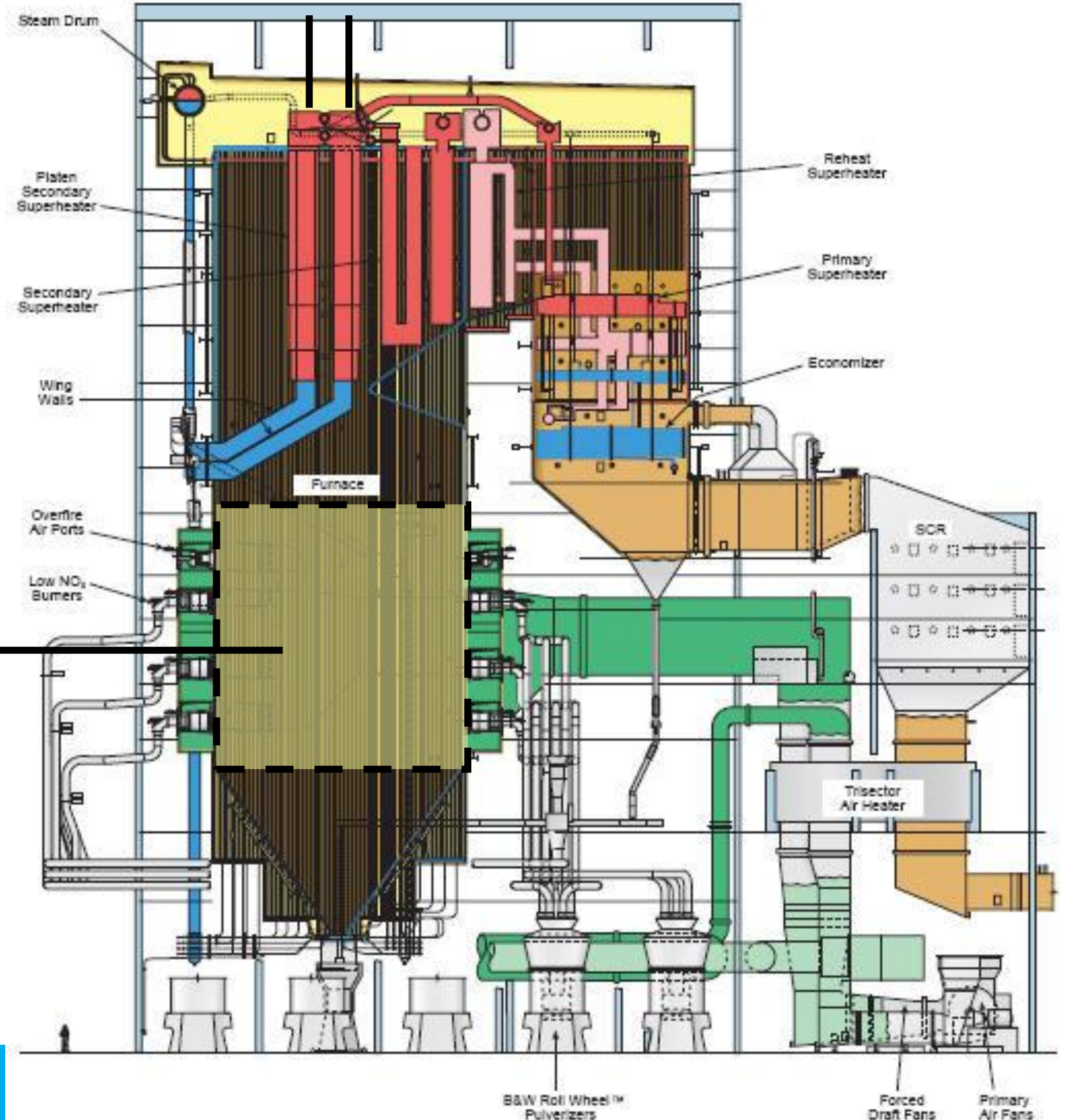


Thermodynamic Model HMI Screen

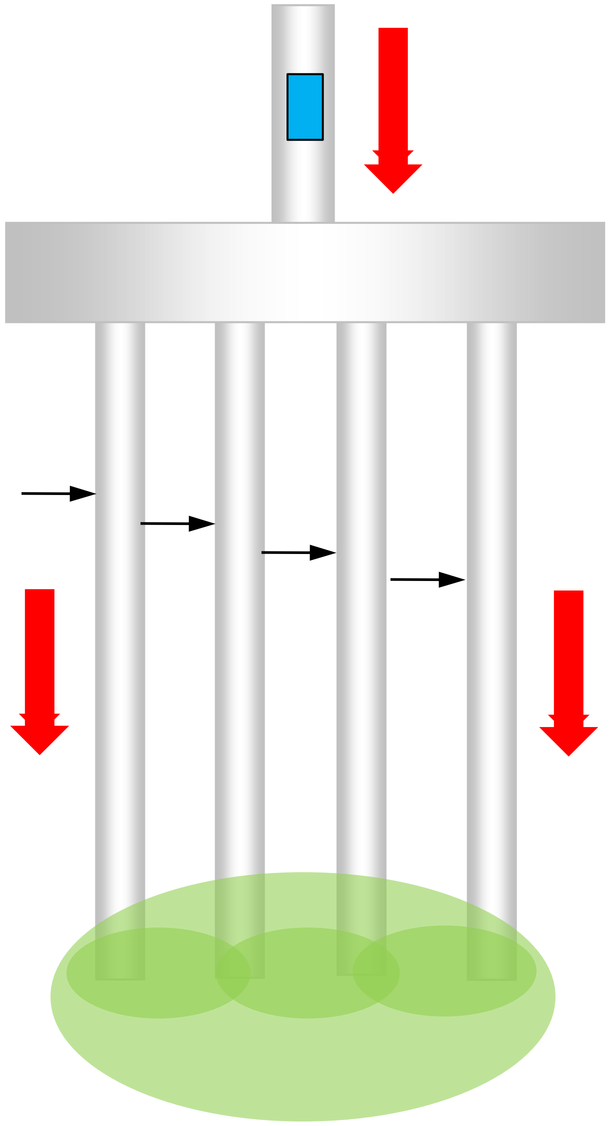


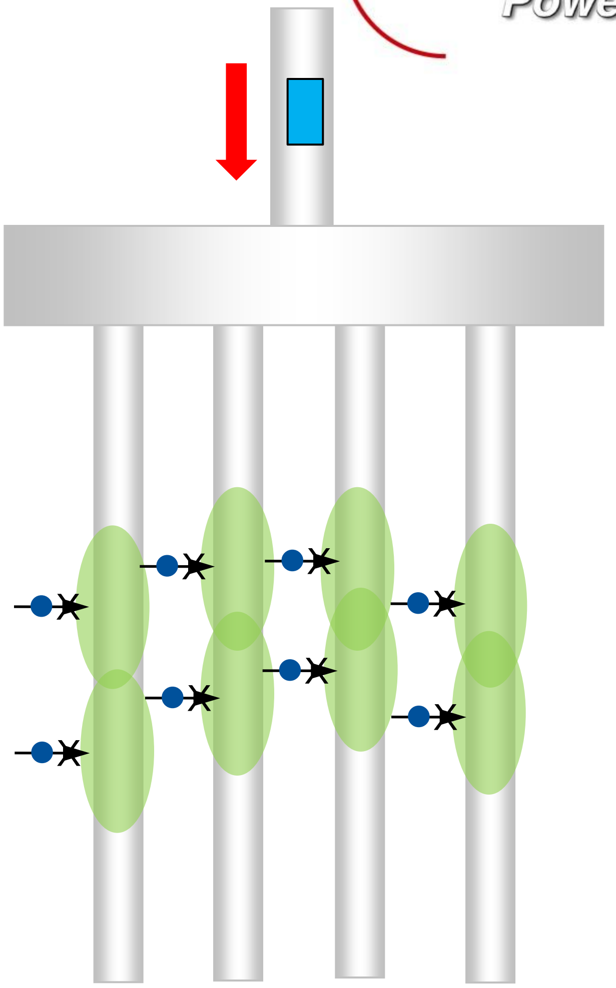
SMART Flux Sensor

SMART Flux Sensor



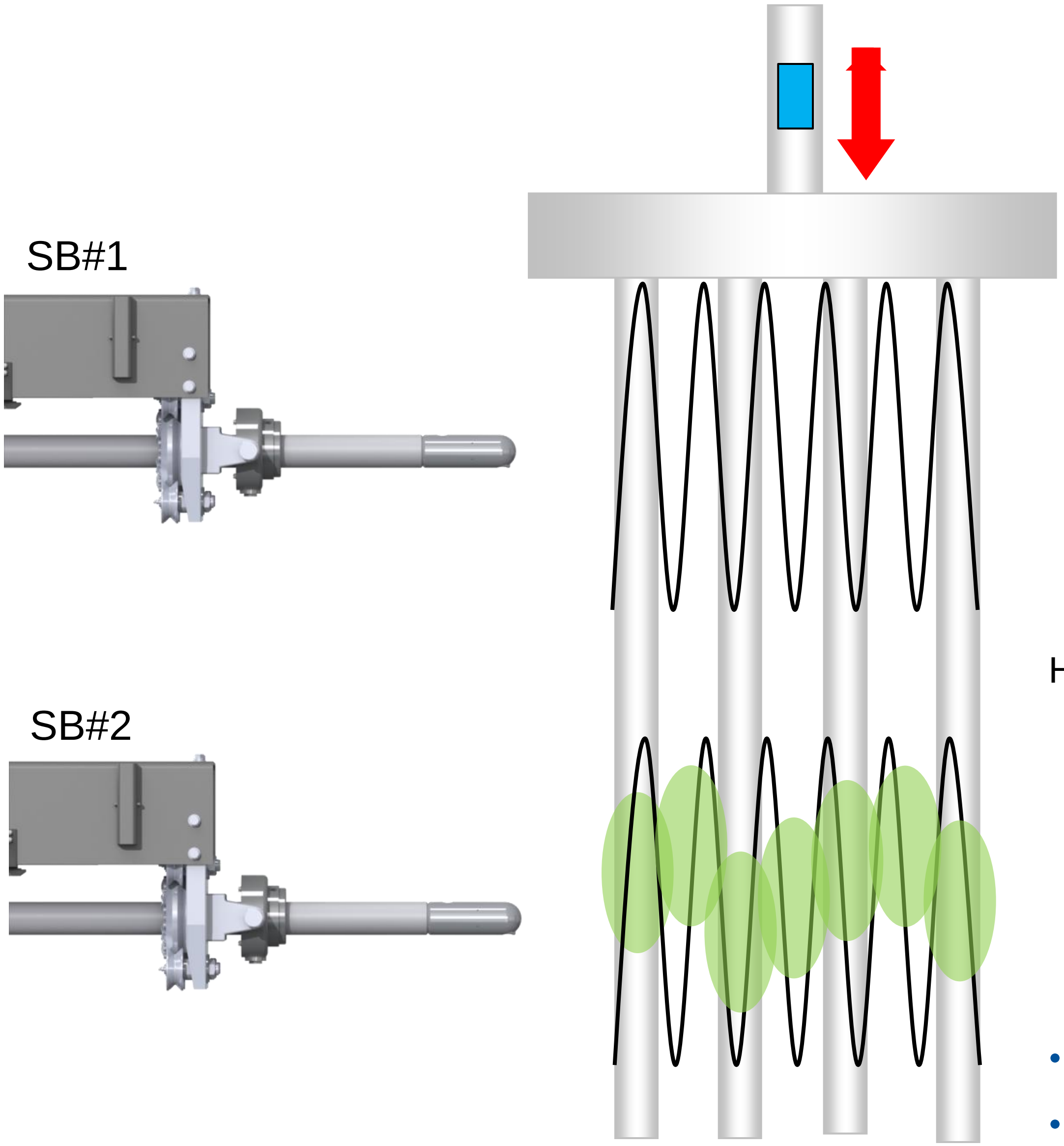
How to Select the Right Feedback Technology?





System	Clinker Formation	Loss in Heat Transfer	Ash Removal
SMART Gauge	Yes	No	Yes
TDM	No	Yes	Yes

SMART Sootblowing

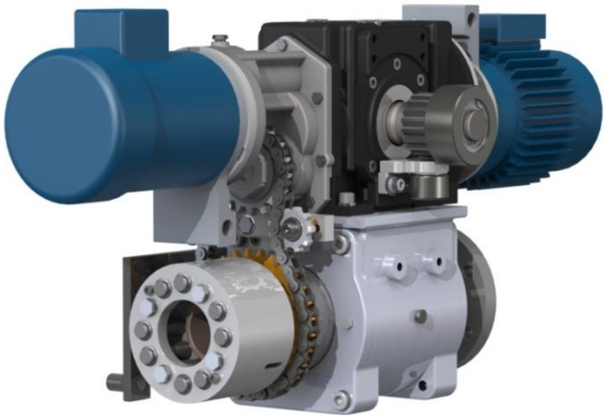


Heat Transfer =

- **System "learns" SB#2 was more effective**
- **Initiates SB#2 first next time**

SMART Retract

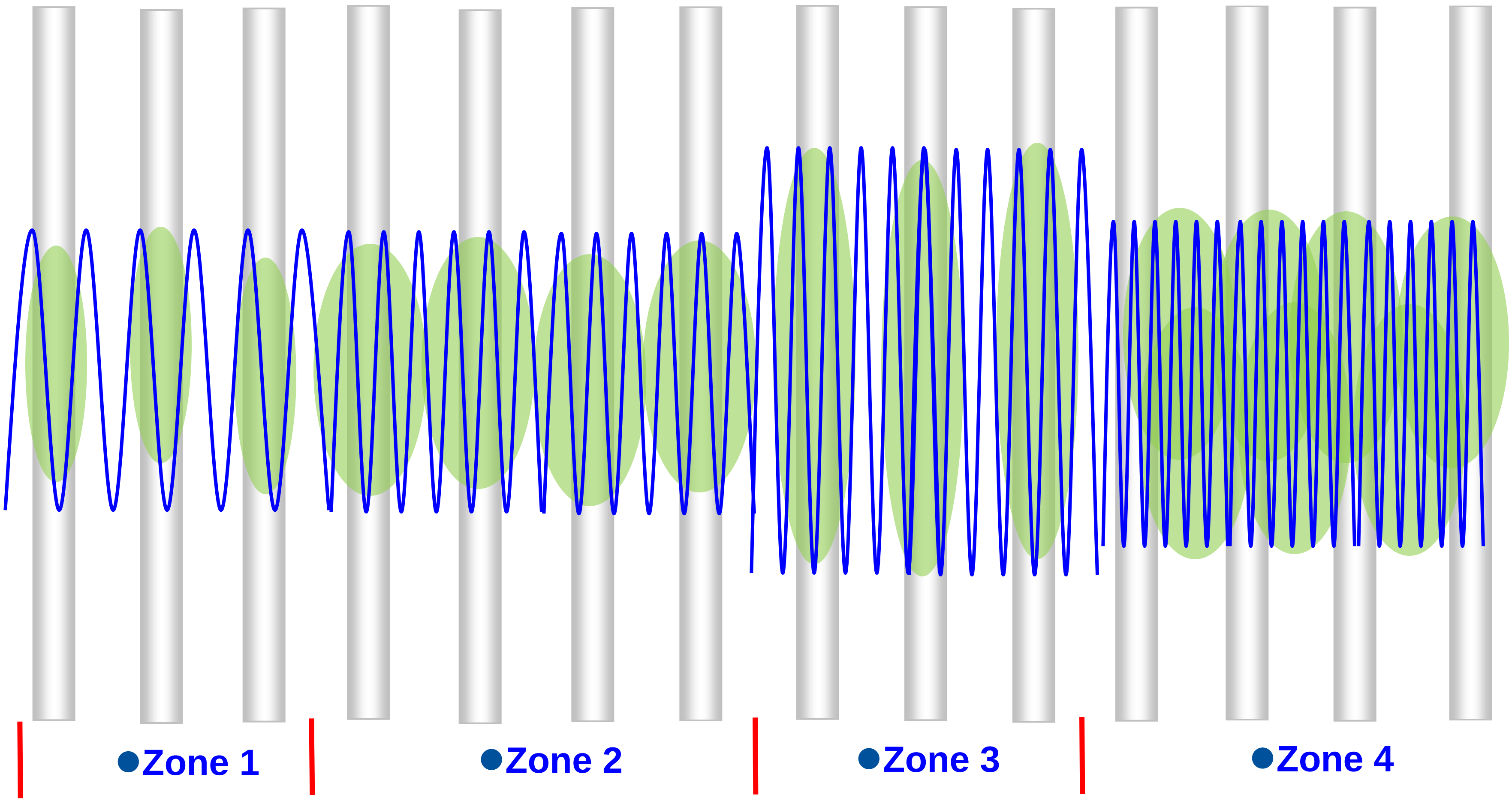
- Targeted Sootblowing
- Variable Intensities:
  - Variable Helix
  - Stop & Go
  - Variable Pressure



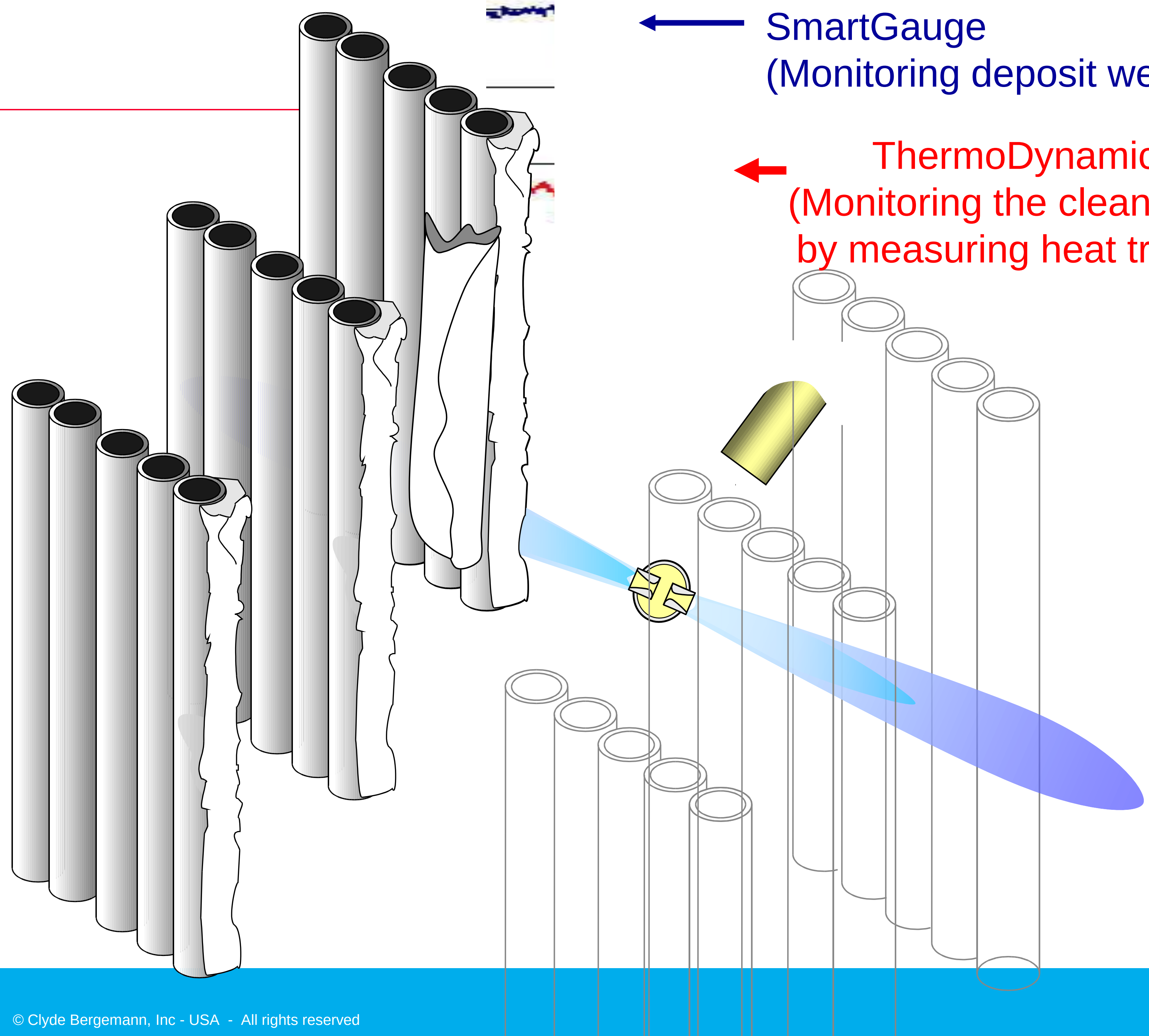
SMART FEATURE	CUSTOMER BENEFIT
Dual Motor Drive	✓ Infinite cleaning patterns ✓ Independent rotation and traversing speeds
Variable Helix	✓ Targeted cleaning for fouling conditions specific to that tube bank
Variable Cleaning Pressure	✓ Remove difficult slag by increasing blowing pressure, or eliminate tube erosion by reducing blowing pressure in real-time
Variable Intensity	✓ Stop the nozzles at specific tube banks that need additional cleaning, or speed through tube banks that are already clean

SMART Retract Strategies

- **Cleaning Intensities**



SHFM & TDM in Operation

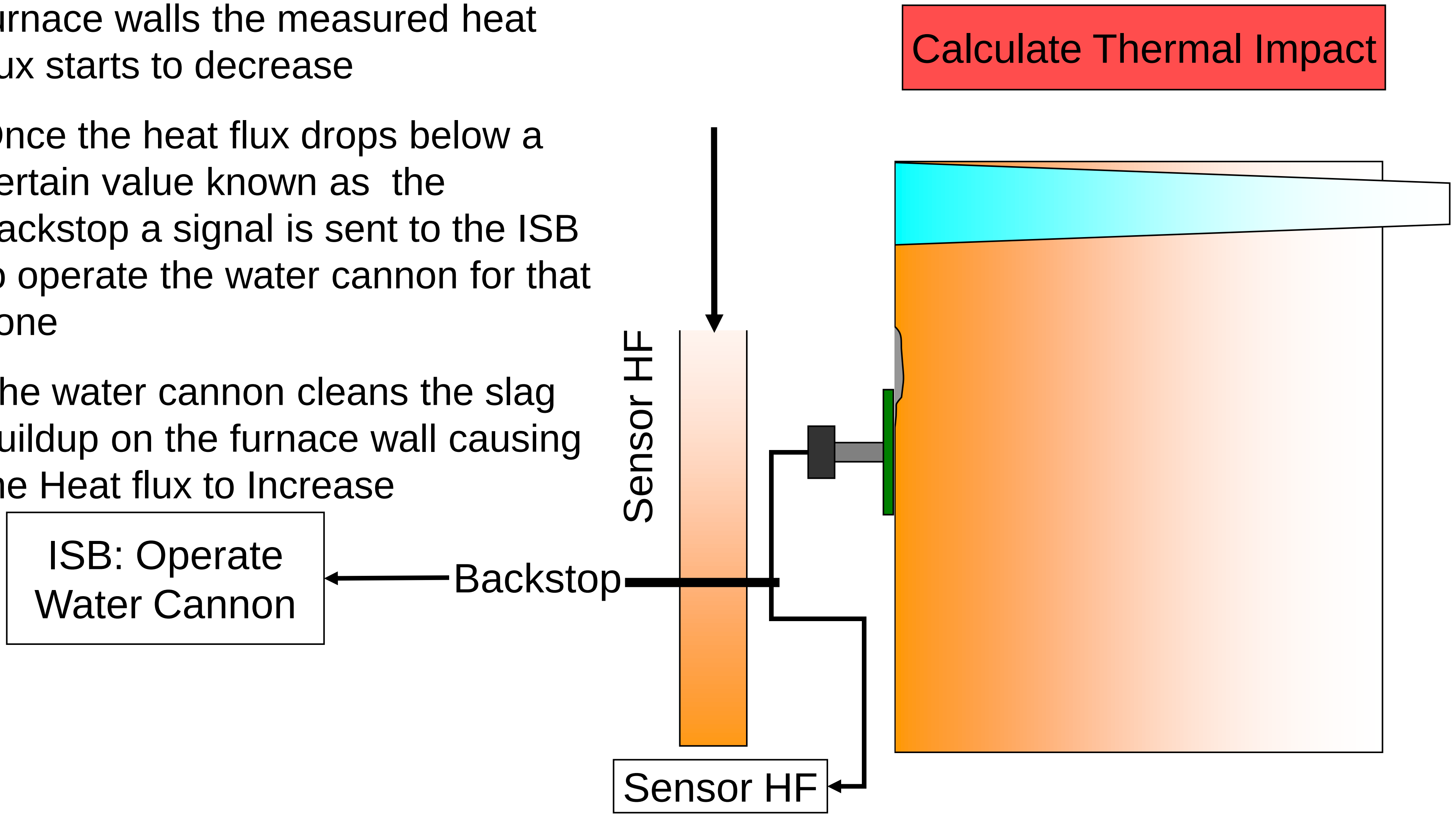


SmartGauge
(Monitoring deposit weight)

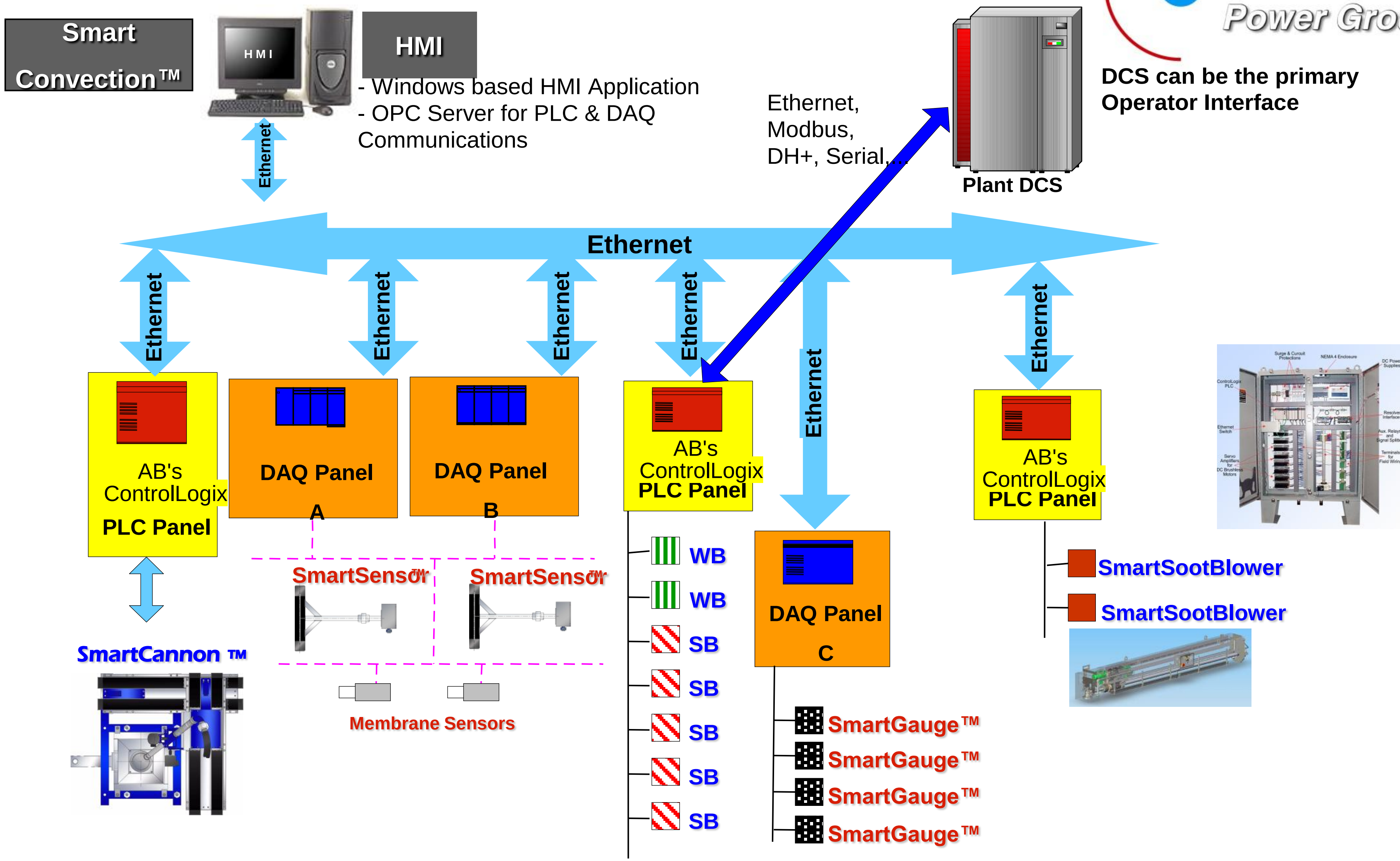
ThermoDynamic Model
(Monitoring the cleanliness factor
by measuring heat transfer rate)

Furnace Cleaning with SMART Cannons

- When slag begins to build up on the furnace walls the measured heat flux starts to decrease
- Once the heat flux drops below a certain value known as the backstop a signal is sent to the ISB to operate the water cannon for that zone
- The water cannon cleans the slag buildup on the furnace wall causing the Heat flux to Increase

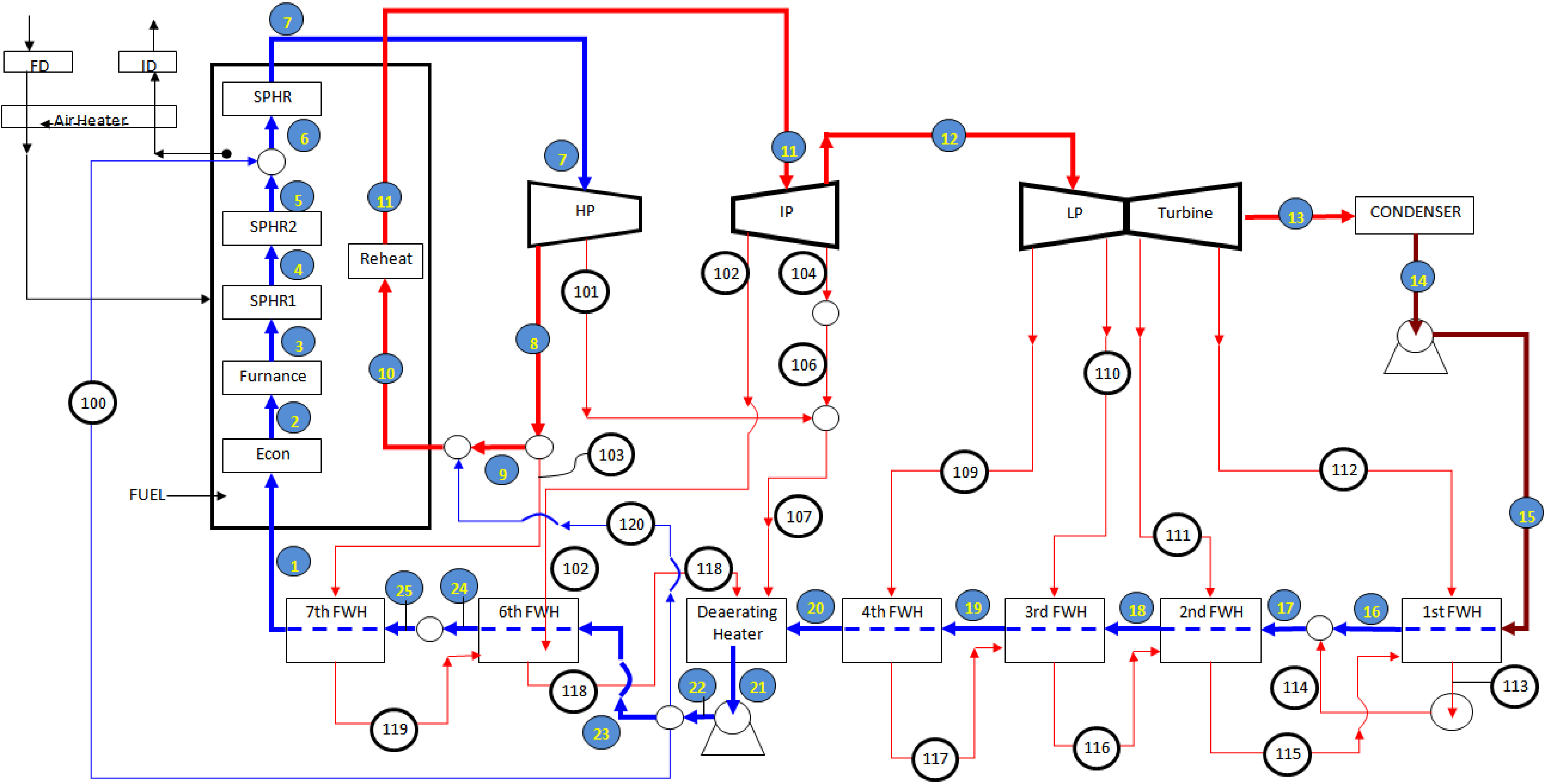


System Integration



Cleaning Strategy for Plant Heat Rate Optimization

600 MW Coal Fired Plant Simulation



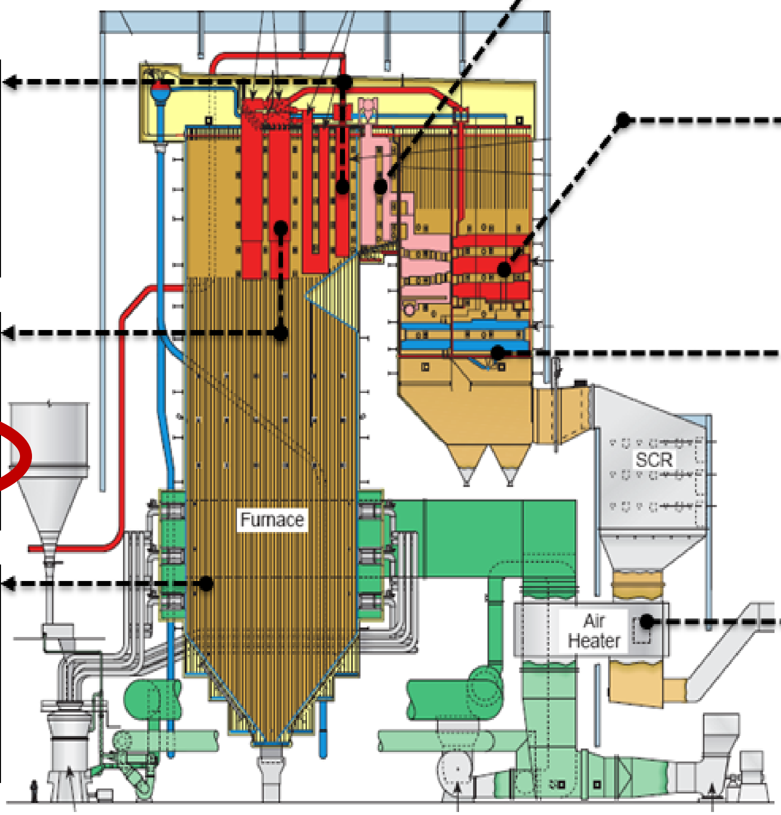
Simulations: PHR and MW Optimization

Current Conditions		
PHR	10,013	Btu/kWh
kW	553,699	kW

SPHR FINAL CLEANING SCNR		PHR Improv	
Estimated Q Improvement		0.57	Btu/kWh
SB#1	0.16%	# of SB to run ==>	3
SB#2	0.02%	MW Improv	
SB#3	0.02%	47	kW
SB#4	0.00%	# of SB to run ==>	3

SPHR - 2 CLEANING SCNR		PHR Improv	
Estimated Q Improvement		0.00	Btu/kWh
SB#5	0.80%	# of SB to run ==>	0
SB#6	0.60%	MW Improv	
SB#7	0.40%	161	kW
SB#8	0.20%	# of SB to run ==>	4

FURNACE CLEANING SCNR		PHR Improv	
Estimated Q Improvement		1.16	Btu/kWh
ZONE#5	0.32%	# of SB to run ==>	3
ZONE#6	0.09%	MW Improv	
ZONE#7	0.05%	714	kW
ZONE#8	0.02%	# of SB to run ==>	3



REHEAT CLEANING SCNR		PHR Improv	
Estimated Q Improvement		0.16	Btu/kWh
SB#9	0.08%	# of SB to run ==>	3
SB#10	0.01%	MW Improv	
SB#11	0.01%	25	kW
SB#12	0.00%	# of SB to run ==>	3

SPHR - 1 CLEANING SCNR		PHR Improv	
Estimated Q Improvement		0.86	Btu/kWh
SB#13	0.08%	# of SB to run ==>	4
SB#14	0.02%	MW Improv	
SB#15	0.01%	97	kW
SB#16	0.01%	# of SB to run ==>	4

ECONOMIZER		PHR Improv	
Estimated Q Improvement		0.54	Btu/kWh
SB#17	0.05%	# of SB to run ==>	3
SB#18	0.01%	MW Improv	
SB#19	0.01%	0	kW
SB#20	0.00%	# of SB to run ==>	0

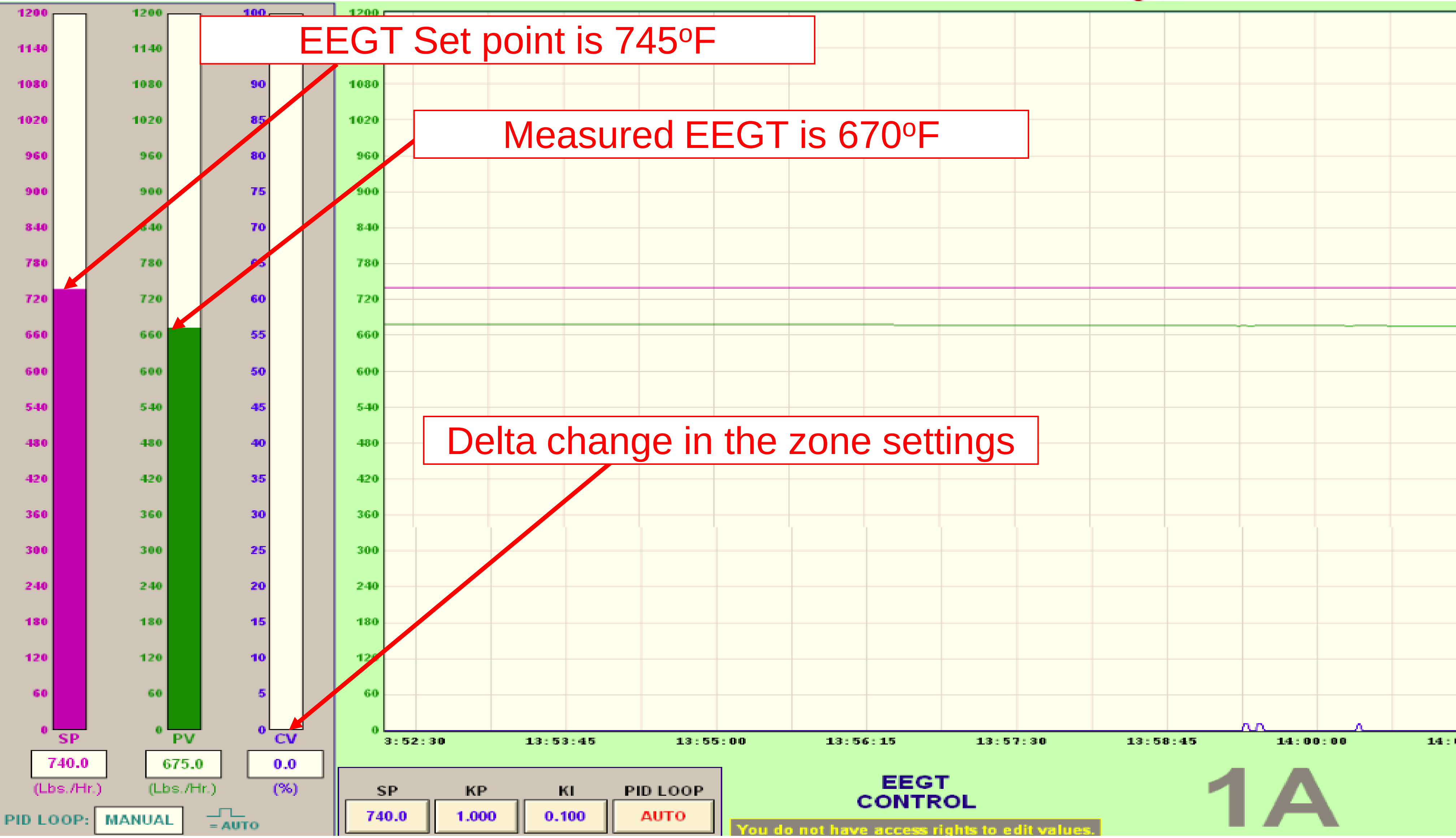
R PREHEATER CLEANING SCN		PHR Improv	
Estimated Q Improvement		1.50	Btu/kWh
ZONE#1	0.08%	# of SB to run ==>	3
ZONE#2	0.02%	MW Improv	
ZONE#3	0.01%	0	kW
ZONE#4	0.00%	# of SB to run ==>	0

Successful Cleaning Optimization Strategy

- **Targets are not static numbers.**
- Keeping each heat exchanger at the same cleanliness level at all times is not the right approach for optimum heat rate and back end gas temperature control.
- SmartClean System makes decisions based on key Performance Targets such as:
  - ➔ Main Steam Temperature
  - ➔ Hot Reheater Temperature
  - ➔ Economizer Exit Gas Temperature
  - ➔ Furnace Exit Gas Temperature
  - ➔ Plant Heat Rate
- The system uses simple heat balance and optimization algorithms to realize these targets and derives the local cleanliness targets dynamically.

Cleaning Strategy for Boiler Back End Temperature Control

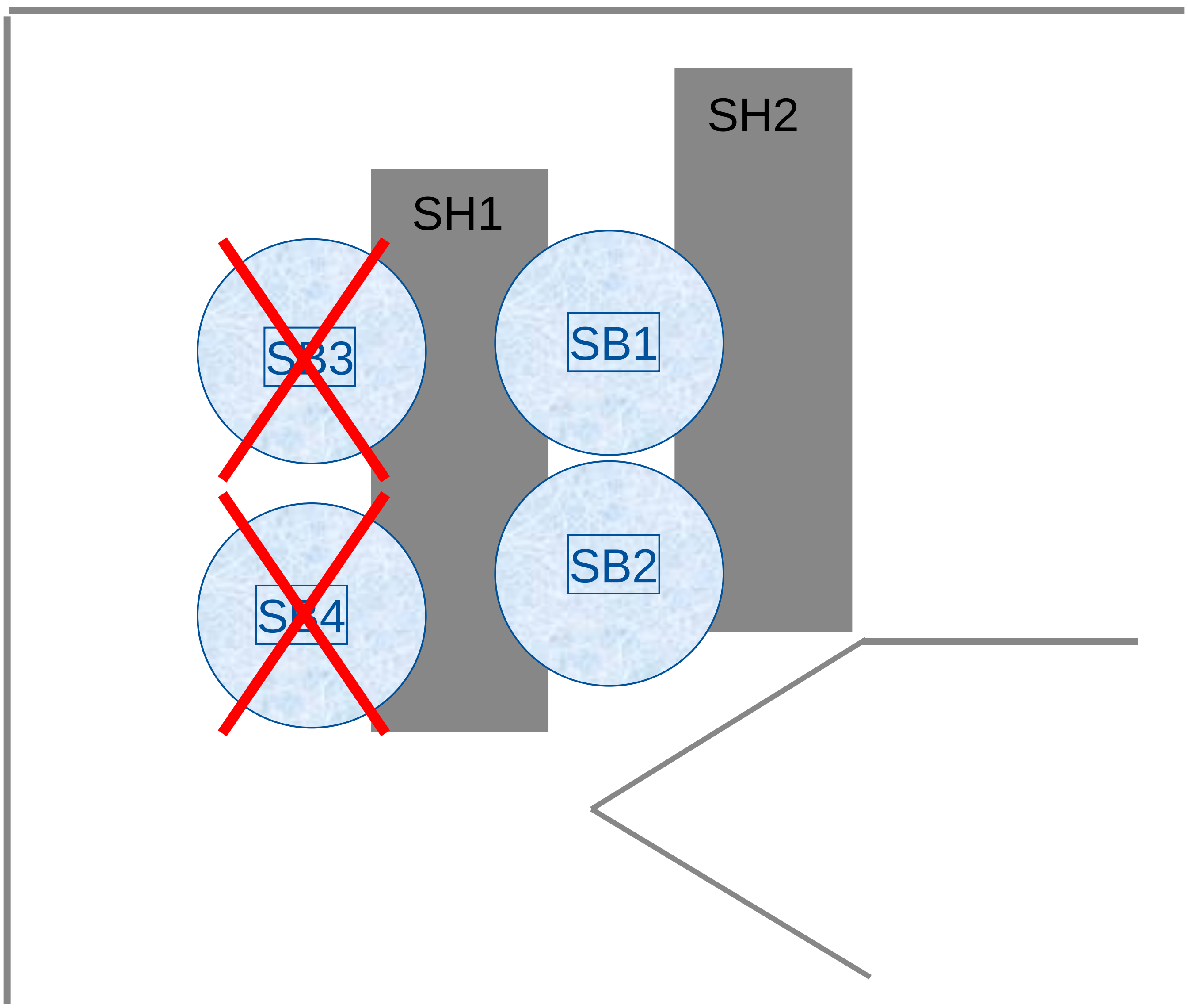
Automated Setpoint Optimization (2010 Platform) – Ex: EEGT Control Loop



Successful Cleaning Strategy

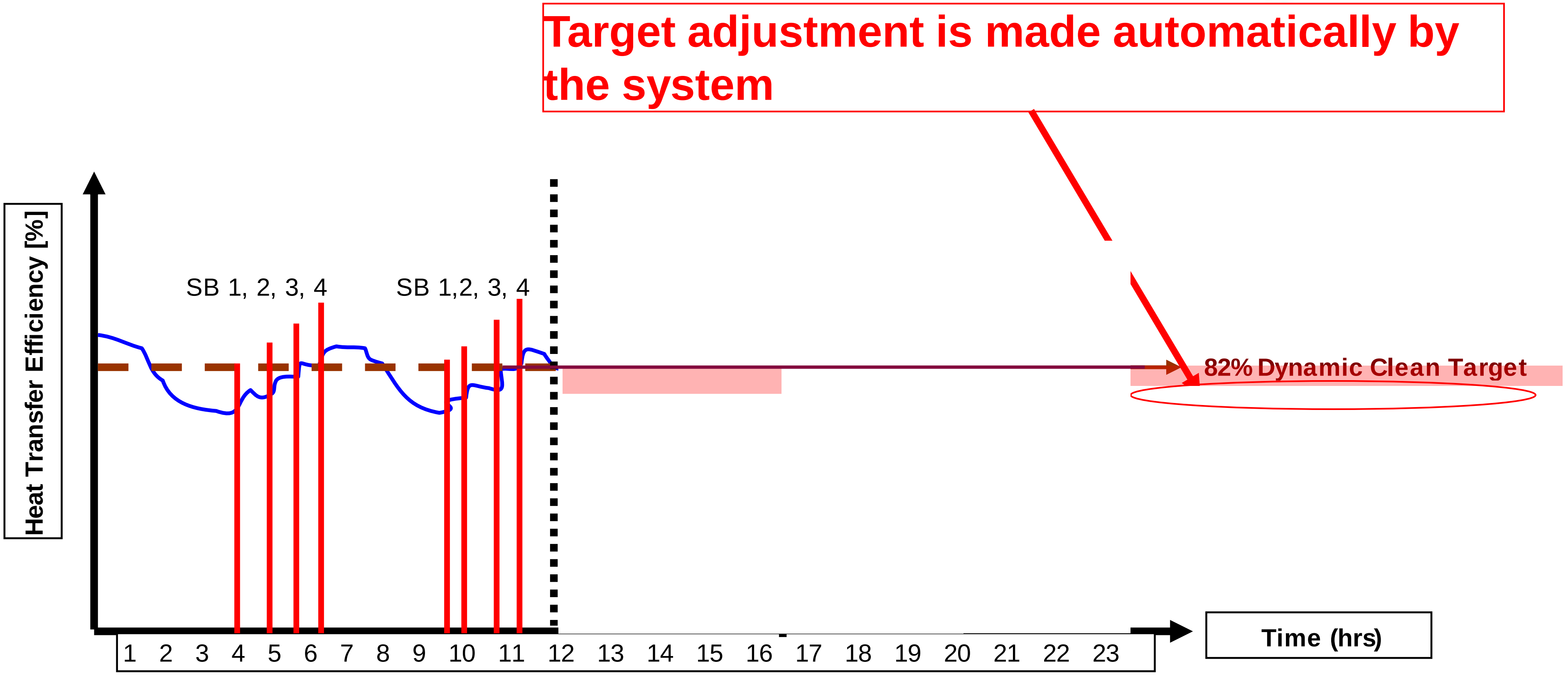
- **Cleanliness Targets are not static numbers.**
- The cleaning ability in a heat exchanger is dependant on the number of sootblowers available for the area.
- If half of the sootblowers are out of duty around a pendant, the system adopts to the new condition and adjusts its targets based on the self learning algorithms.
- When new blowers are made available to clean a section, SmartClean learns the effectiveness of the new blowers and revises its targets accordingly.

SMART Clean Cleaning Strategy



SMART Clean Technology

Dealing with change in sootblower availability

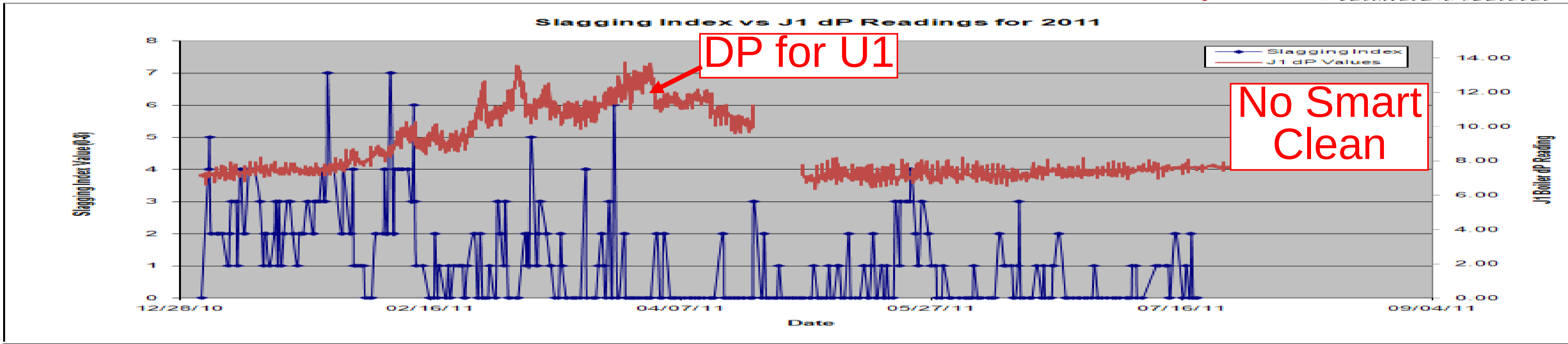


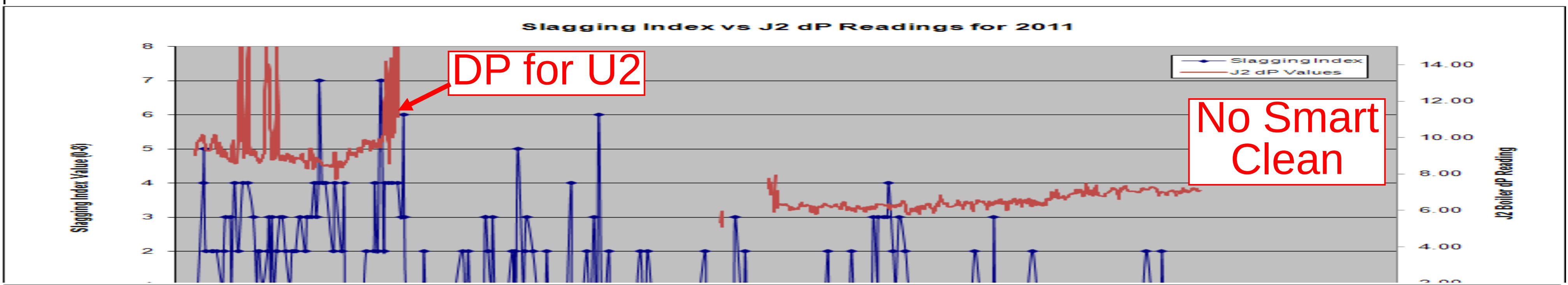
- SMART Clean adjusts its target based on the new condition.

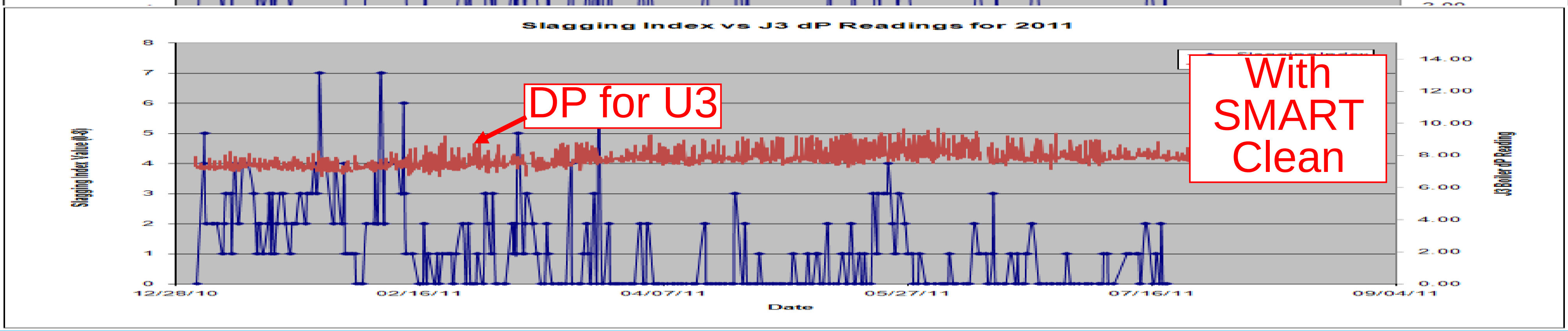
CASE STUDY

PRB Fuel Conversion

Flue Gas DP Comparison for 3 identical PRB Coal Fired Boilers







Background

- Dynegy Havana Power Station in Havana, Illinois
    - ➔ 488MW B&W wall fired , Sub Critical
    - ➔ PRB coal

Operational Challenges After Fuel Switch

- Heavy ash build-up
- Degradation of precipitator performance
- Higher FEGT and EEGT
- Higher superheater temperature and higher superheater spray flows
- Boiler flue gas draft pressure increase
- Impact on induced draft (ID) fan.
- Higher heat rate
- Forced outages due to sootblowing induced tube leaks and ESP pluggage
- Capacity limitations (10-20 MW de-rate)

SMART Clean™ System

SMART CONVECTION

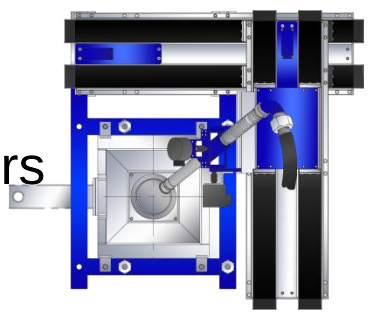
48 Retractable Sootblowers

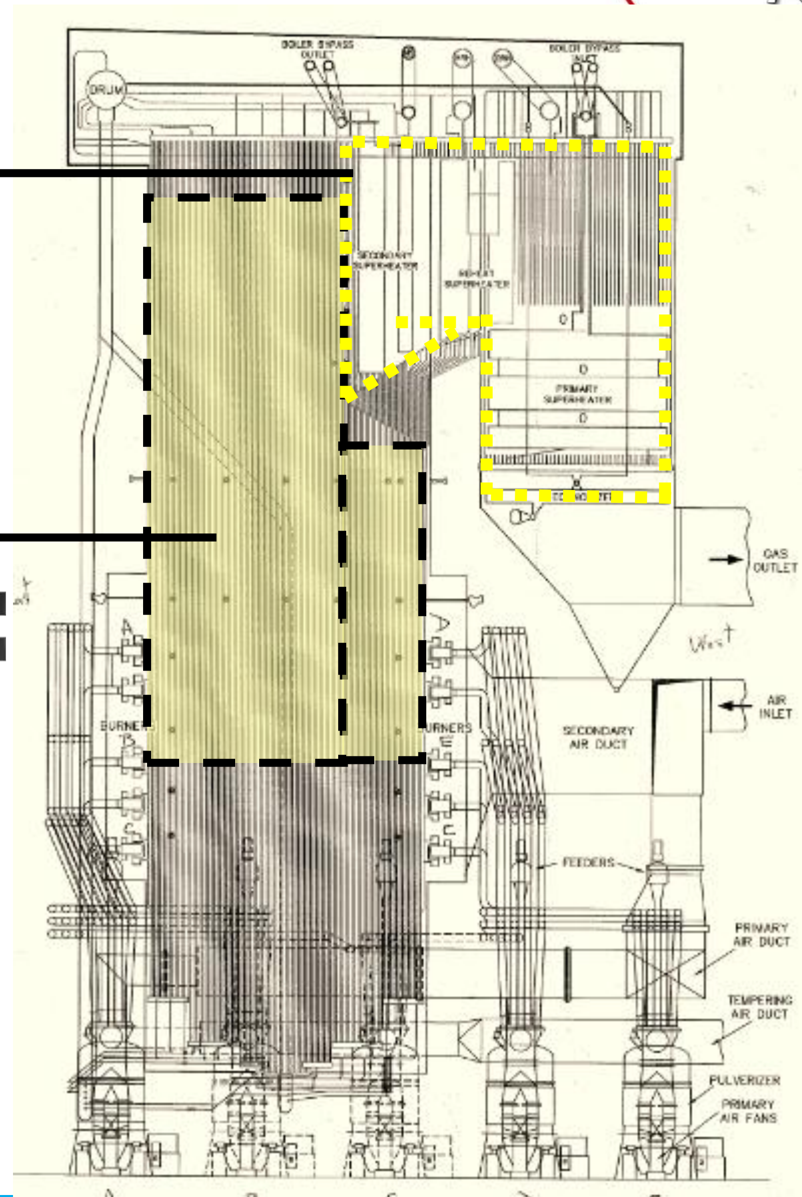
TDM **T**hermo **D**ynamic **M**odel

SMART FURNACE

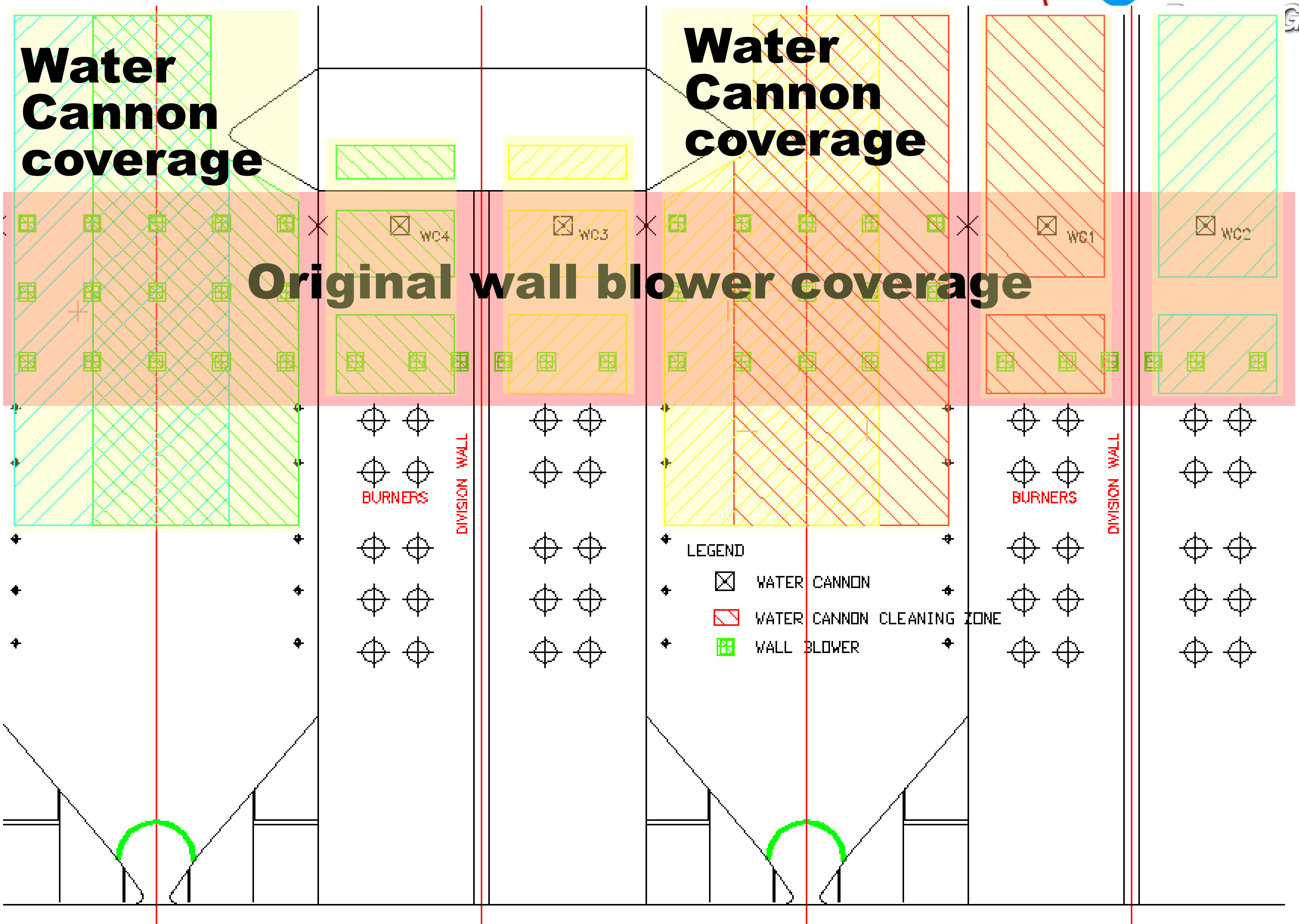
4 SMART Cannons

44 SMART Flux Sensors



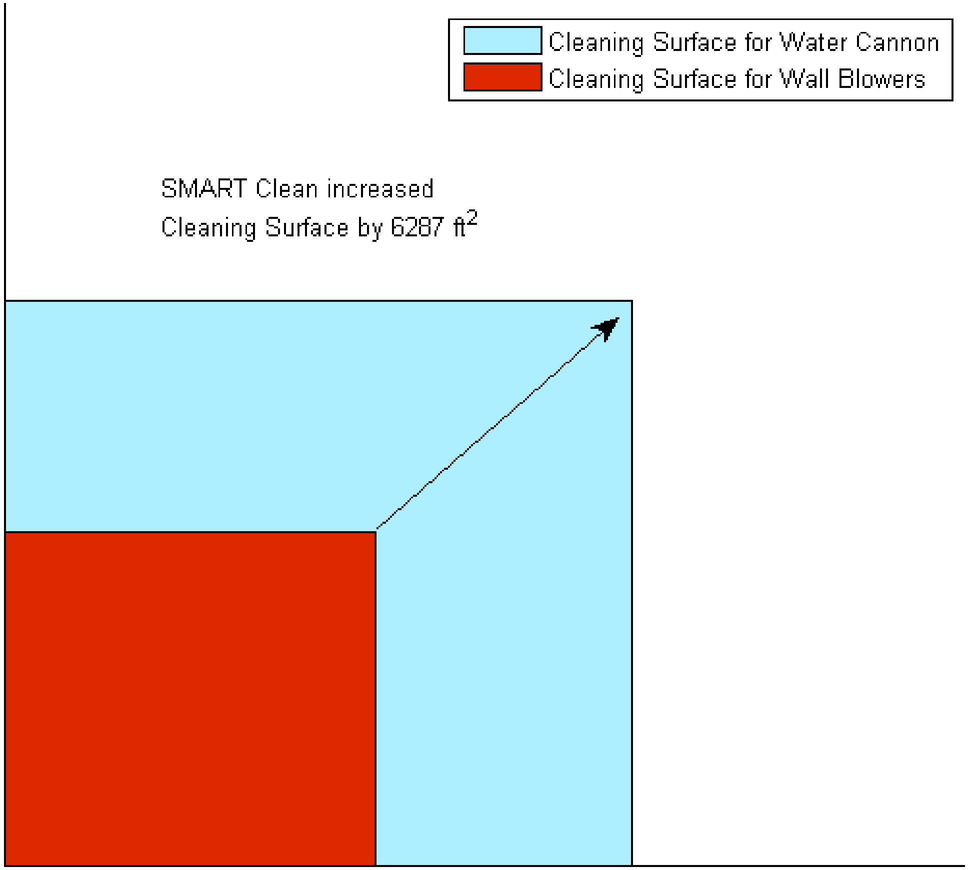


Boiler Furnace

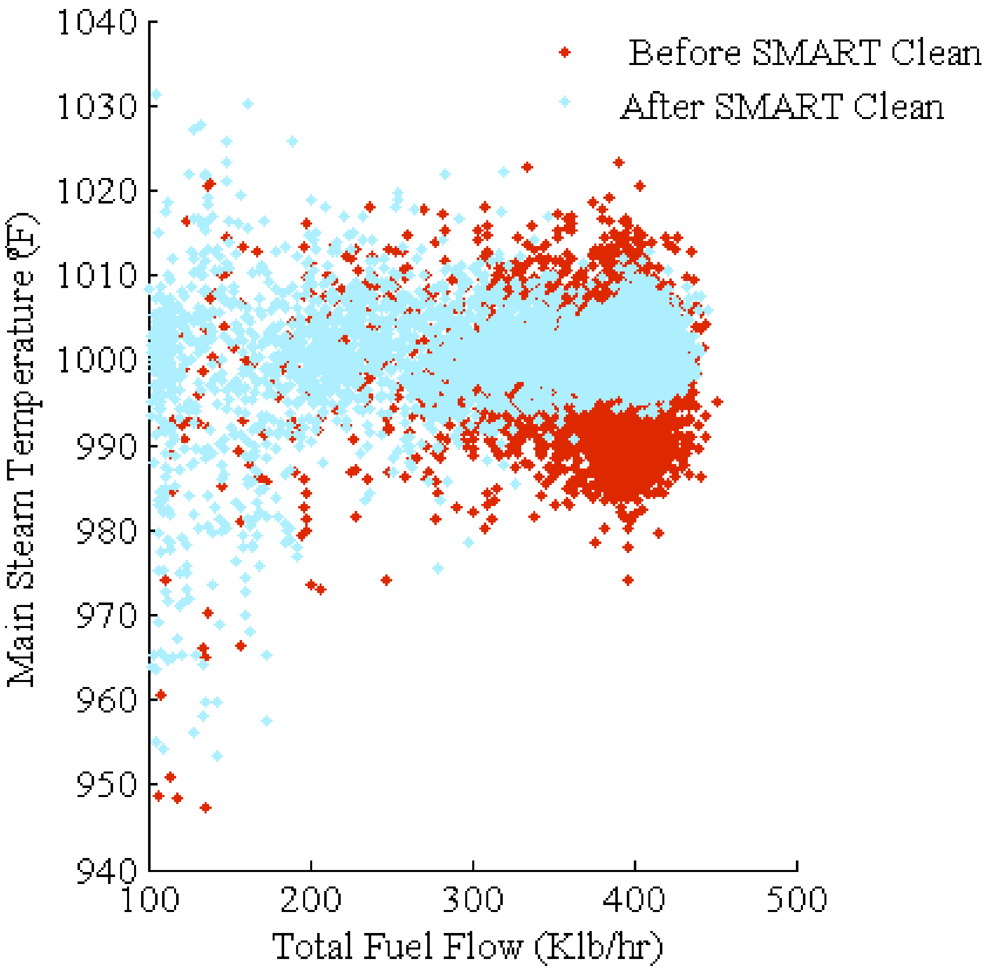


Cleaning Surface comparison

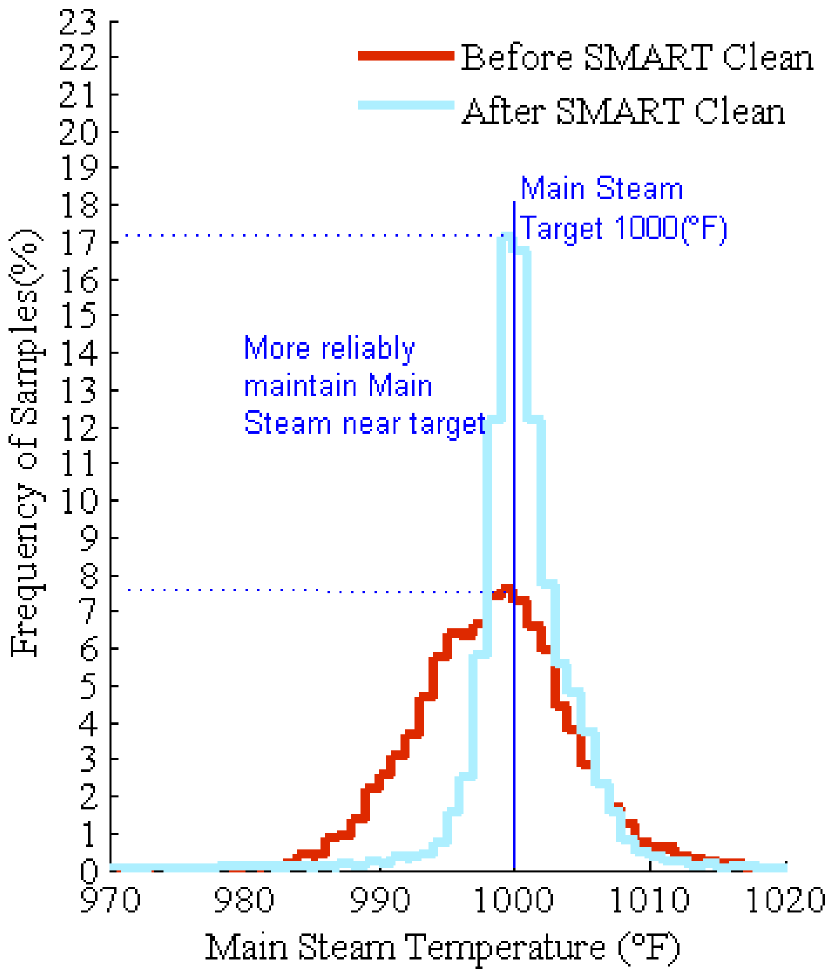
- 43 wall blowers clean 40% of Furnace
- 4 Water cannons clean 80%
- Furnace Cleaning Surface was Doubled.
- Therefore, Wall Blower taken out operation.



Main Steam Temperature Improvement

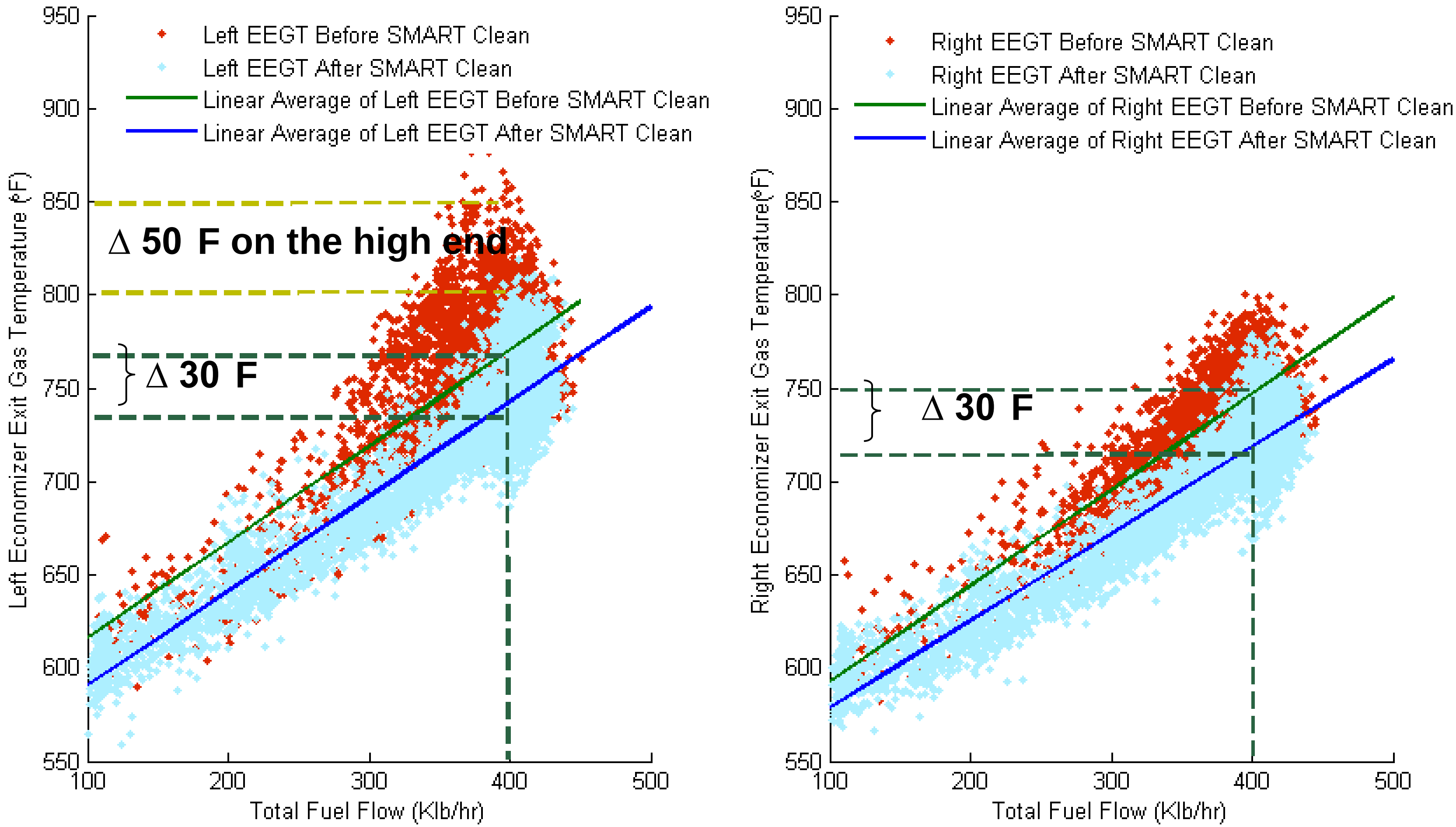


Steam temperature control compared to fuel flow



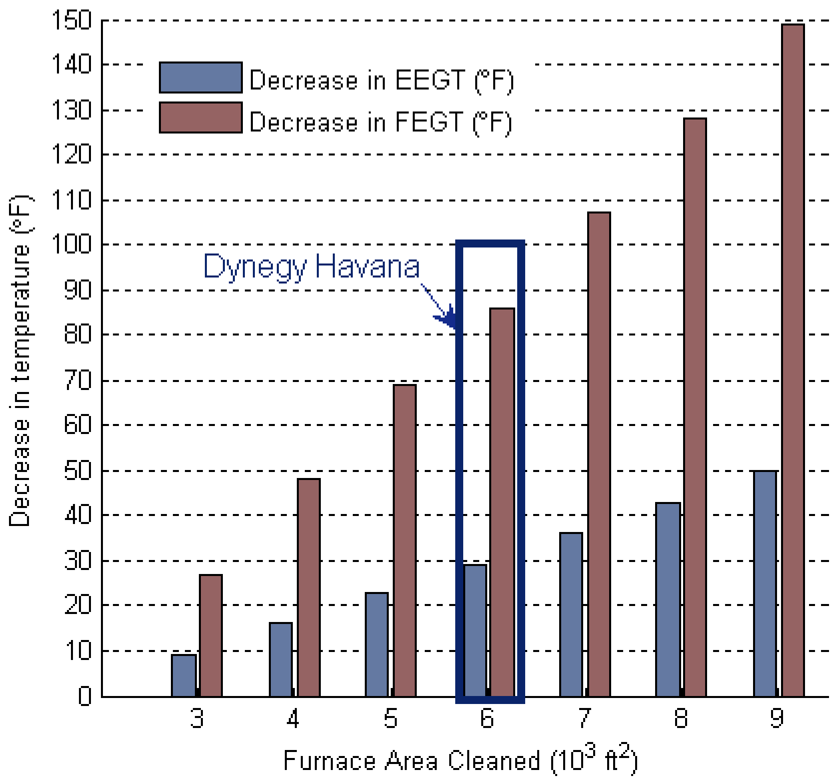
Improvement in steam temperature control

E.E.G.T. Improvement



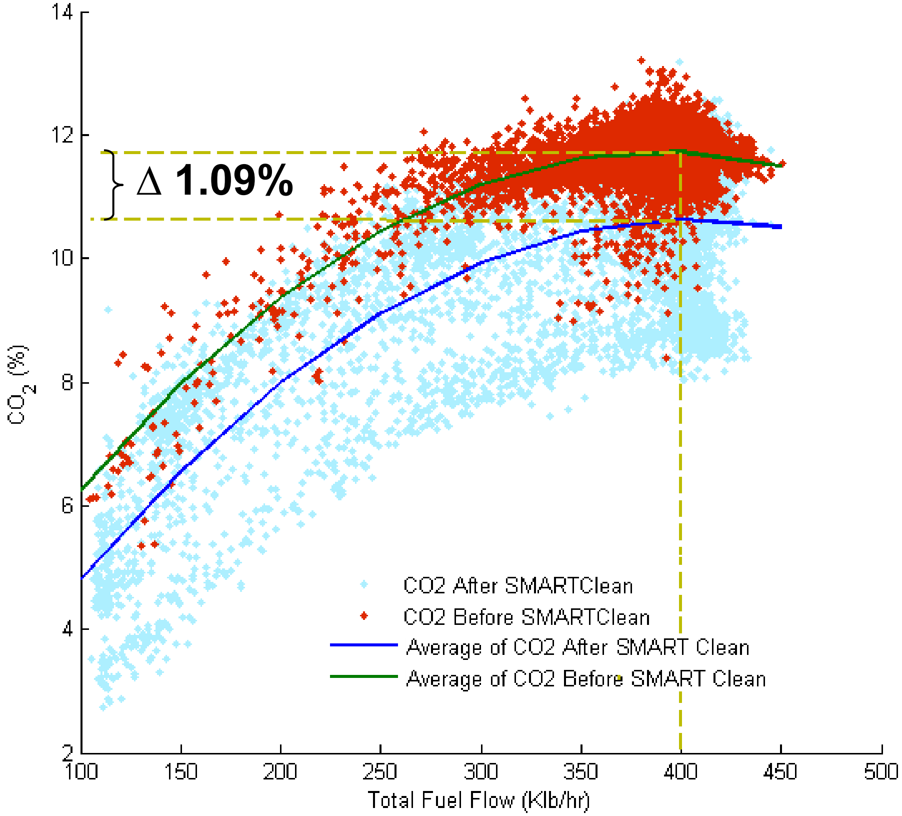
F.E.G.T. Improvement

- Calculation Inputs
  - ➔ Average HF improvement =10%
  - ➔ Base line Plant Heat Rate = 10900
  - ➔ Nominal Power Generation = 488 MW
  - ➔ Furnace Heat Transfer = 36% of total heat absorbed
  - ➔ HHV of Coal = 8800 btu/lb

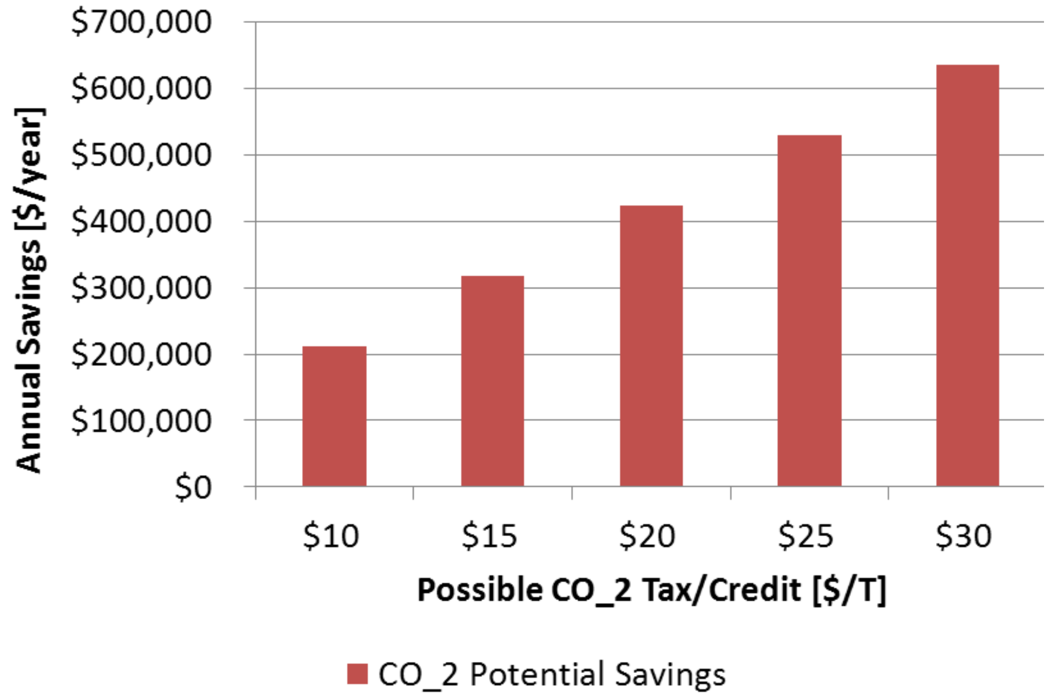


- EEGT Improved by 30 F
- FEGT (calculated) improved by ~ 85 F

Reduction in Carbon Dioxide

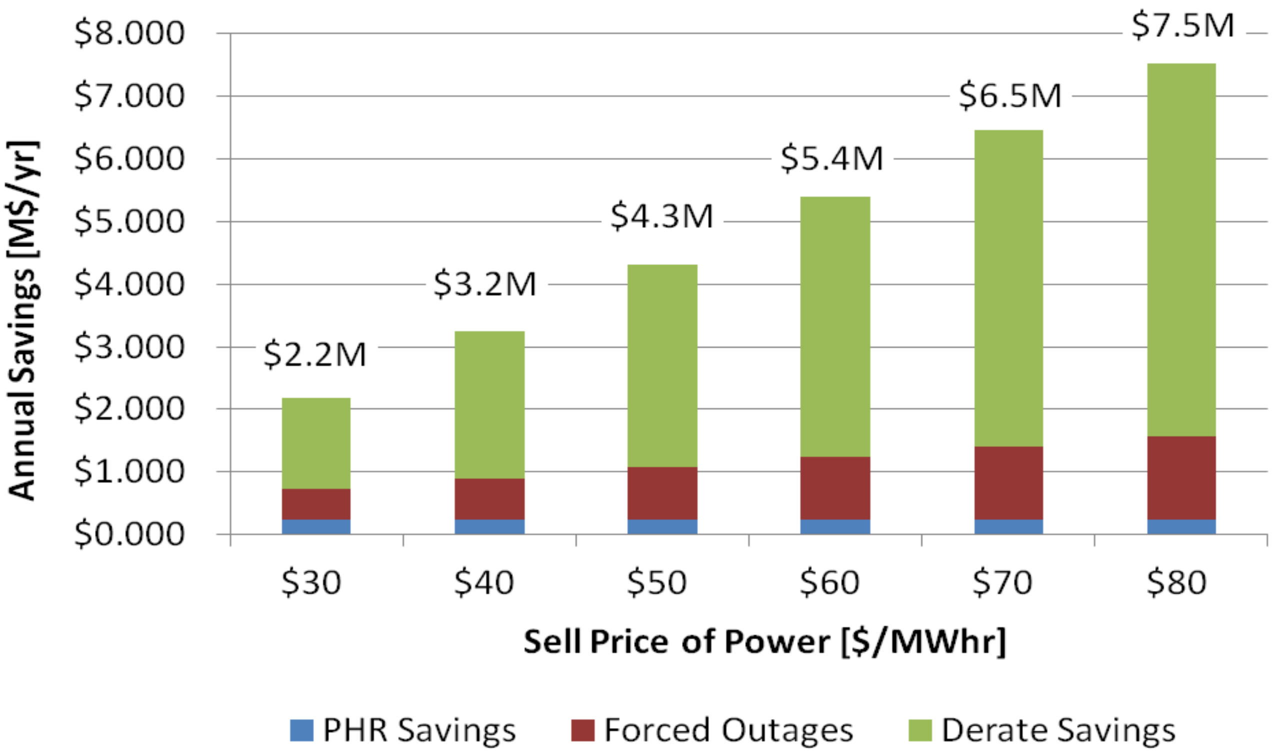


Potential Savings based on CO_2 tax



- Dynegy Havana reduced their CO_2 by 1.09% (2.48 T/hr)

Economical Analysis



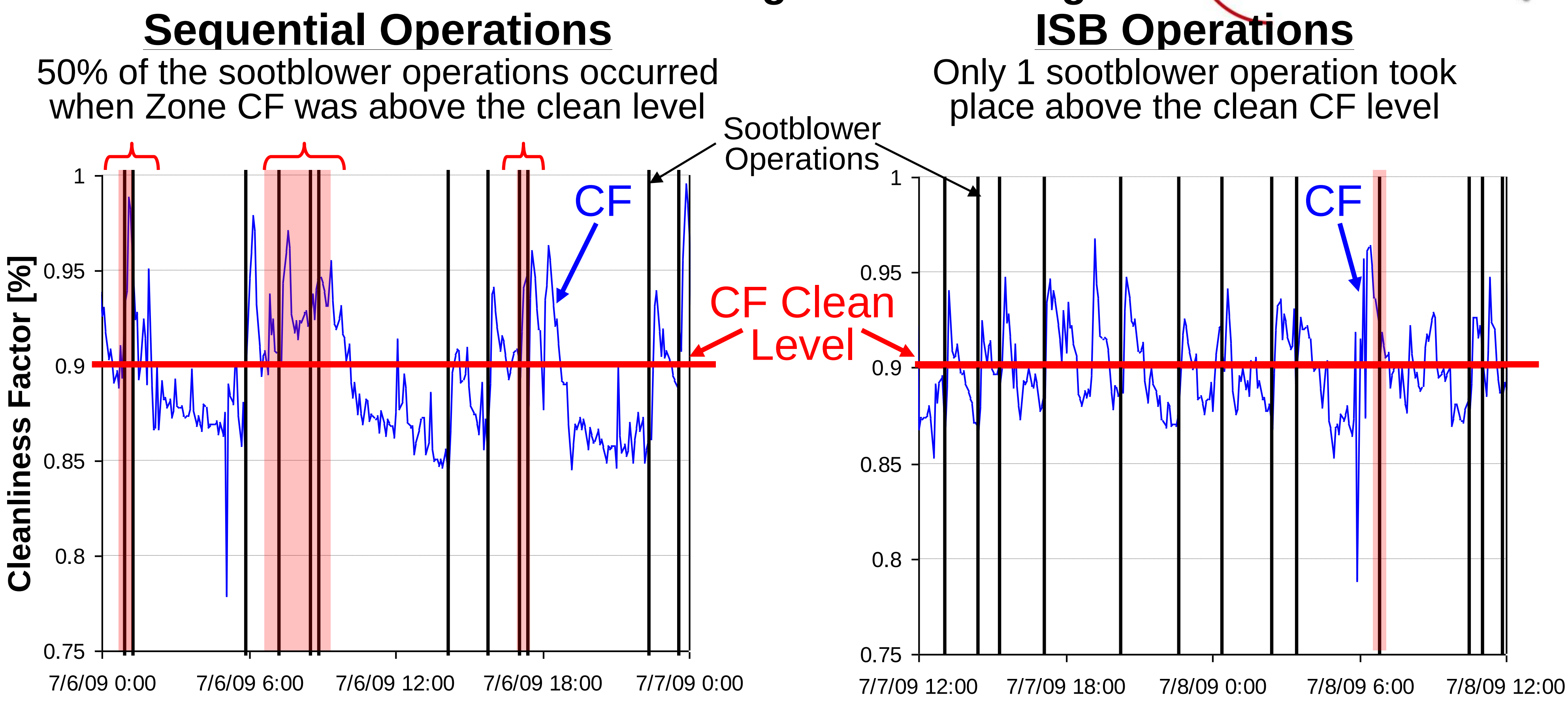
- Total savings ranges from $2.2M to $7.5M
  - ➔ 0.59% Plant Heat Rate improvement = $287,000
  - ➔ Elimination of 2 days forced outages from furnace tube leaks and ESP pluggage ranges in savings from $500,000 to $1,300,000
  - ➔ Elimination of average 15 MW Derate ranges in savings of $1,400,000 to $6,000,000

CASE STUDY

Reliability and Tube Life Improvement

SRP Navajo

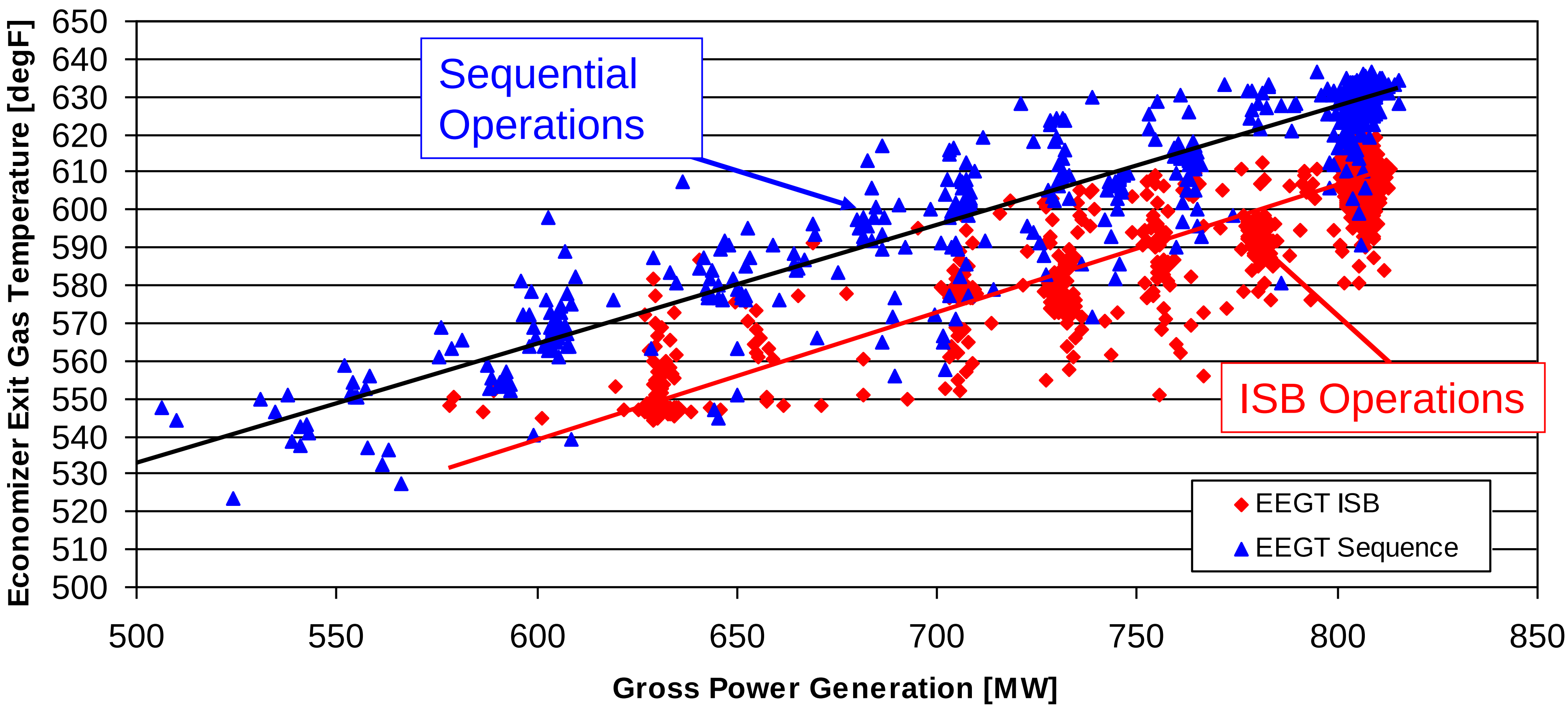
Preventing Over-Cleaning



- Both Sequential and SmartClean ISB had similar number of operations/day.
- However, ISB initiated 92% of the cleaning operations below the clean level of 0.9 CF, reducing the risk of over cleaning and tube erosion.

Improvement in EEGT – SRP Navajo

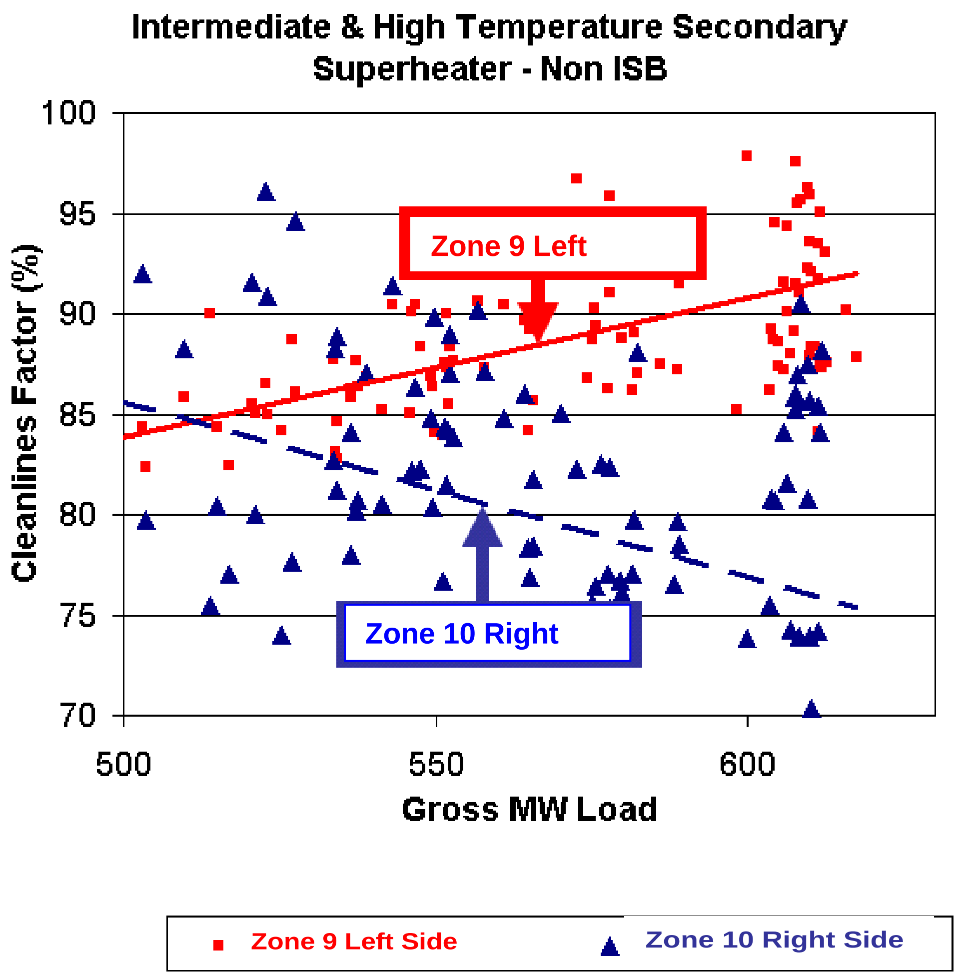
- 20 F reduction in Economizer Exit Gas Temperature (~0.6% improvement in Boiler Efficiency)

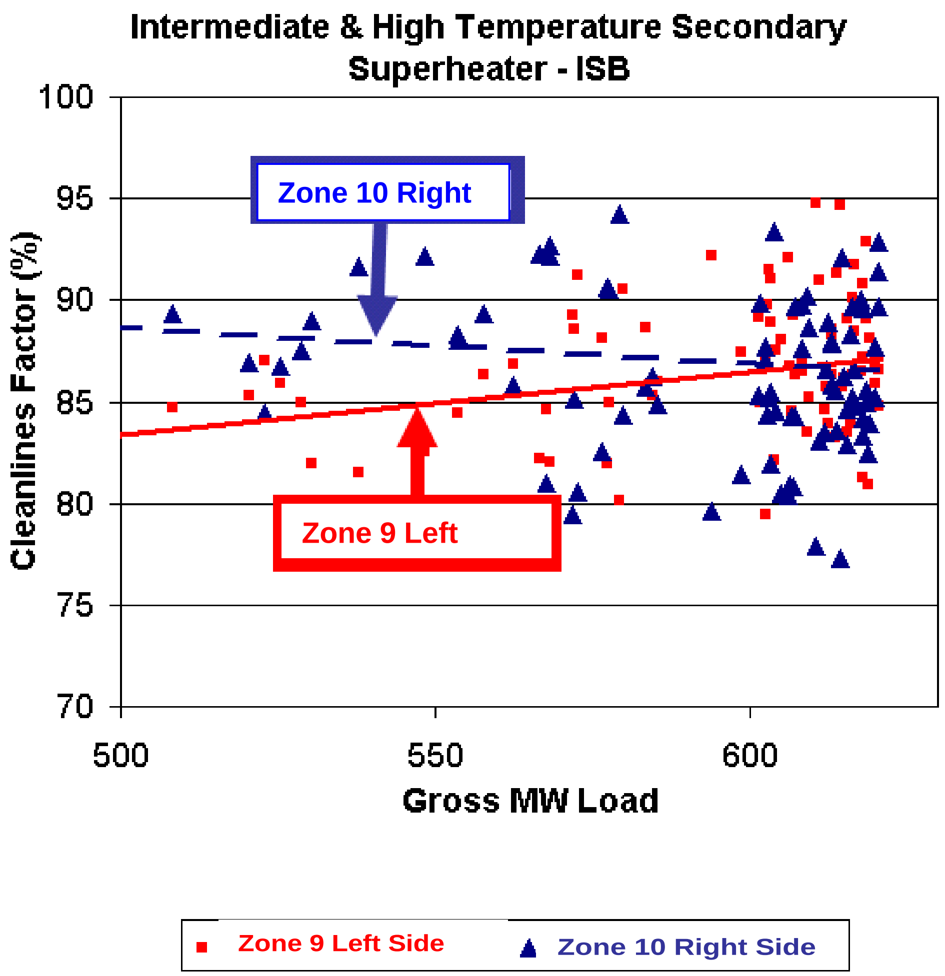


Resolving Heat Transfer Imbalance

NON-ISB

ISB





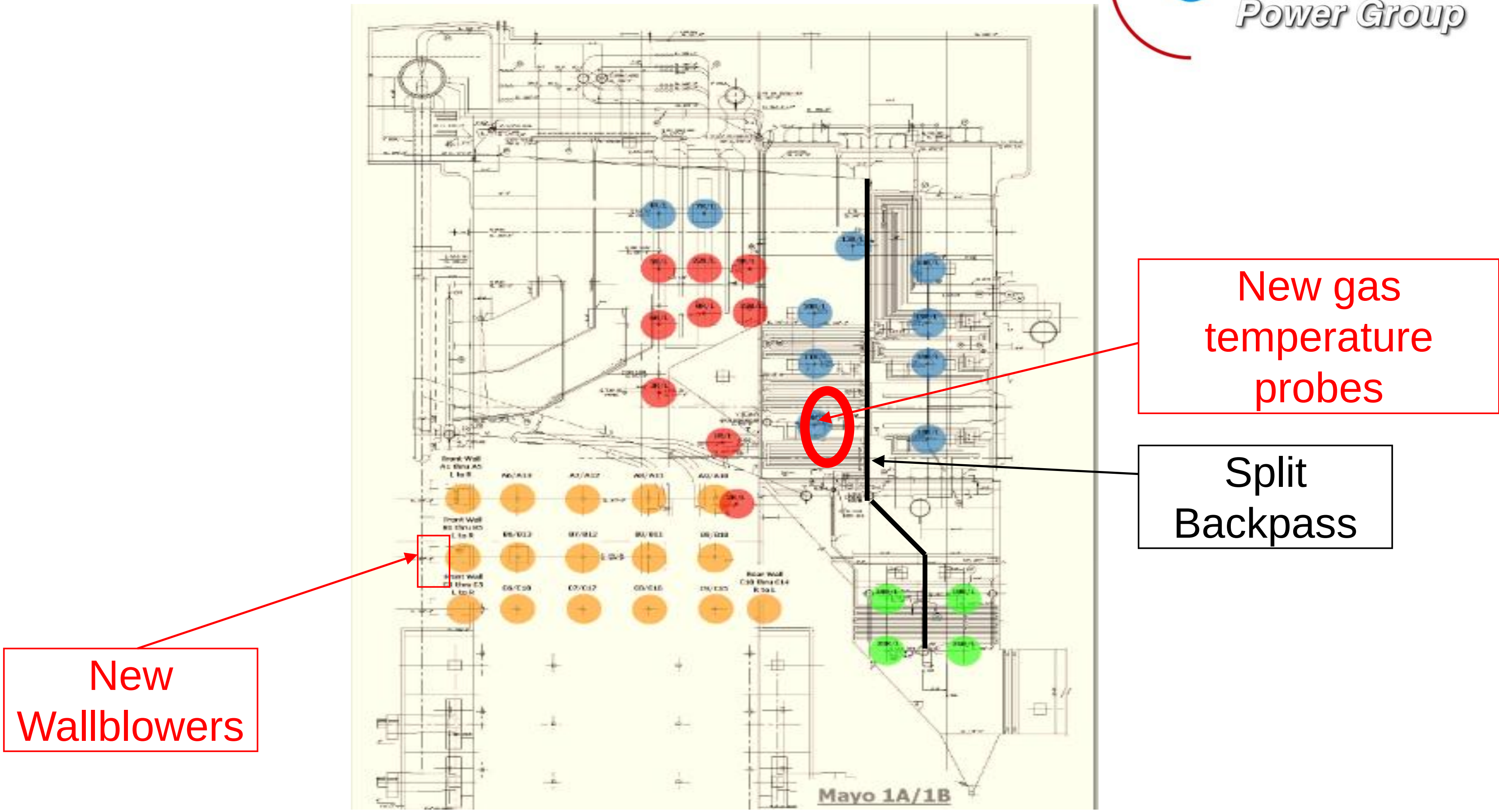
CASE STUDY

SCR Temperature Control

MAYO Power Station (Duke/PGN Energy)

- Located near Roxboro, N.C.
- 1983 dual-boiler (Foster Wheeler) unit fired with Bituminous Coal. 800MW Gross.
- Clyde Bergemann SMART Clean Intelligent Sootblowing System was installed and commissioned in June 2010 along with 84 Clyde Bergemann VS sootblowers.

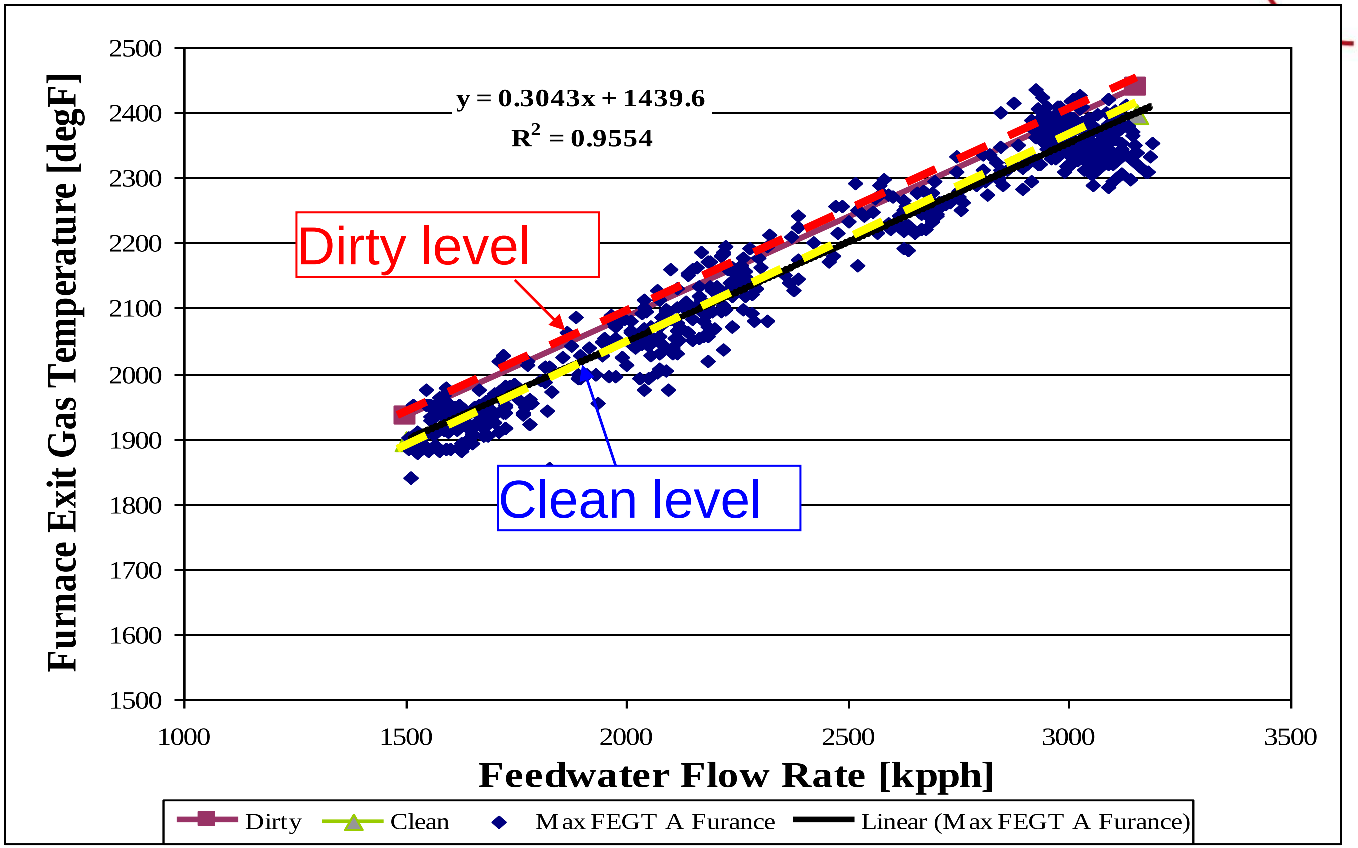
MAYO - Boilers A & B



SCR Inlet Flue Gas Temp Control

- Challenge:
  - ➔ Furnace fouling is an impact on SCR inlet gas temperature
  - ➔ The effect of furnace cleanliness needed to be taken out of the equation to improve the SCR inlet gas temperature control
- Solution:
  - ➔ Keep furnace cleanliness stable thus stabilize FEGT
  - ➔ How?
    - Set cleanliness targets dynamically => A sliding scale FEGT target was determined for each firing rate
    - Clean the furnace via SMART Clean => Wall Blowers were tied into closed loop control and system was run in automatic mode which operates the wall blowers that has the greater effect on FEGT more frequently

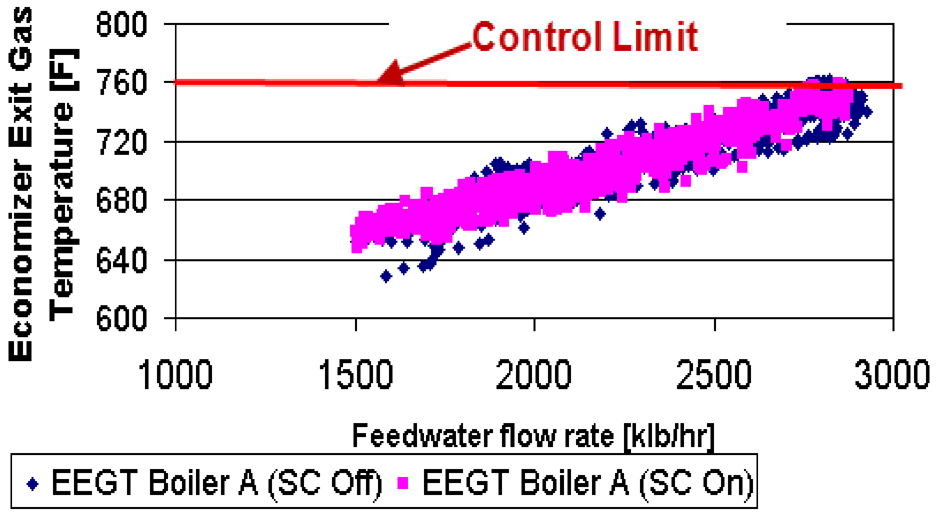
SCR Inlet Flue Gas Temp Control



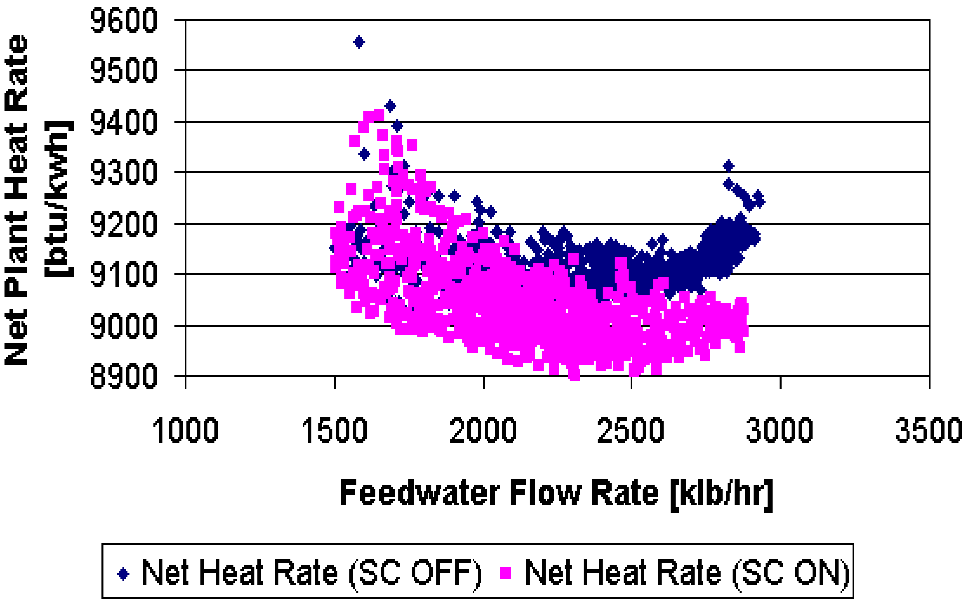
- FEGT clean target is adjusted as a function of the feedwater flow rate to stabilize furnace cleanliness.

SmartClean ISB– PGN MAYO

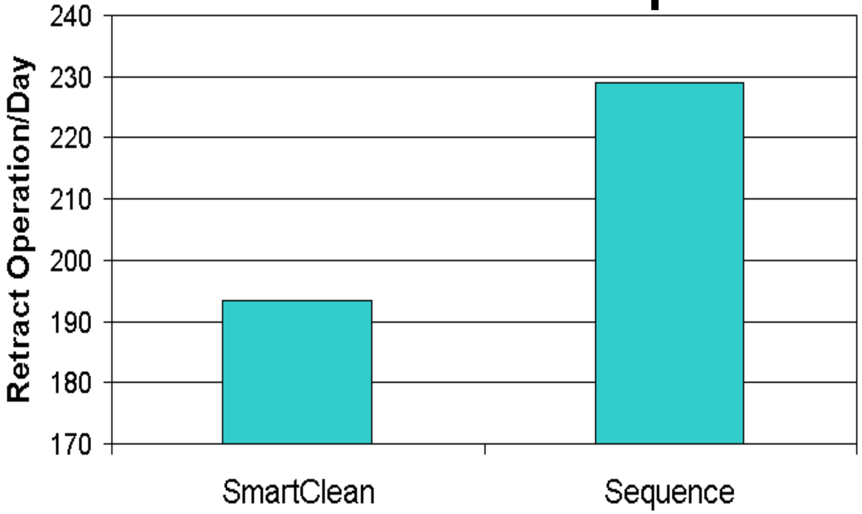
EEGT and SCR Inlet Gas Temp Control



PHR Improvement



Reduction in Retractable Operations



Questions?