

REINHOLD ENVIRONMENTAL®



2026 Reinhold/PCUG Round Table Presentation

Hosted by TVA, Southern Company and Vistra
in the Sonesta Nashville Airport Hotel, Nashville, TN
on June 22-23, 2026

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Range of Uses and Benefits of Data-Driven Knowledge Capture Automation



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Taber International, LLC. – Automation Engineer & Developer

2026 Reinhold/PCUG Conference
June 2026 | Nashville, TN

SOLUTION EXPERIENCE



Taber International

- **20+ years** of operation deploying cutting-edge technology and fully customized optimization solutions for power generation on units from **across Southeast Asia, Europe, South America, Australia, and the United States.**
- Have worked on **all major boiler makes and designs of various sizes** (as large as 900 MW units) assisting with **achieving stable operation as low as ~12% MCR without major hardware installations**



Griffin Open Systems

- **Objectives and priorities within systems can readily evolve** to meet the changing energy landscape
- **100% of installations are engaged and in-use**, many are self-sustaining, requiring only minimal attention Develops and maintains The Griffin AI Toolkit™ software platform, a graphical programming environment for process optimization, used by Taber to implement optimization applications
- **An open system framework, providing transparency and clarity** to solutions and an intuitive and easy-to-use platform designed for engineers and operators to quickly and simply automate the mundane and optimize the complex, realizing significant process advantages

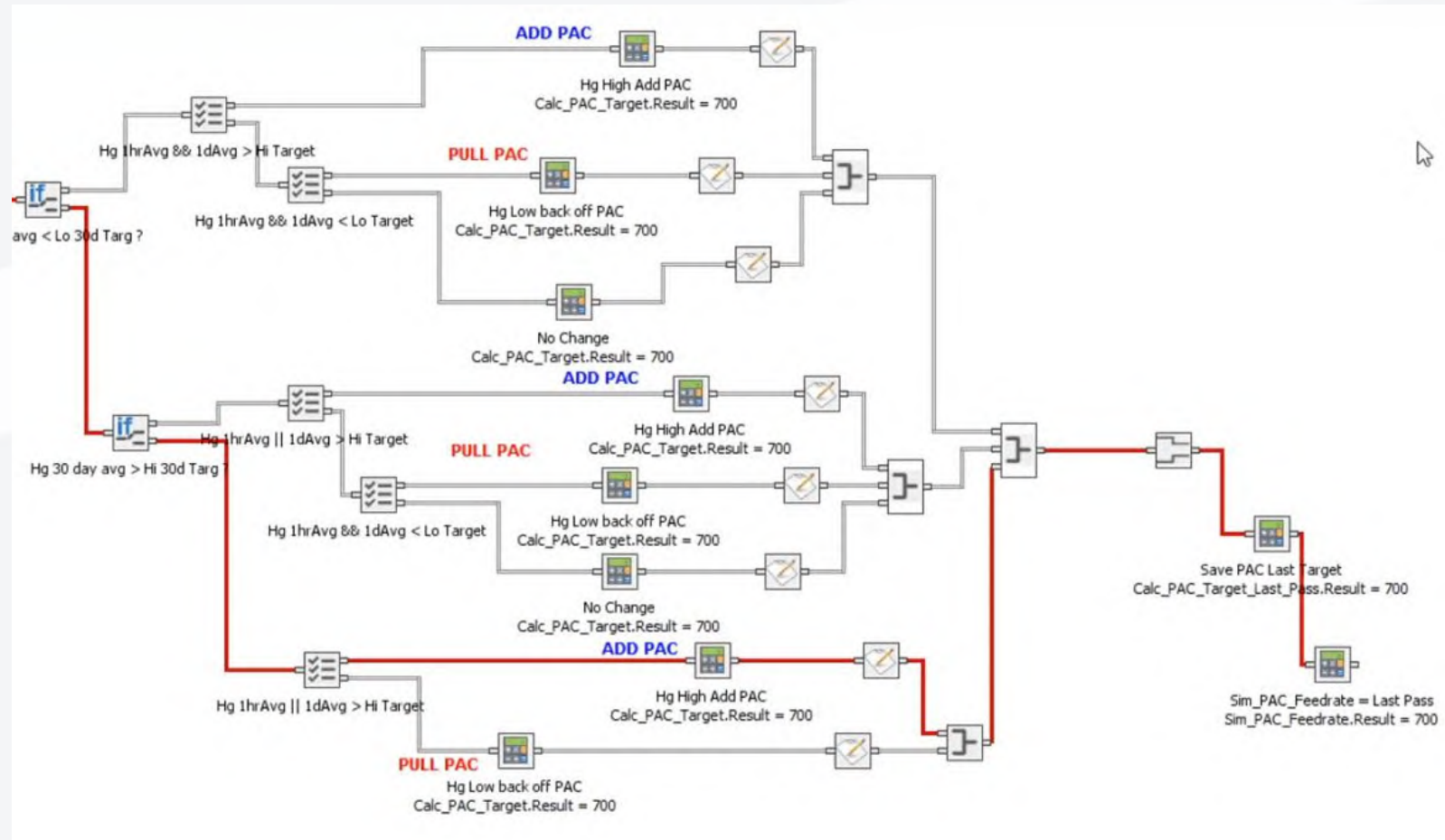
WHAT IS “DATA-DRIVEN KNOWLEDGE CAPTURE”?

Let the actual data from the process tell you about the process and inform you.

Absorb and integrate the knowledge and experience of seasoned operators, engineers, process owners, etc. from around the site DIRECTLY within the system, PERMANENTLY.

The effective combination of “direct-from-the-process” data & “best at site” seasoned experience results in a highly dynamic and capable system, able to maximize the capability of systems across a wide-array of conditions and circumstances.

KNOWLEDGE CAPTURE



“Knowledge Capture” is the process of codifying operator experience, so that the control system can take those same actions automatically.

Taber’s systems developed in the Griffin AI Toolkit platform provide unparalleled ease and simplicity for accomplishing this.

WHAT KINDS OF THINGS CAN BE DONE WITH “DATA-DRIVEN KNOWLEDGE CAPTURE”?

Well... What do you need done?

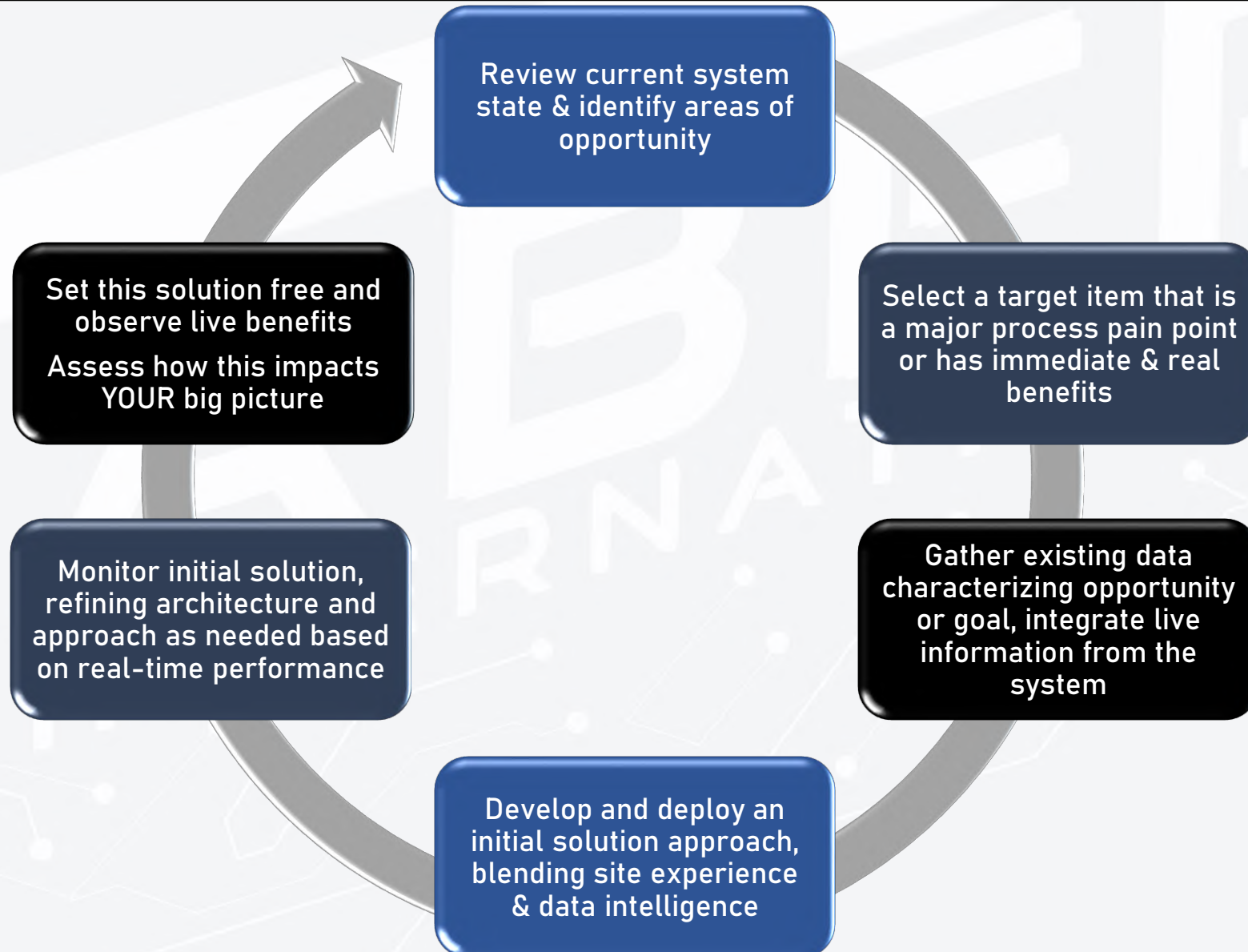
The defining feature or characteristic is simply:

Do you have data describing the problem or objective?

If you have data describing the system or process (online or offline, either works), this data can be utilized within an intelligent processing system, understanding extracted, and this used for informed decision-making.

This information and understanding can then be guided and validated by expert knowledge capture, again in either an offline or online approach.

SOLUTION DEVELOPMENT CYCLE



TECHNIQUES & APPROACHES USED

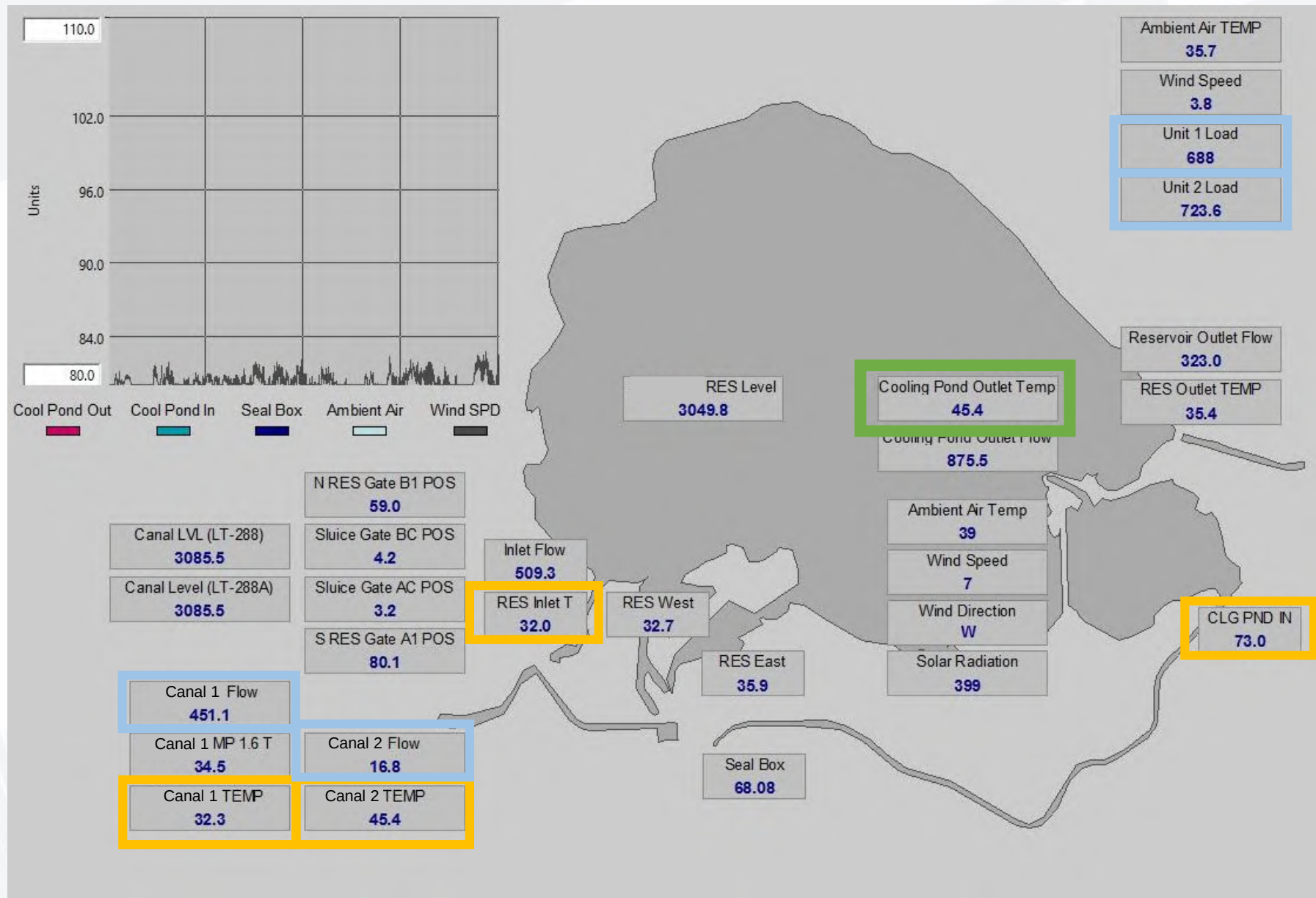
The techniques and approaches, and therefore the implementation possibilities, can essentially be considered endless through thousands of integration and deployment combinations.

Some of the building blocks include:

- Basic feedback response (i.e., if “x”, then do “y”)
- Curve relationships (from fixed curves to self-identifying curves)
- PID Controls (all structures)
- Predictive / Feed-forward Structures
- Automatic Historical Observation Retrieval
- Simple Modeling (regression, etc.)
- Advanced Pattern Recognition (APR)
- Machine Learning
- Artificial Intelligence

PROCESS MONITORING & PREDICTION

OFFLINE EXAMPLES – COOLING POND MODELING



COOLING POND MODELING

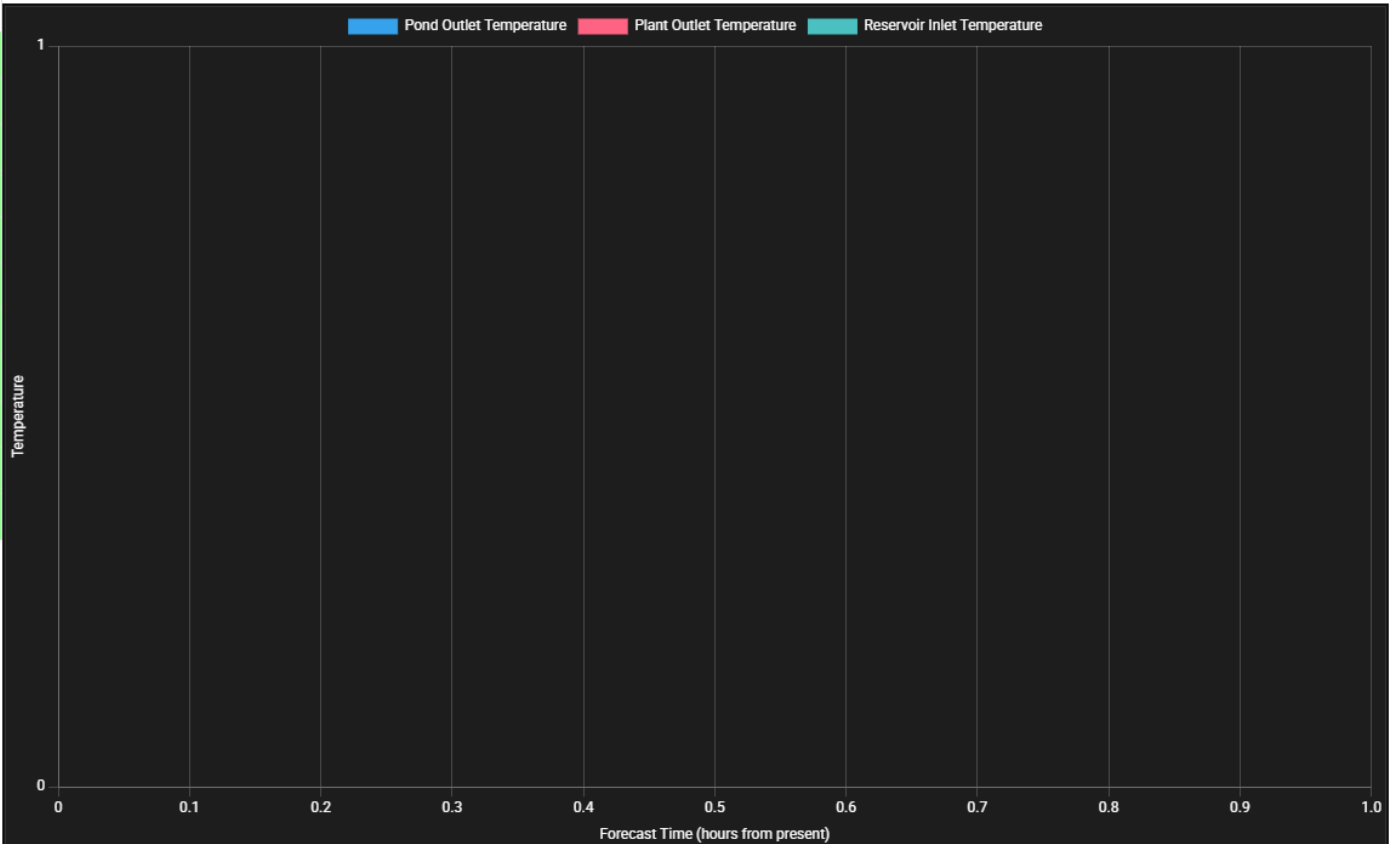
Cooling Pond Overview

# Days Ahead	Canal 1 Flow (CFS)	Canal 2 Flow (CFS)	Well Flow Before Plant Inlet	Well Temp Before Plant Inlet	Well Flow After Plant Outlet	Well Temp After Plant Outlet
0	0	450	0	0	0	0
1	0	450	0	0	0	0
2	0	450	0	0	0	0
3	0	450	0	0	0	0
4	0	450	0	0	0	0
5	0	450	0	0	0	0
6	0	450	0	0	0	0
7	0	450	0	0	0	0
8	0	450	0	0	0	0
9	0	450	0	0	0	0
10	0	450	0	0	0	0

Save

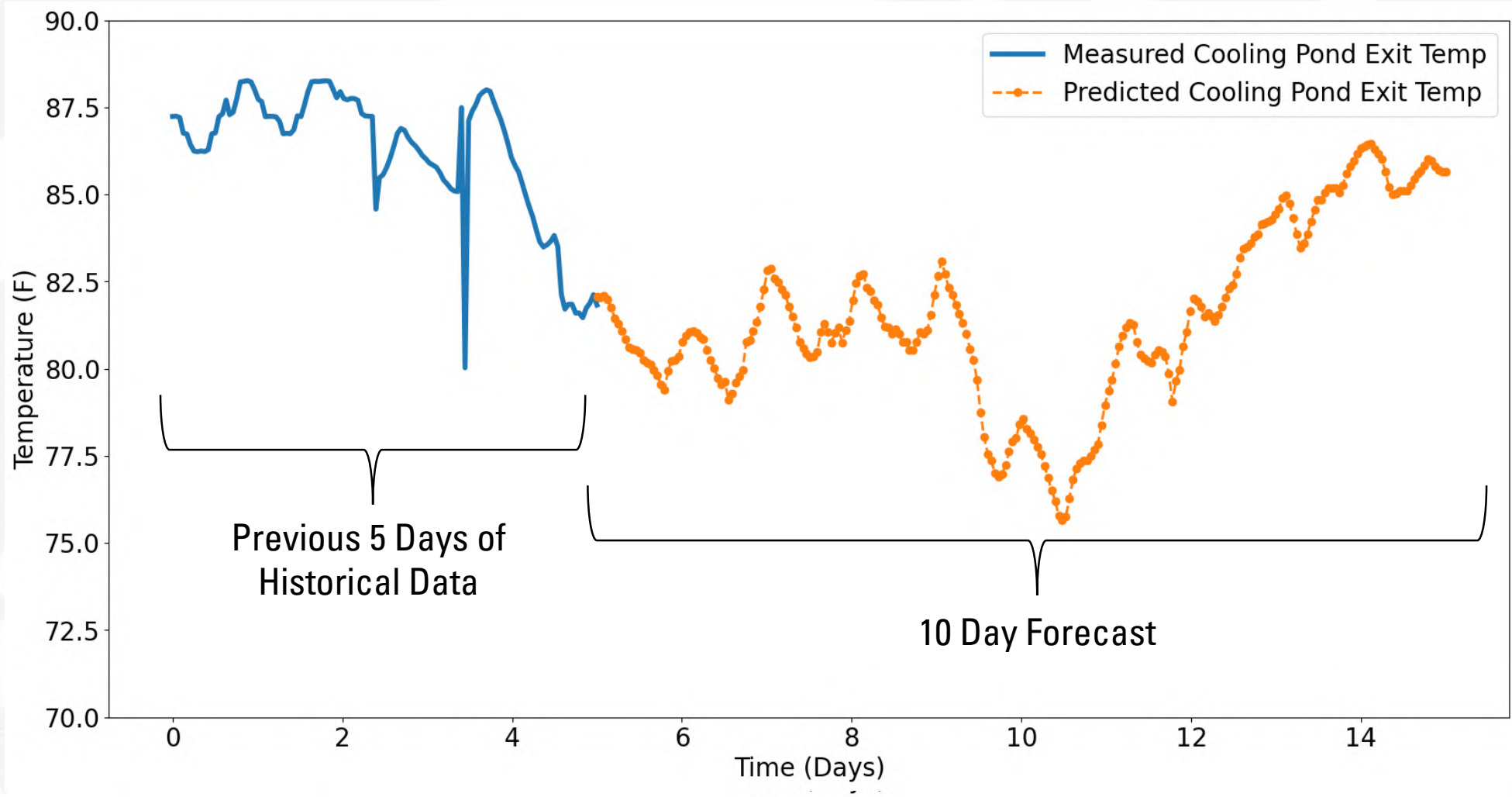
Last Forecast Completed :

☒ Forecast Temps ☐ Forecast Temps – Max Load ☐ Pond Out 1-day Prediction ☐ Plant Out 1-day Prediction



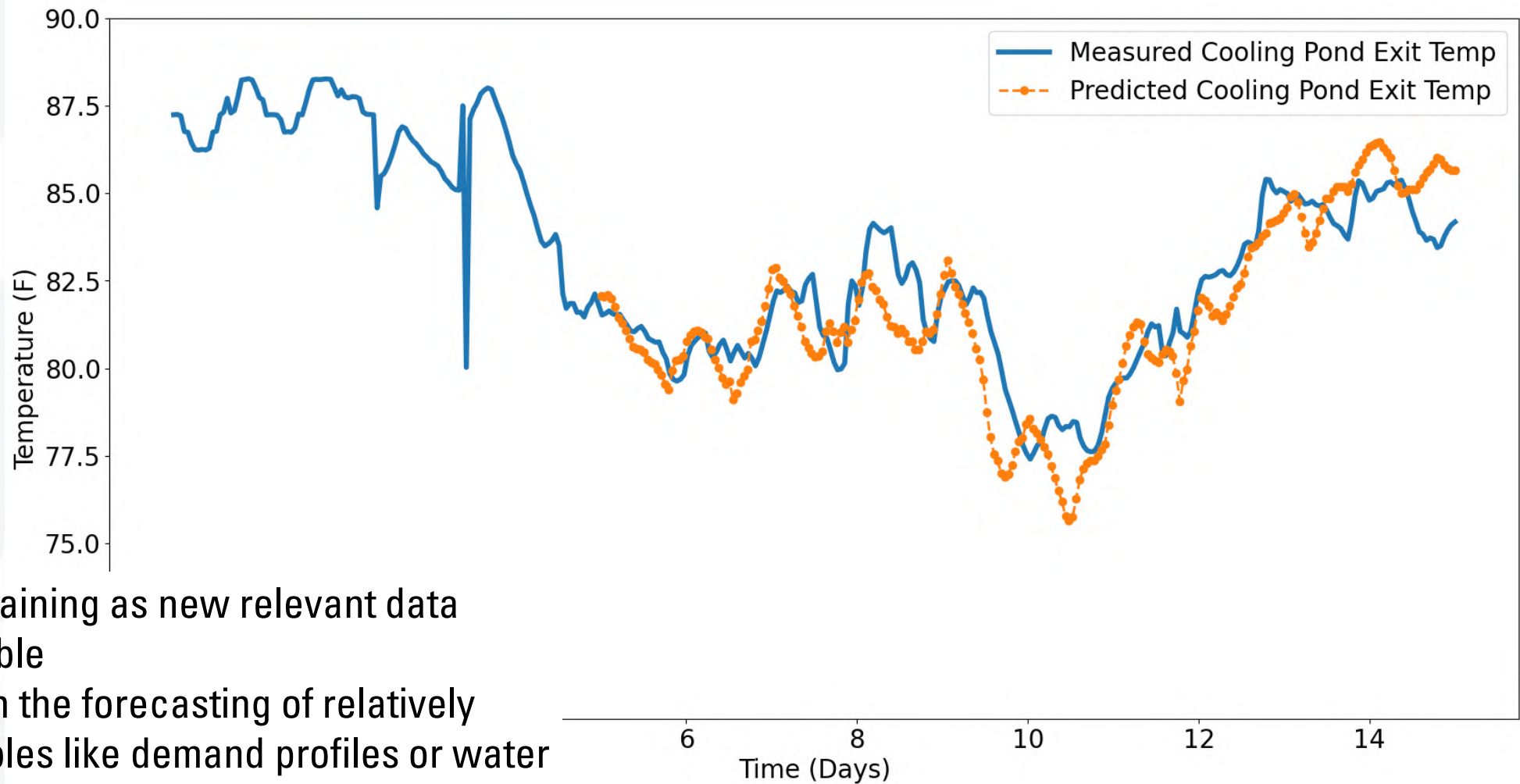
COOLING POND MODELING – PREDICTION ABILITY

- Long Short-term Memory (LSTM) models take recent time-series data and uses that to predict how conditions will change in the future
- The predicted cooling pond exit temperature can be taken multiple steps to anticipate changes over the next several days



COOLING POND MODELING – PREDICTION ABILITY

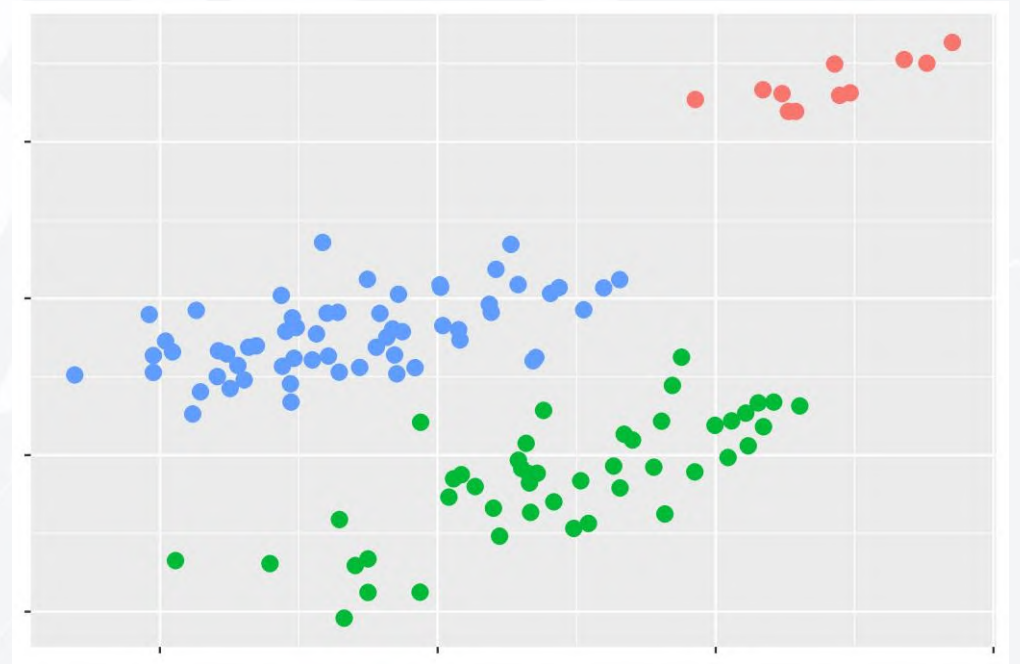
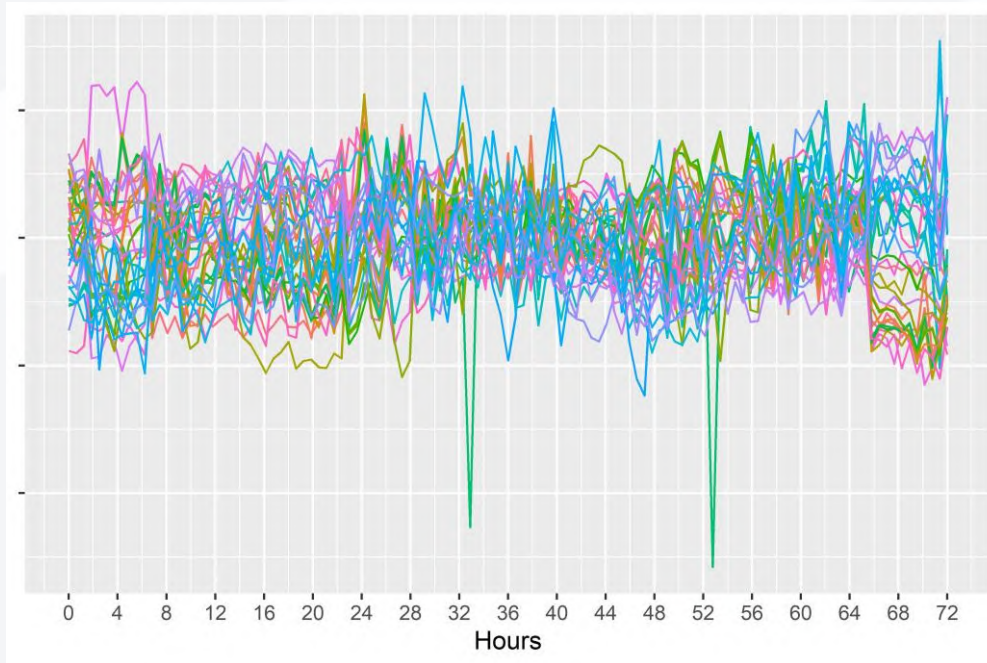
- Comparison of the predicted cooling pond exit temperature shows good predictive capability of the LSTM models.
- These models will continue to be improved upon through:
 - Further model training as new relevant data becomes available
 - Improvements in the forecasting of relatively uncertain variables like demand profiles or water availability via canals



ANOMALY DETECTION

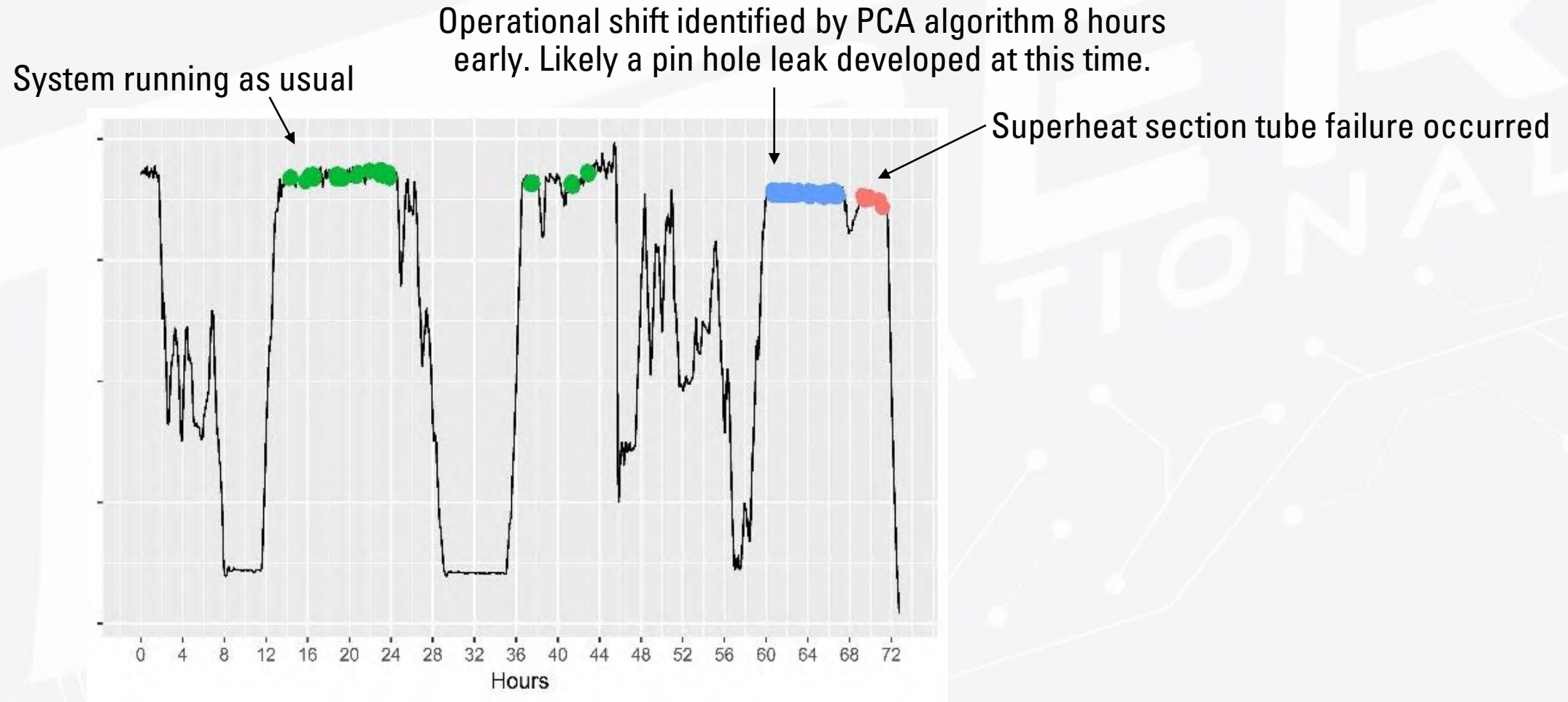
OFFLINE EXAMPLES – ANOMALY DETECTION

CAN YOU IDENTIFY THE PROCESS SHIFT?



WHAT IS IT?

OFFLINE EXAMPLES – ANOMALY DETECTION



VIRTUAL SENSORS TO PROVIDE DEEPER KNOWLEDGE

VIRTUAL SENSORS TO BETTER INFORM CONTROLS

At many sites, coal quality can be highly variable and rarely consistent. Taber provides a means to identify the characteristics of as-fired coal in real-time to respond and adapt to these impacts.

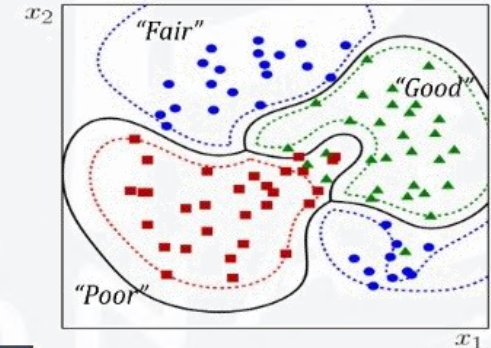
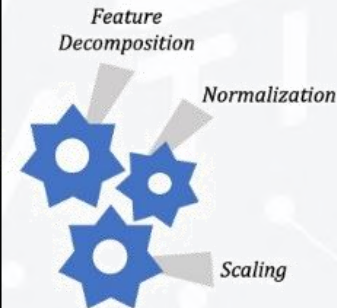
- Real-time DCS measurements
- Coal quality modeled & predicted in real-time
- Adapt combustion and sootblowing practices in response to coal characteristics

Live Operational Data

Feeder Speeds
Mill Amps
Hot Air Damper
Position
Unit Load
etc.



Coal Quality Estimator

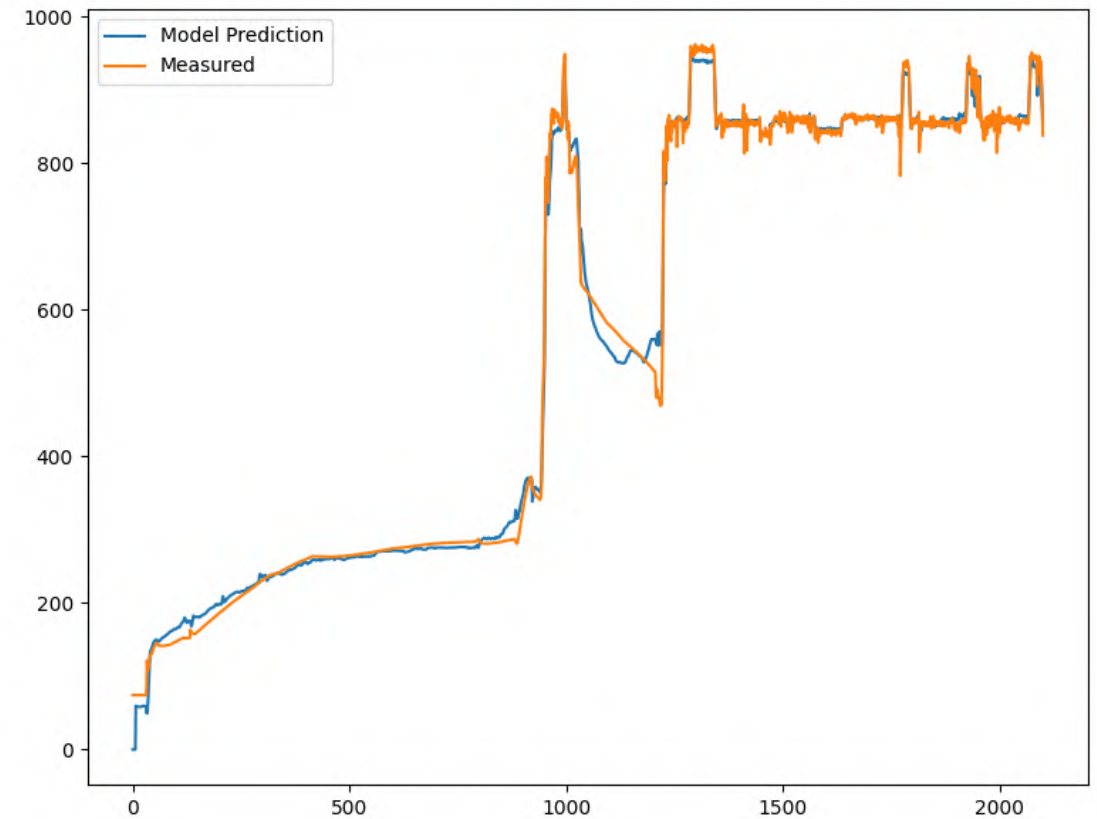
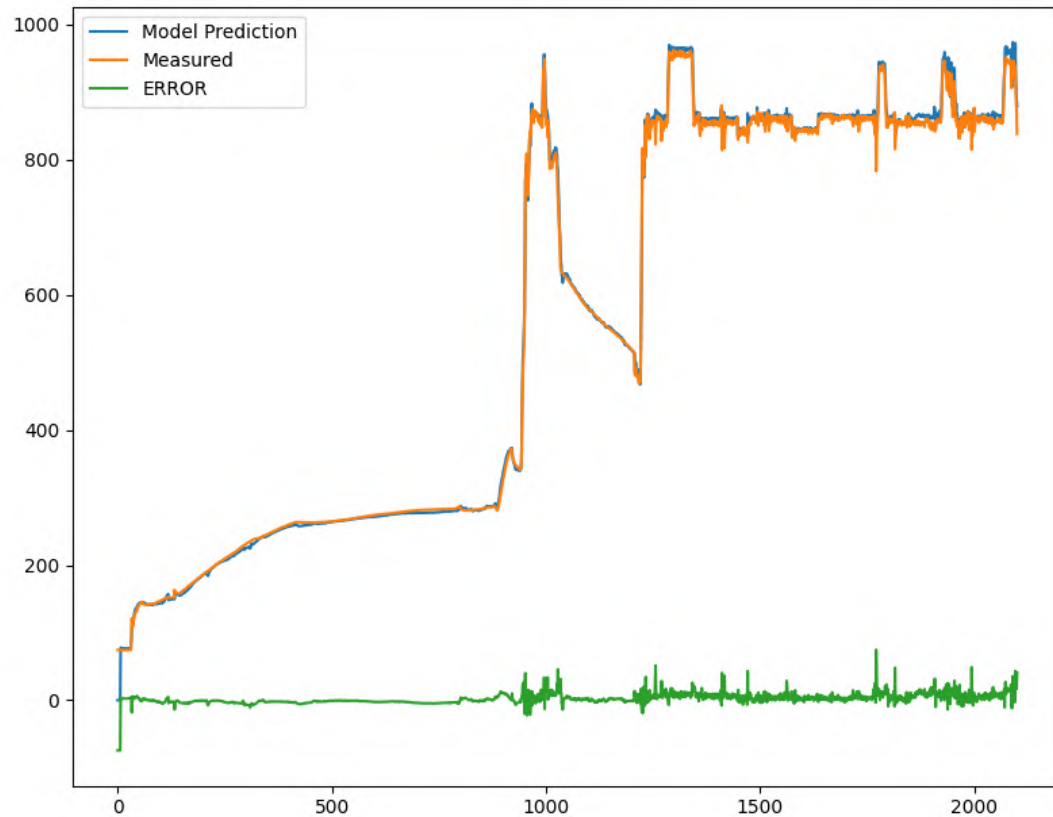


HHV	= 23260 kJ/kg
Ash-%	= 28.6%
Moisture-%	= 16.1%
Sulphur-%	= 4.3%

VIRTUAL SENSORS TO BETTER INFORM CONTROLS

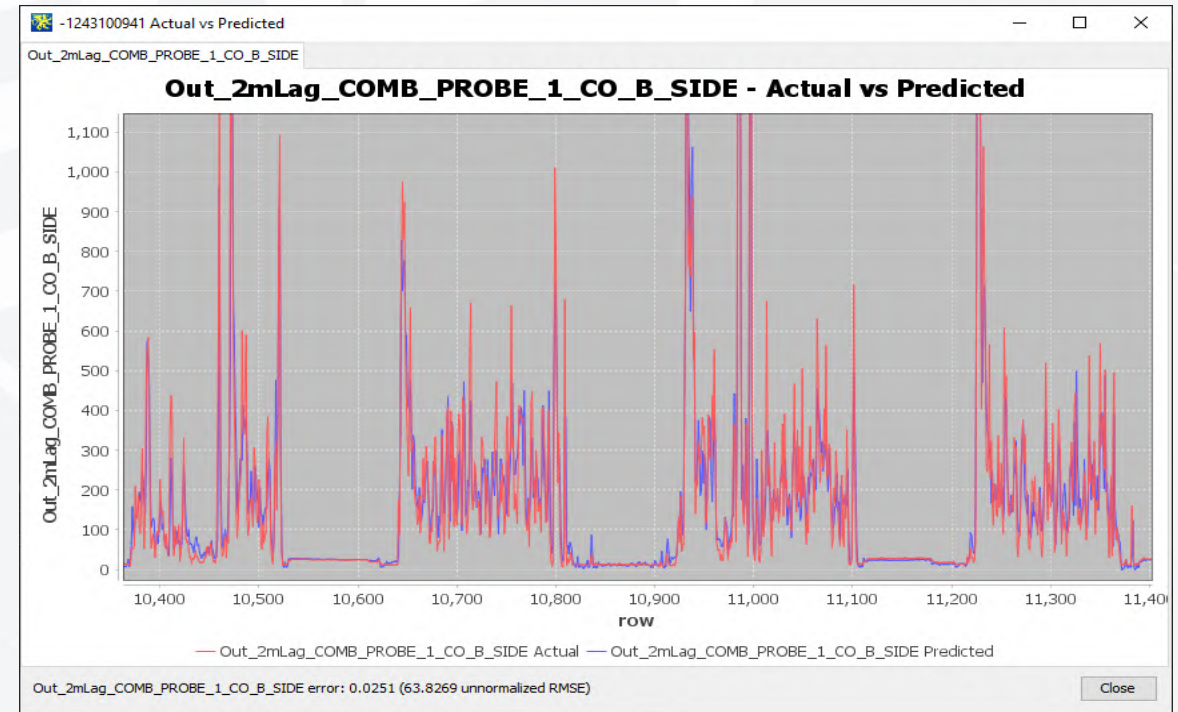
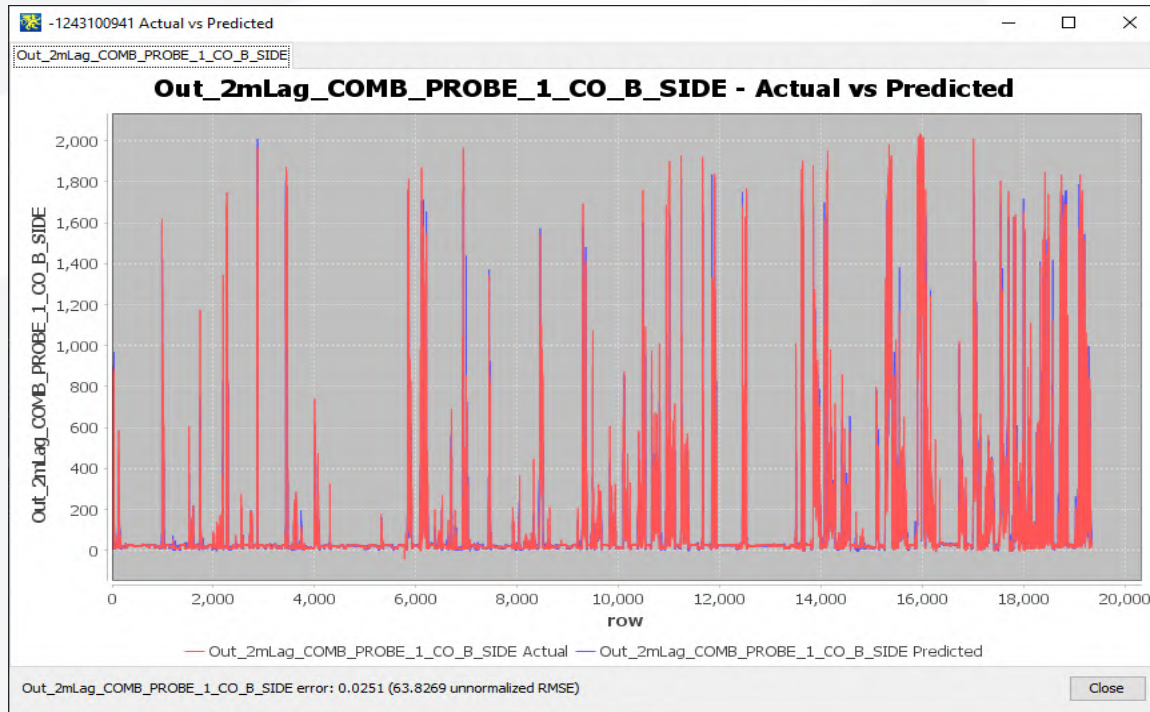
Replacing finicky or suspect sensor measurements can provide greater reliability and consistency to process, as well as inform other elements of the process (start-up turbine stress calcs, etc.)

*Start-up turbine 1st stage
temperature model error = 8.89°*



VIRTUAL SENSORS TO BETTER INFORM CONTROLS

Replacing finicky or suspect sensor measurements can provide greater reliability and consistency to process, as well as inform other elements of the process (start-up turbine stress calcs, etc.)



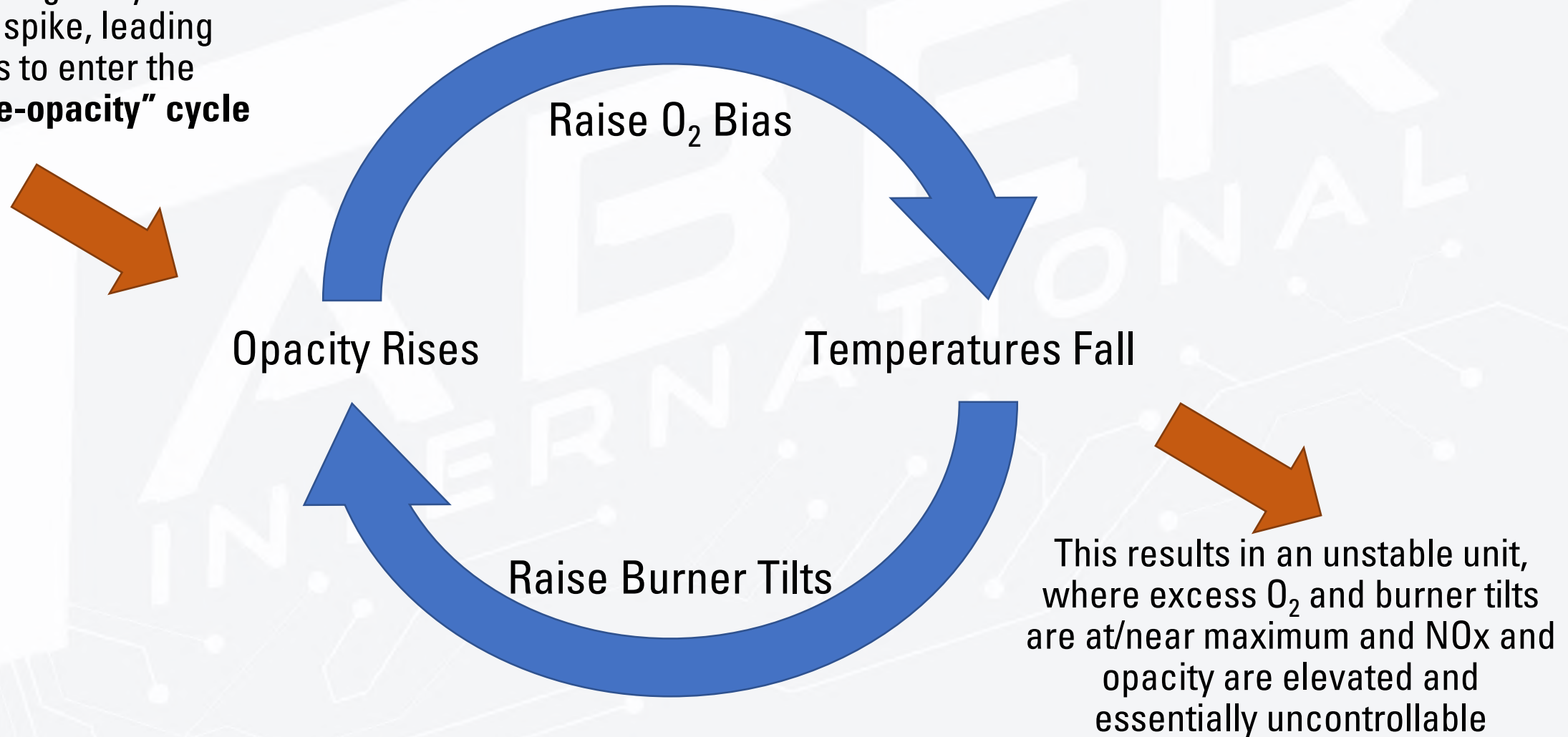
MERCURY & ACI

OPTIMIZATION



MERCURY & ACI OPTIMIZATION

Injecting PAC regularly causes opacity to spike, leading operators to enter the **"temperature-opacity" cycle**

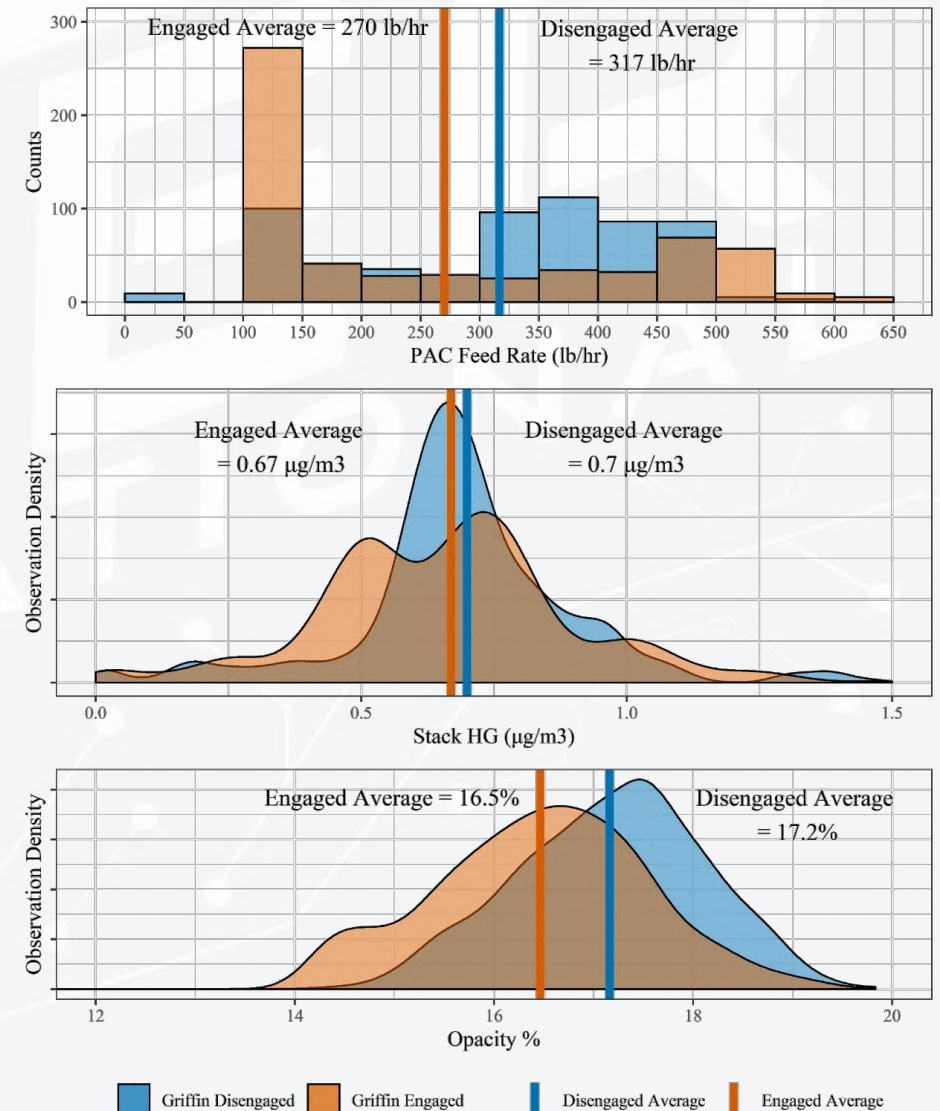


MERCURY & ACI OPTIMIZATION

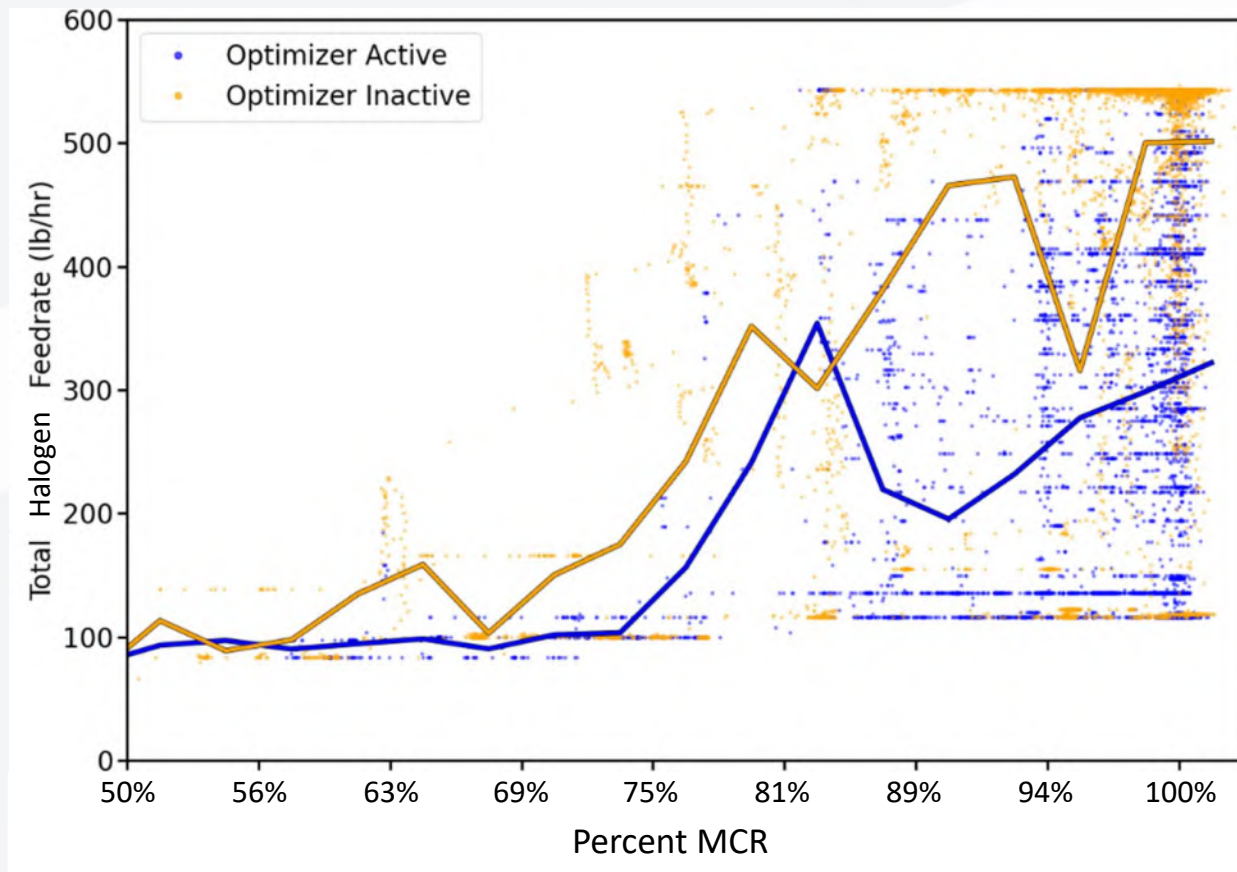
Developing control schemes that account for the upstream impacts and downstream effects of a subprocess to the overall system can provide opportunities for global improvements, while also minimizing operating cost and improving overall operations.

One such example has been custom-built powdered activated carbon (PAC) Injection Optimization (PACopt) which intelligently balances activated carbon injection with operating limits (opacity readings) as well as ongoing chemical reactions and available constituents (halogens, activated carbon injection rate, flue gas temperatures, etc.)

Application of this custom control has resulted in better-controlled mercury emissions and PAC savings beyond \$500,000 annually, all while improving the impact on total unit operation.



ACI <-> HALOGEN INJECTION



Incorporating optimization of the PAC injection system to also directly control and correlate to halogen injection (halogens promote mercury oxidation, a requirement for capture using activated carbon) has extended observed benefits.

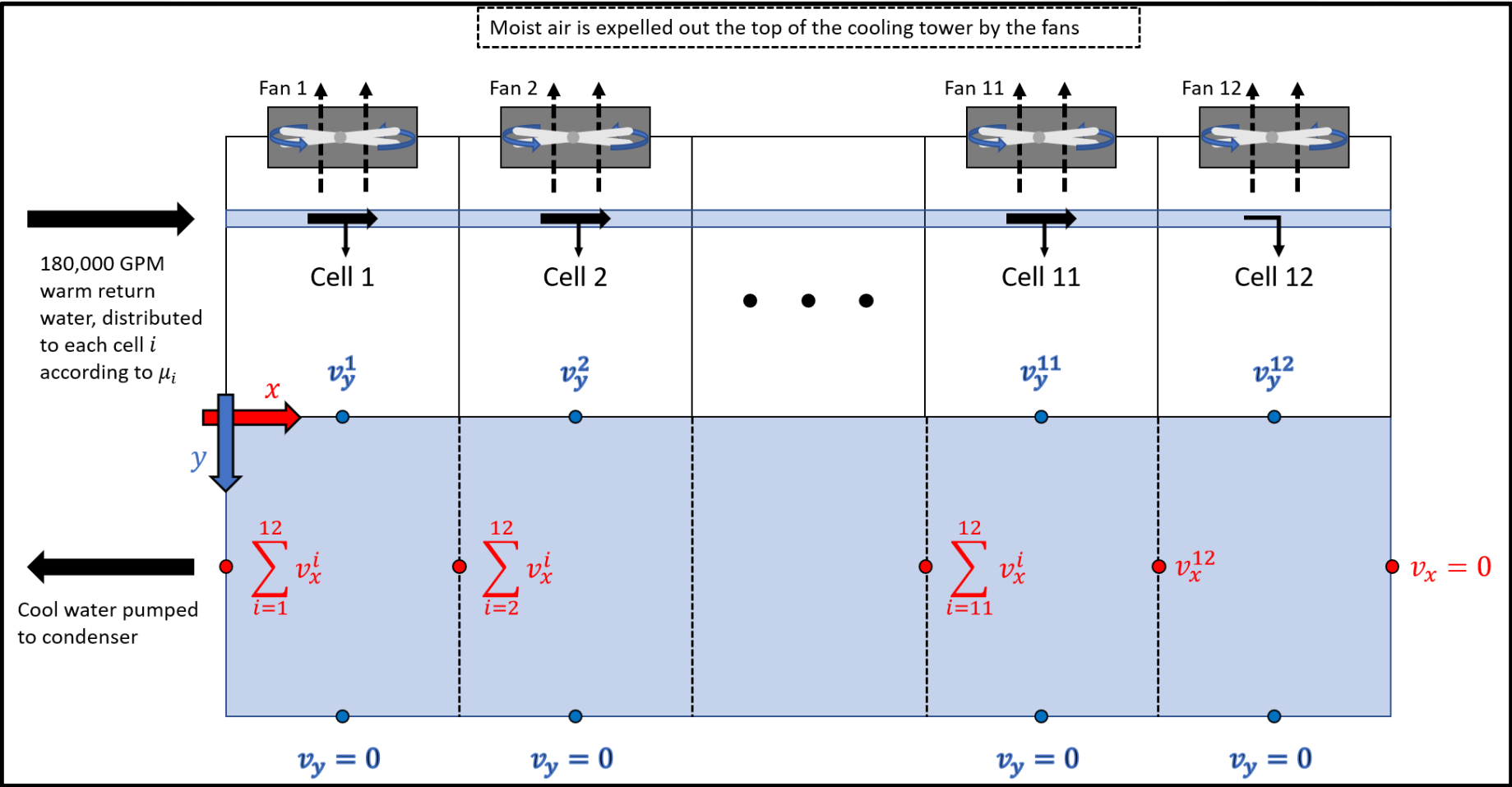
By synchronizing all of these elements of the system within an intelligent control scheme, per unit annual savings have been extended to an estimated \$900,000, simply by reducing activated carbon and halogen requirements, while maintaining mercury emission rates below operating targets.

On average, halogen usage was decreased by 36%.

COOLING TOWER OPTIMIZATION

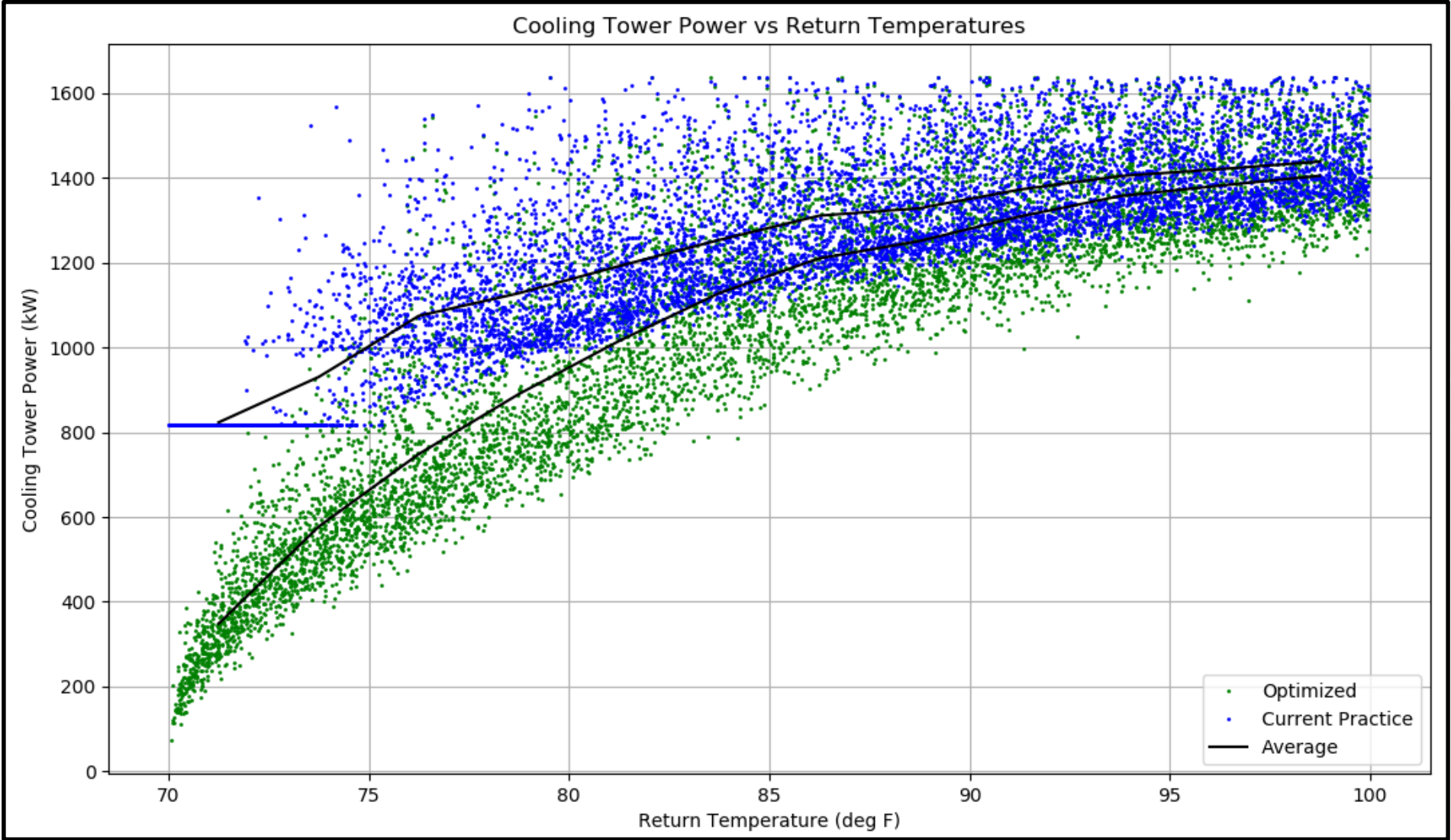
COOLING TOWER OPTIMIZATION

Physical Model of the Cooling Tower :

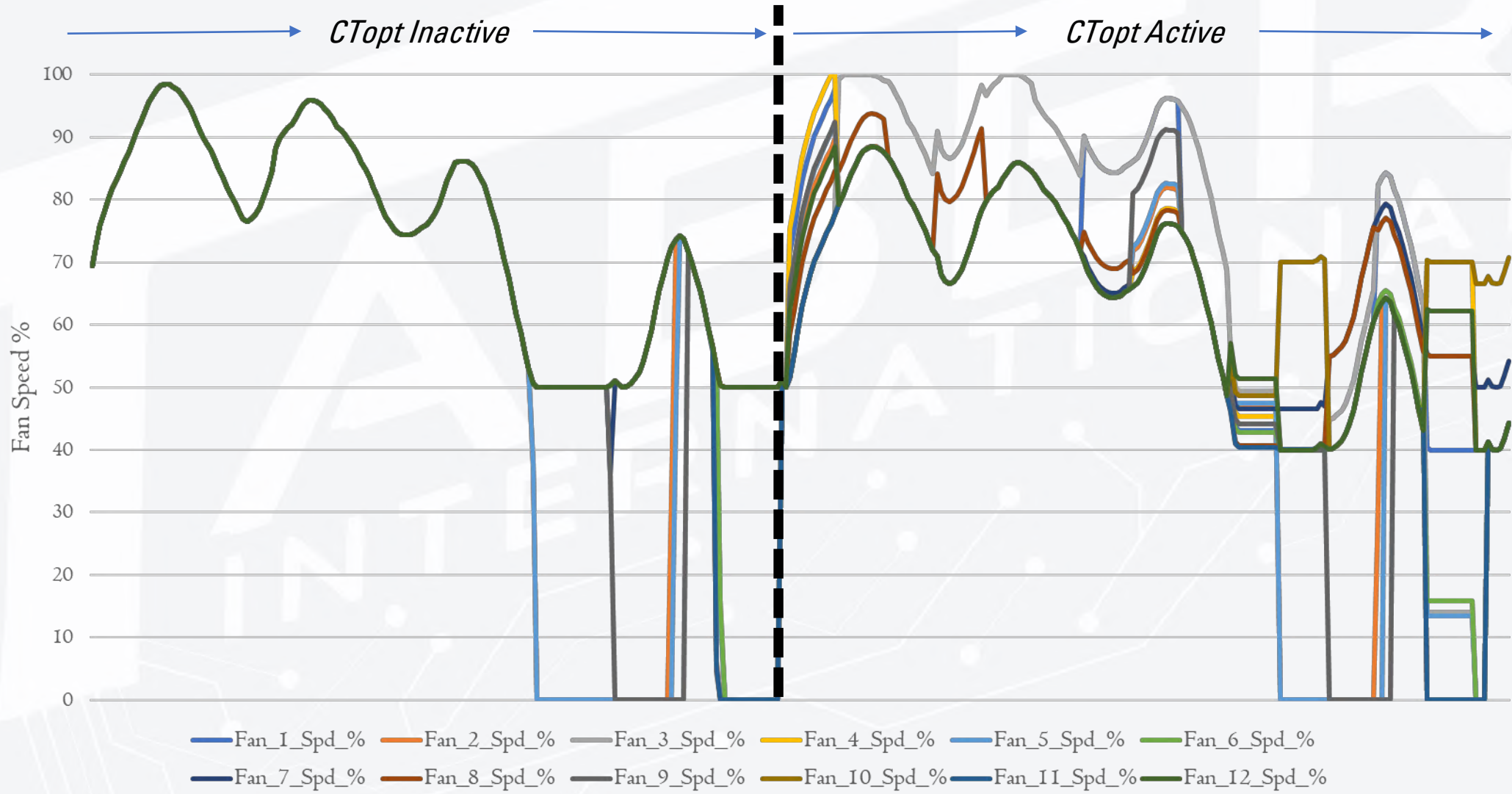


COOLING TOWER OPTIMIZATION

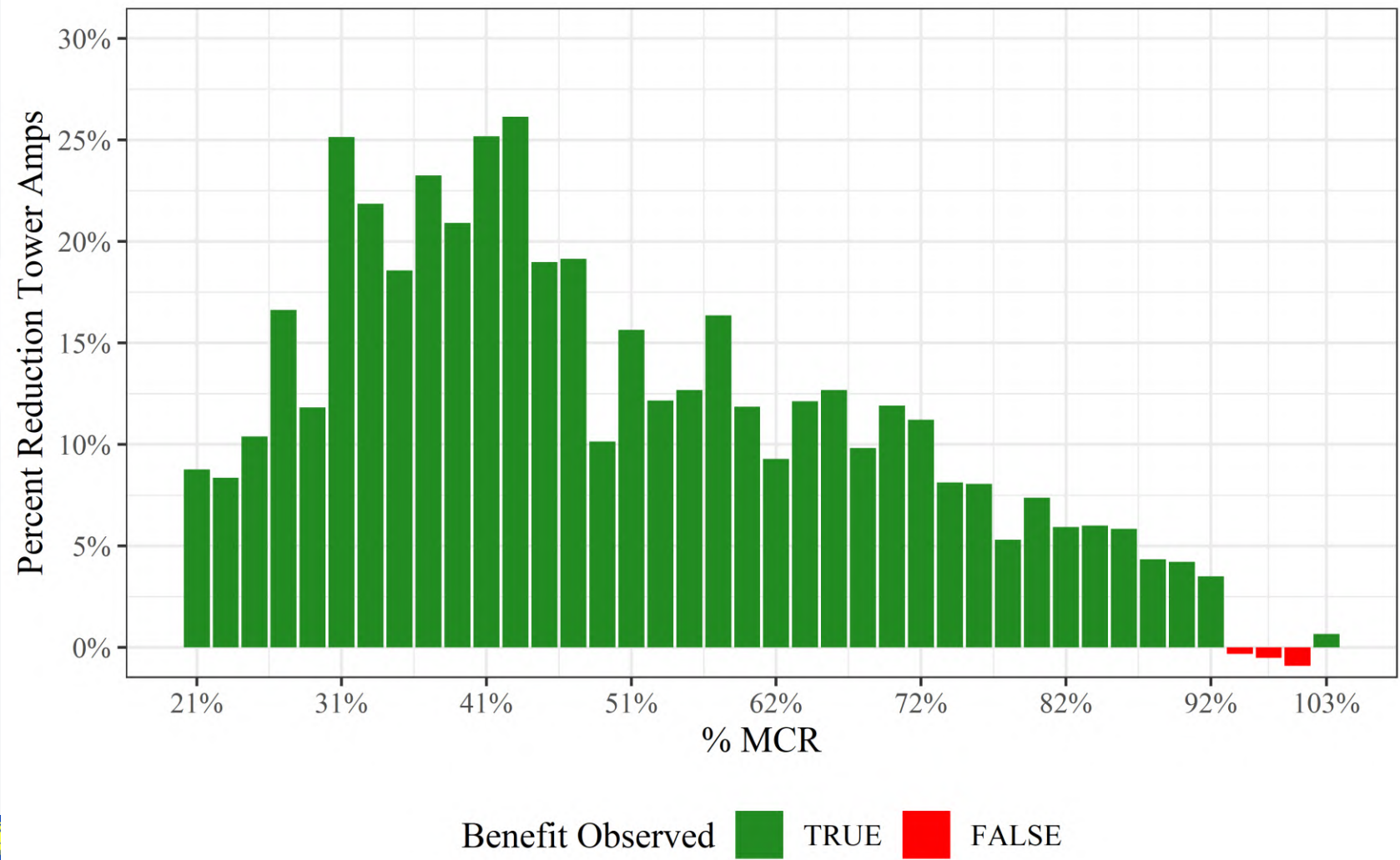
Optimization Results (Simulation) :



COOLING TOWER OPTIMIZATION



COOLING TOWER OPTIMIZATION



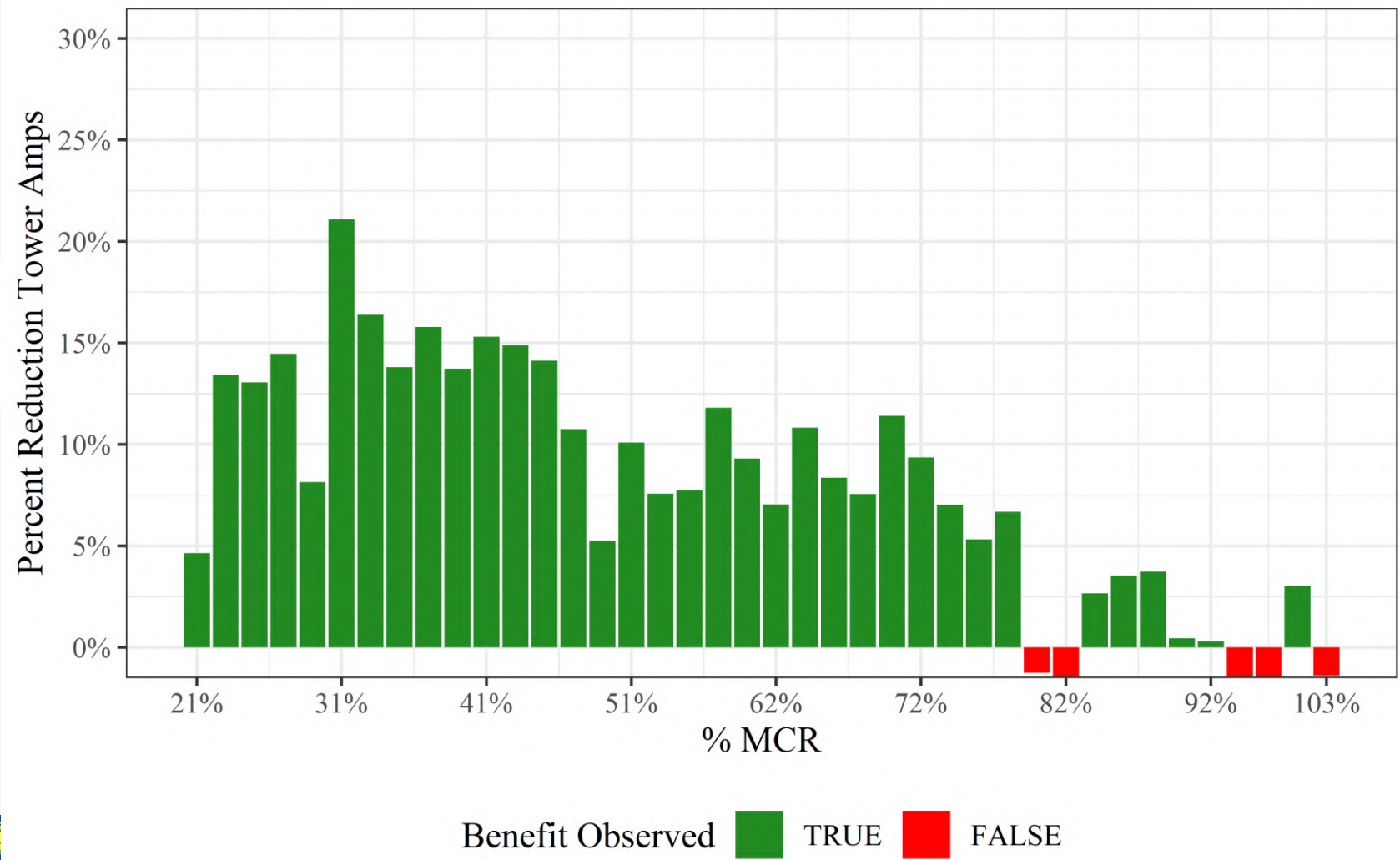
Up to 25% improvement in power consumption was observed at specific load ranges of the unit.

On average, a 7.70% reduction in power consumption was observed using the CTopt system.

Assuming this power is then available for retail sale, at the current average domestic electricity rate of \$0.23, this results in a benefit of \$223,169.80 during the 6-month analysis period.



COOLING TOWER OPTIMIZATION



Water consumption benefits were observed primarily at low and mid generations levels. Full load saw negligible water consumption benefits.

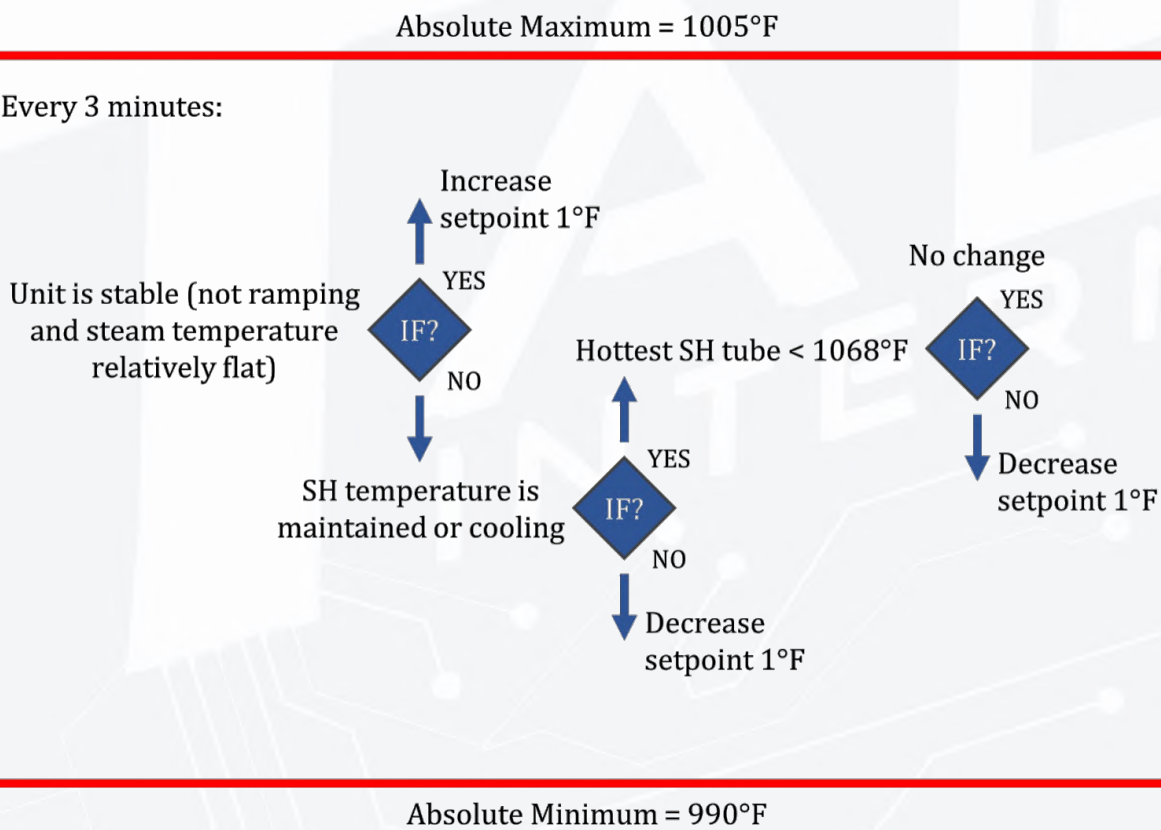
Overall, a 3.91% reduction in water makeup flow was observed during the analysis period.

If water consumption were the higher priority, the CTopt system could easily be adapted to prioritize water consumption benefits over power consumption minimization.

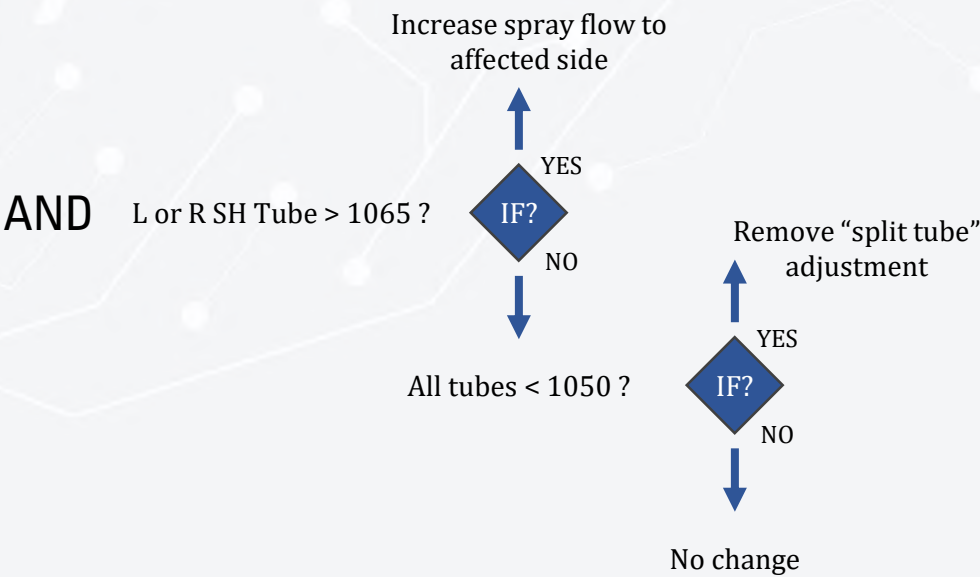
STEAM TEMPERATURE CONTROL

STEAM TEMPERATURE CONTROL

Sometimes, breaking operational habits is the barrier between the status quo and improved performance. Using a simple approach to produce operator comfort and confidence, coupled with more advanced and stable control has resulted in improved steam temperatures and heat rate at multiple sites.

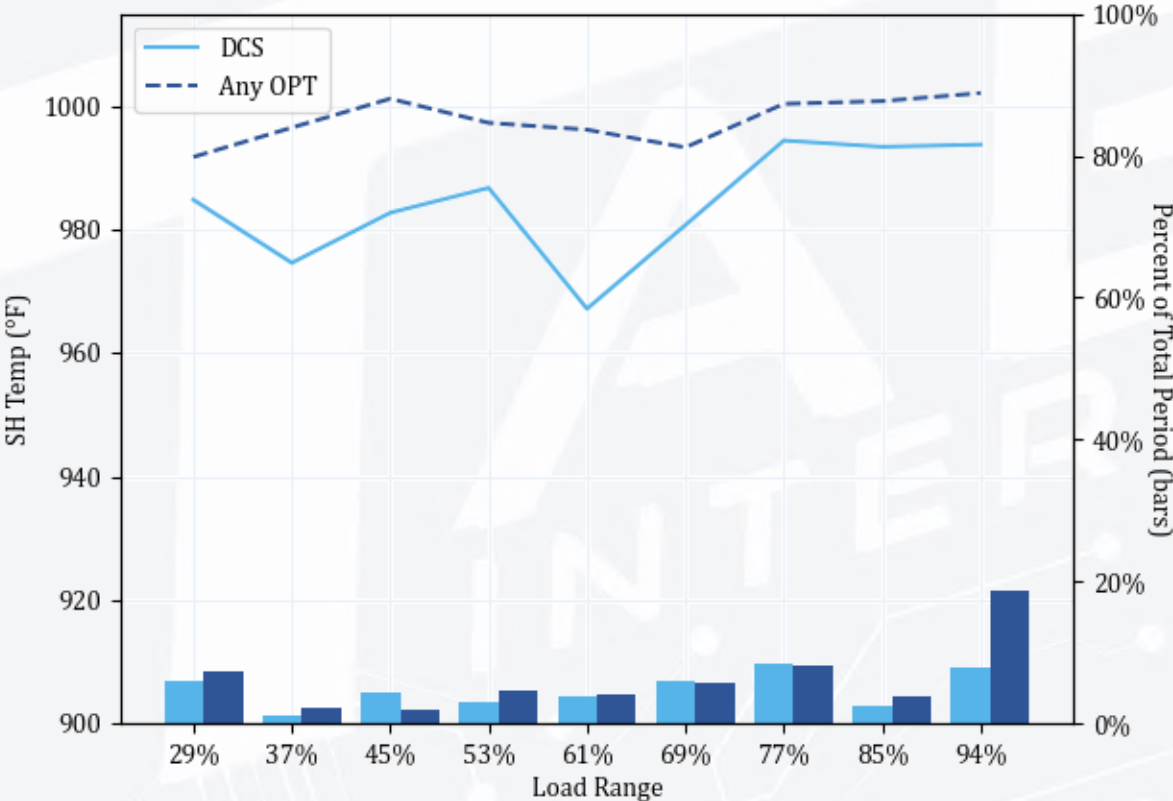


- Multi-faceted steam temperature control (setpoint + attemperation + pass dampers)
- Maintains SH temperature setpoint prioritizing unit protection, followed by efficiency
- Responds to both final SH steam temperature & tube metal temperatures to maintain below key thresholds
- Higher frequency evaluation than AI model optimization process to allow for flexibility in rapidly changing conditions

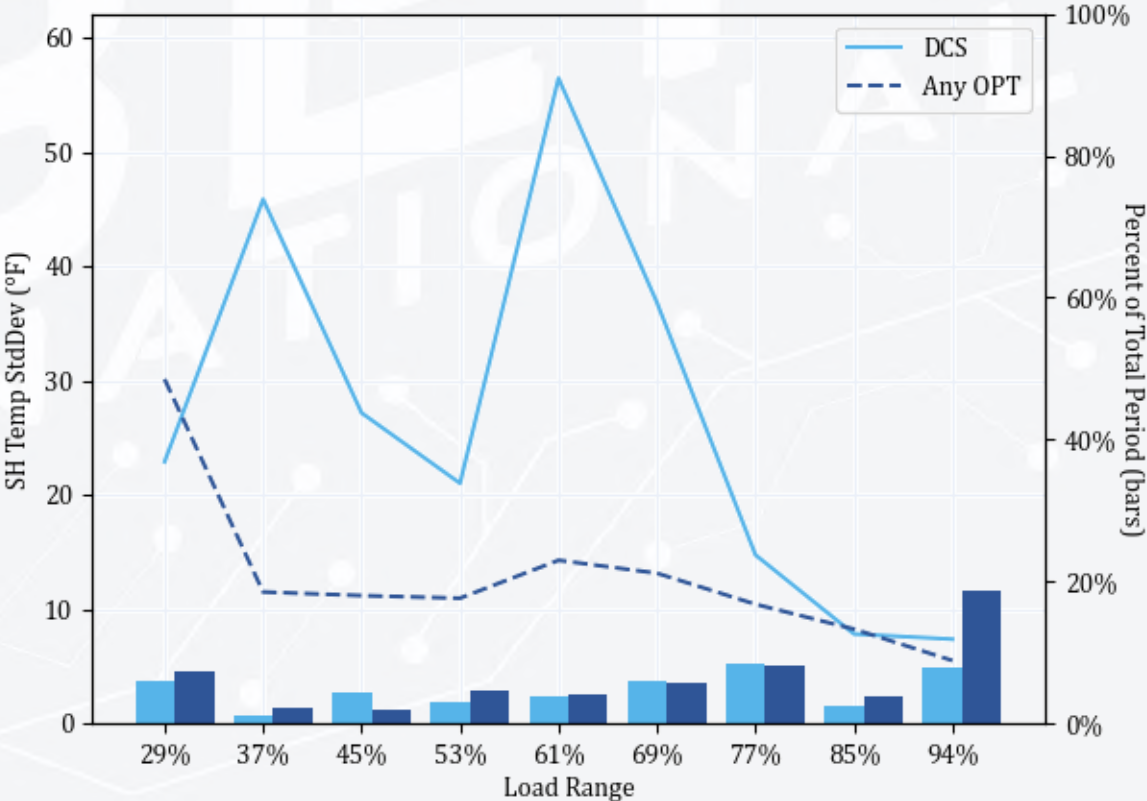


STEAM TEMPERATURE CONTROL

Improved Superheat Temperature



Reduced Superheat Variability

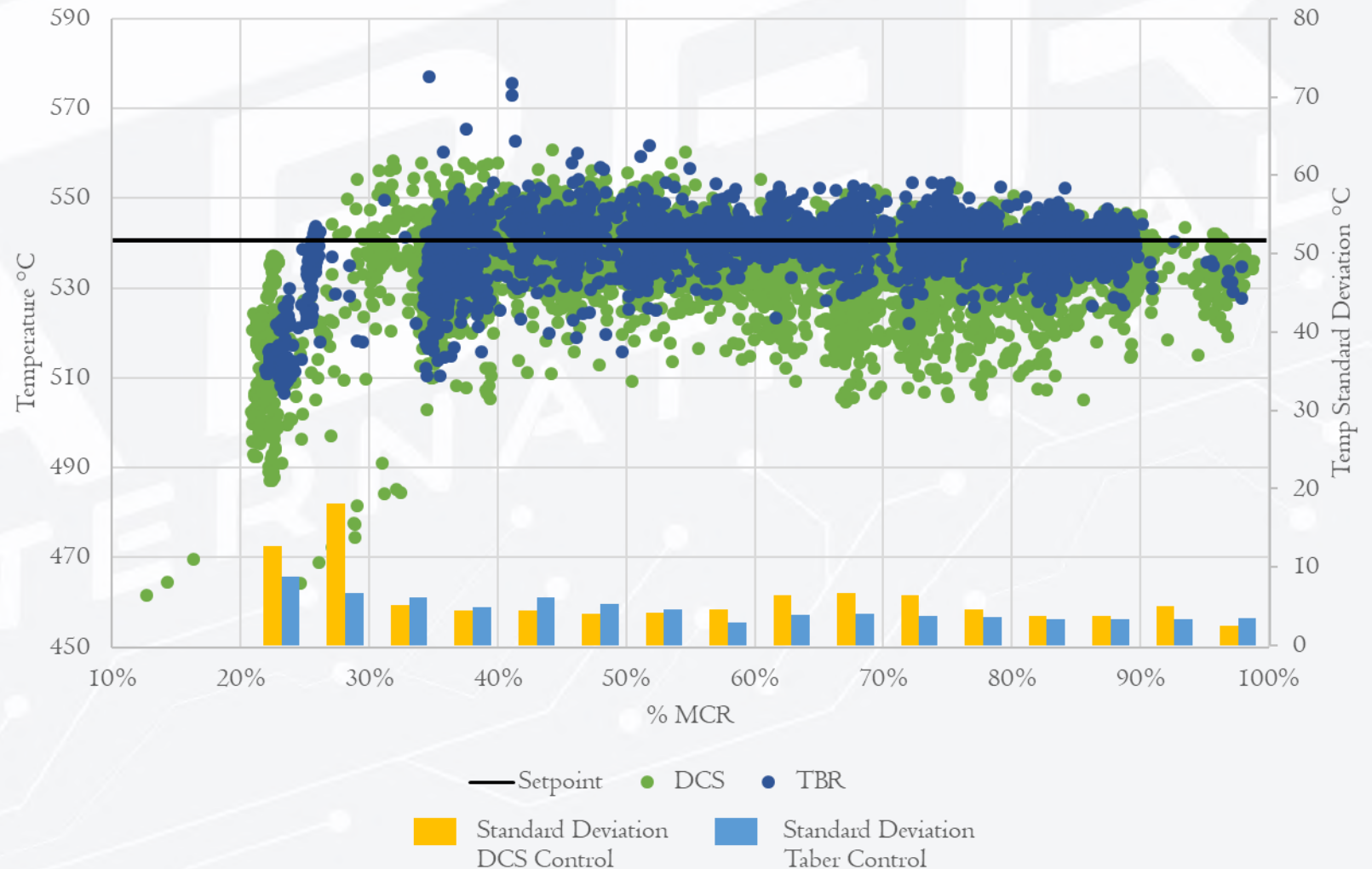


STEAM TEMPERATURE CONTROL

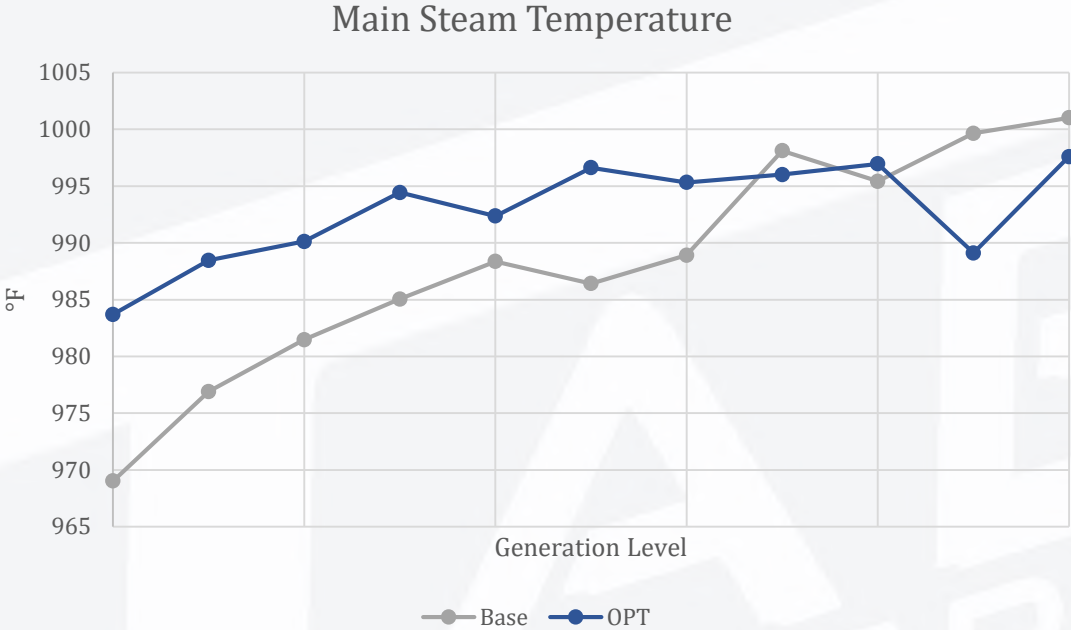
Improving steam temperature control across the load range improves turbine thermal cycling effects, and avoids other potential water induction damage.

Reduced steam temperature variation and stability improvements across the load range have been observed.

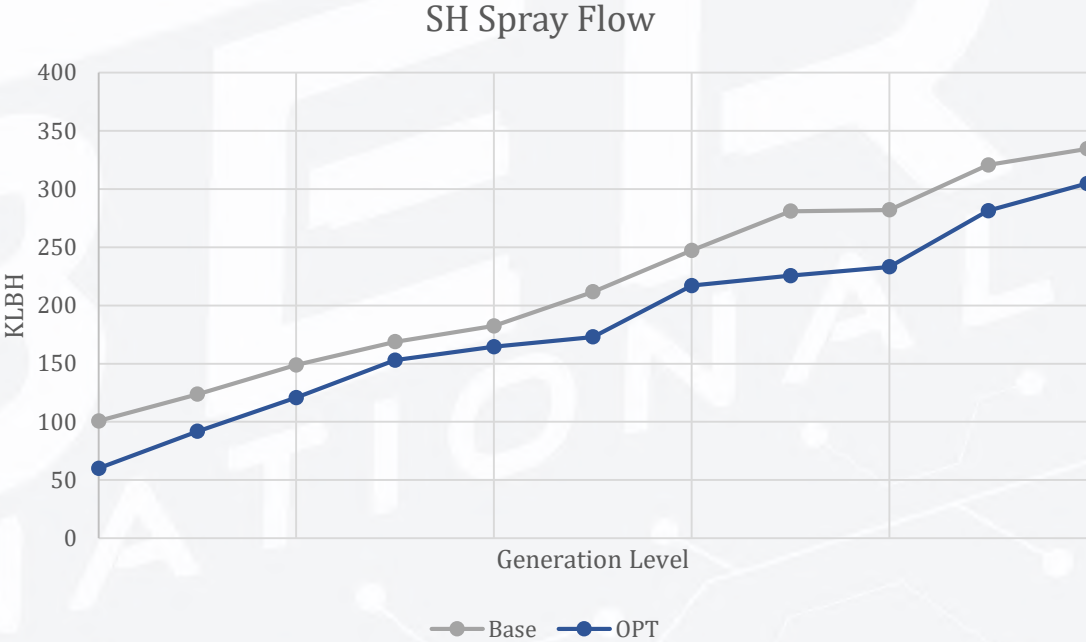
Taber control realizes nearly 27% more temperature stability and 35% better setpoint attainment, avoiding many under- and over-temperature events



STEAM TEMPERATURE CONTROL



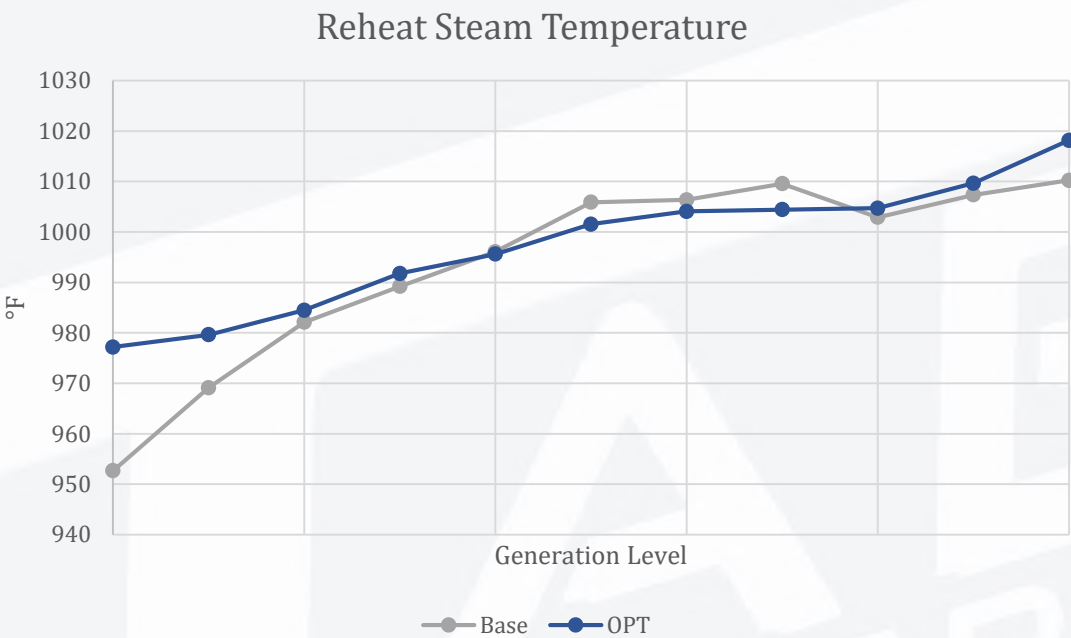
Superheat setpoint realization improved 31.7%



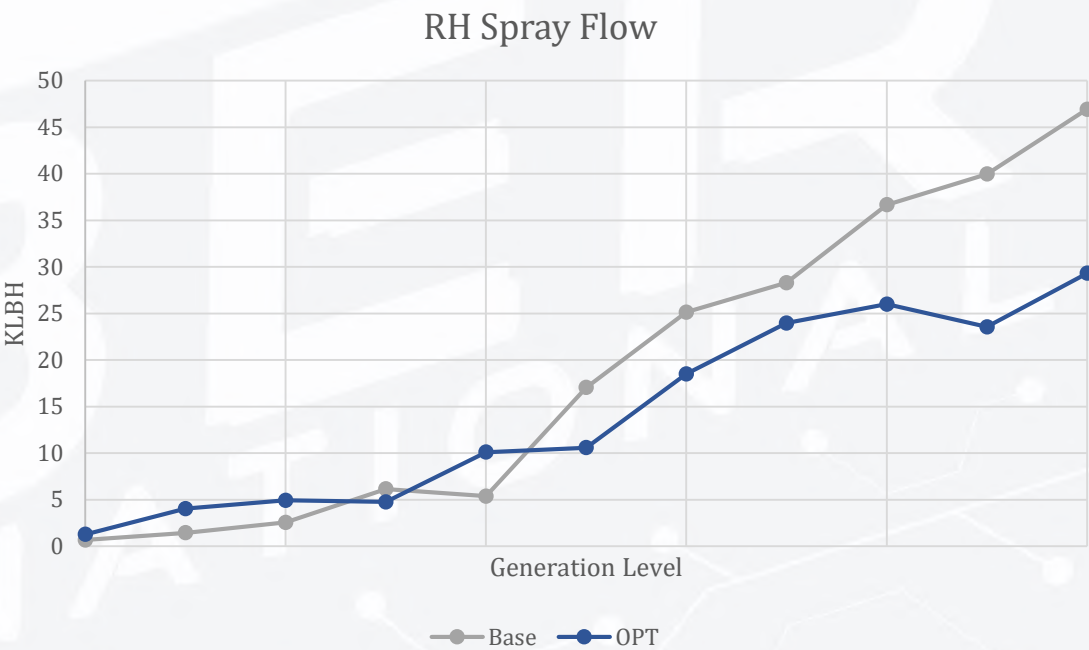
Superheat attemperator reduction 29.2%

This system DOES NOT act on the attemperator valves for either the Superheat or Reheat. However, through pass damper and air flow optimization, able to dramatically improve heat rate factors and steam temperatures

STEAM TEMPERATURE CONTROL



Reheat setpoint realization improved 49.0%
(primarily attributed to low load)



Superheat attemperator reduction 26.1%

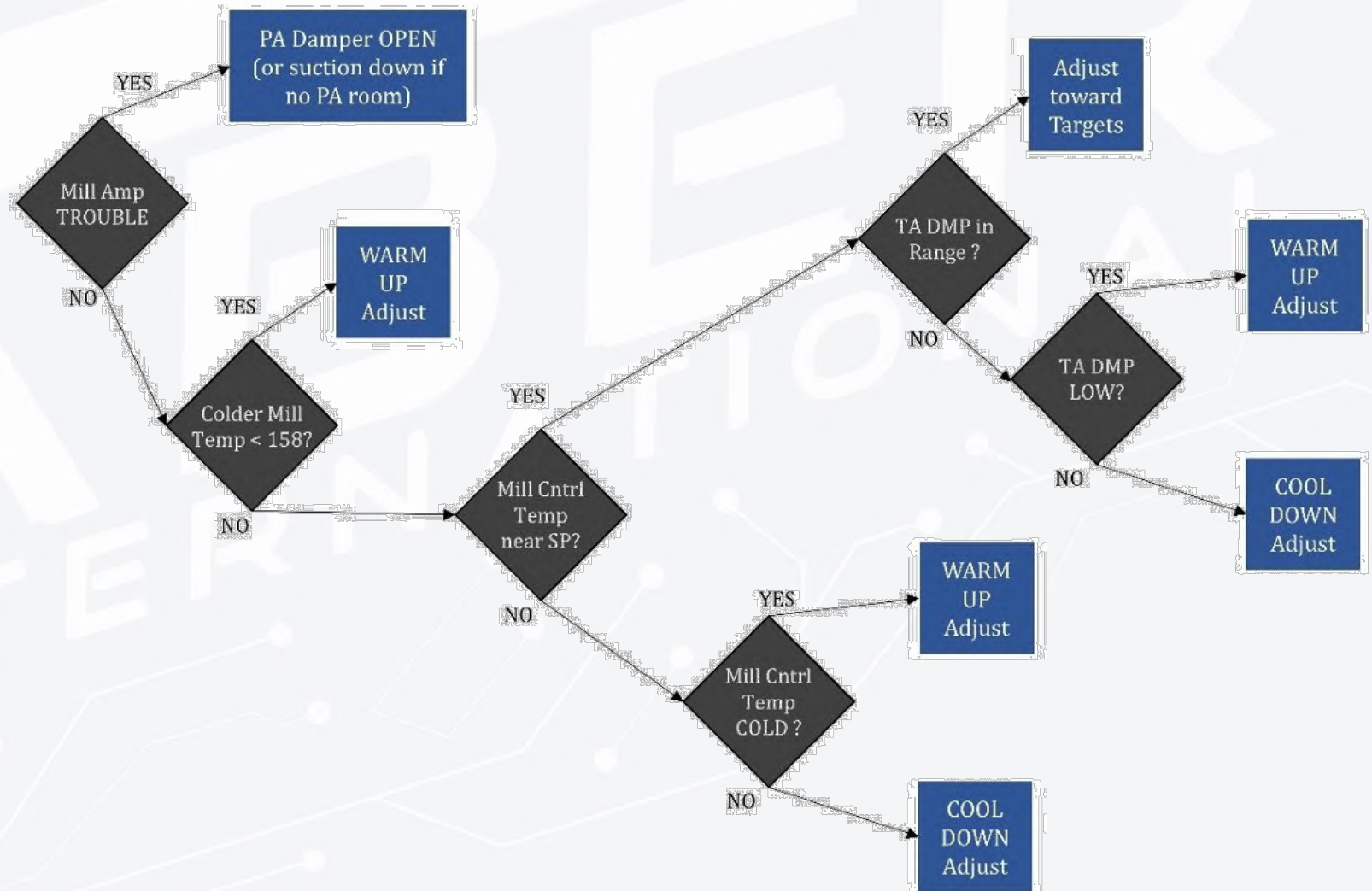
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MILL FUEL & AIR OPTIMIZATION

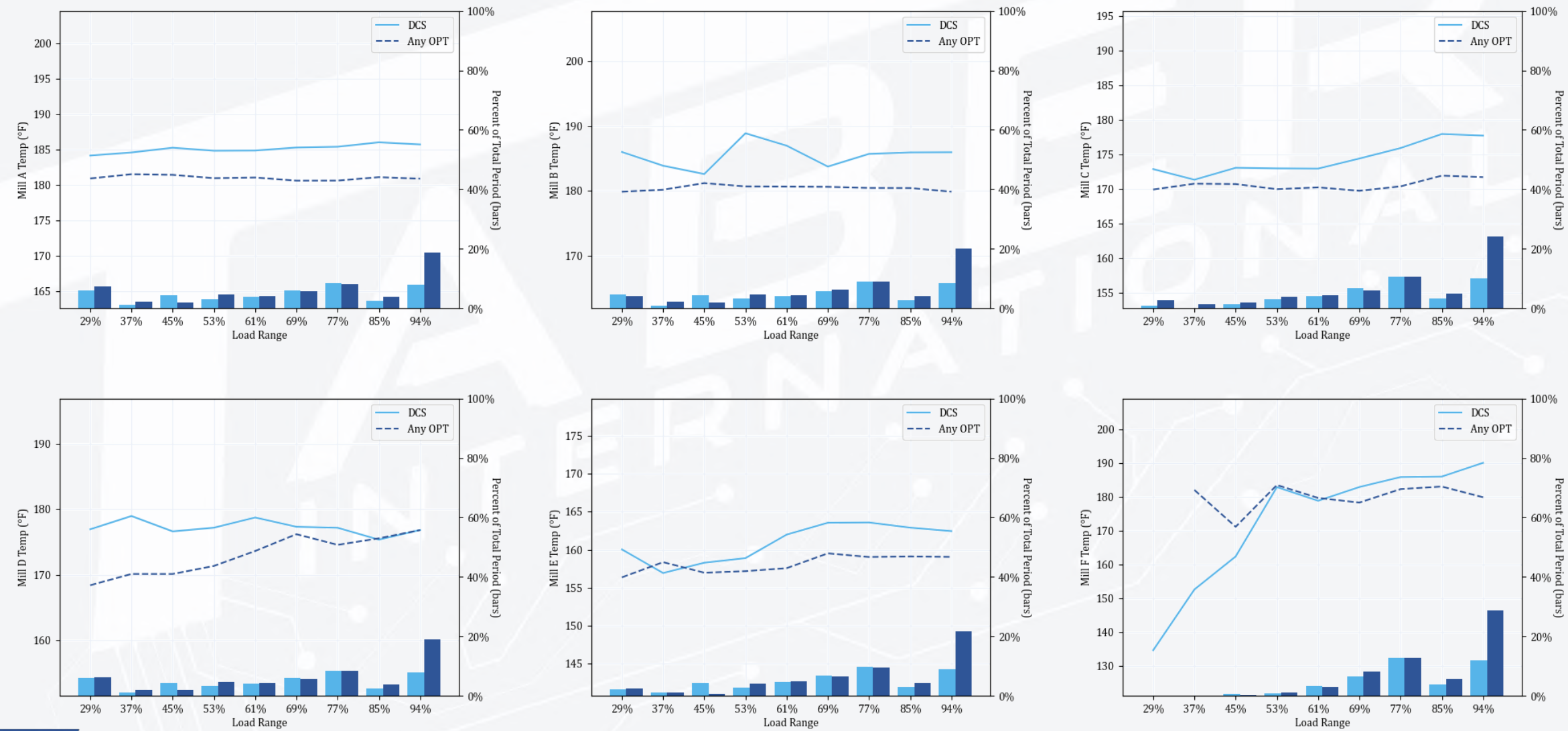


ONLINE EXAMPLES - MILL FUEL, AIR, & TEMPERATURE

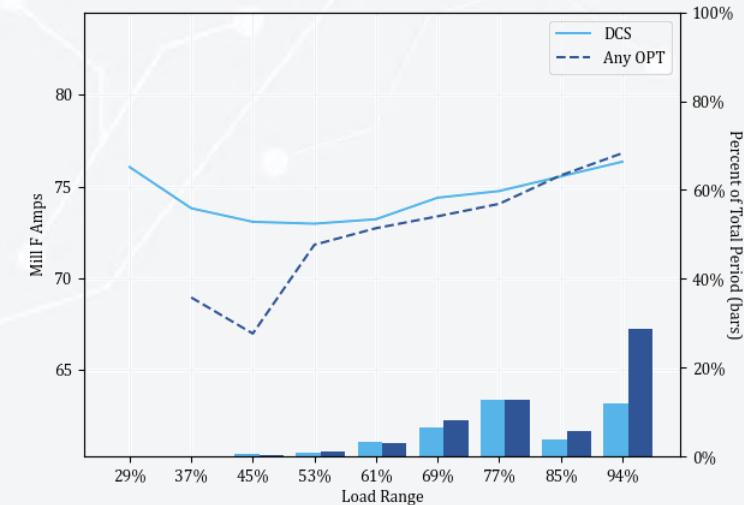
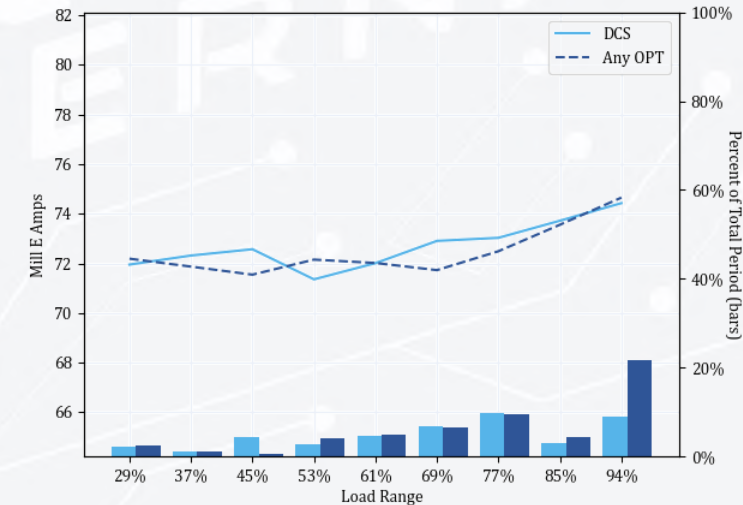
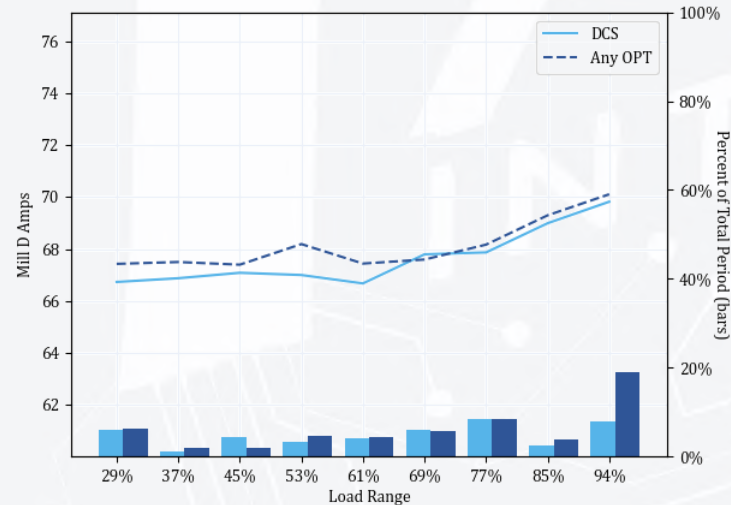
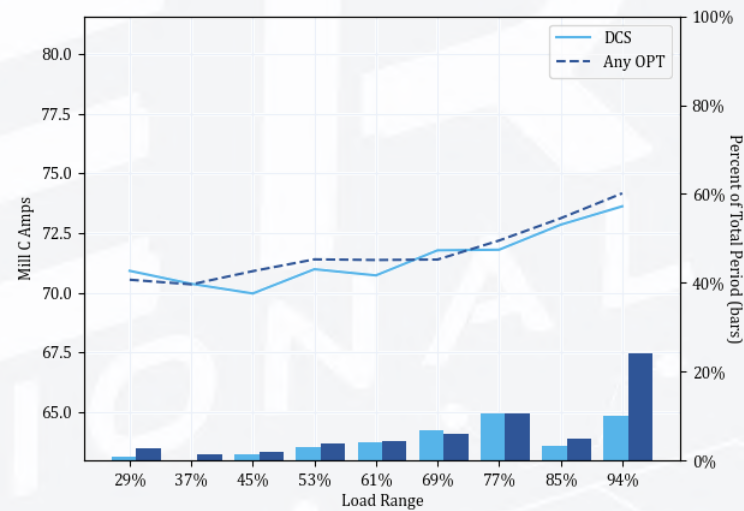
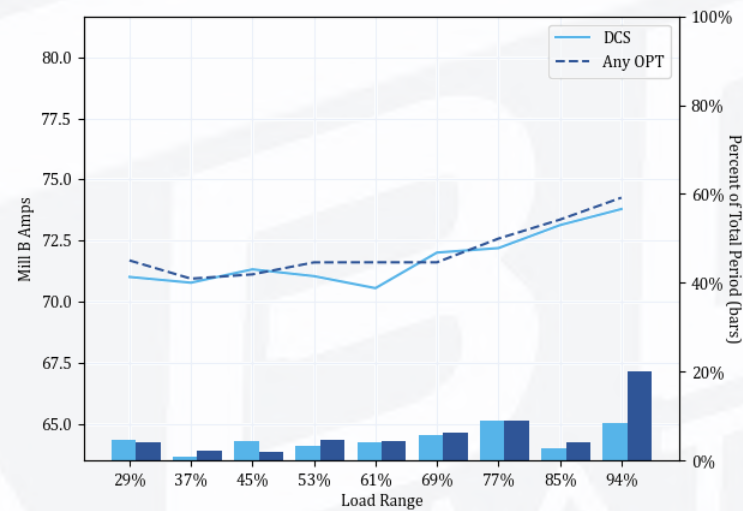
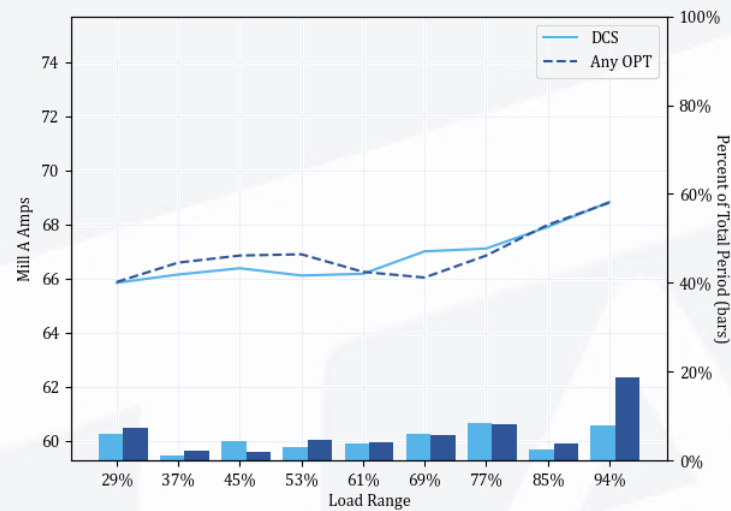
- Control loops are built with the combination of optimization and safety in mind
- Maintain set points for reliable and safe mill operation
- Once priority conditions are met, optimization is allowed to work within established boundaries
- Automatic sensing of mill overloading or pluggage trigger immediate mitigation responses
- Higher frequency response loops (15 secs) for critical thresholds, such as mill amps



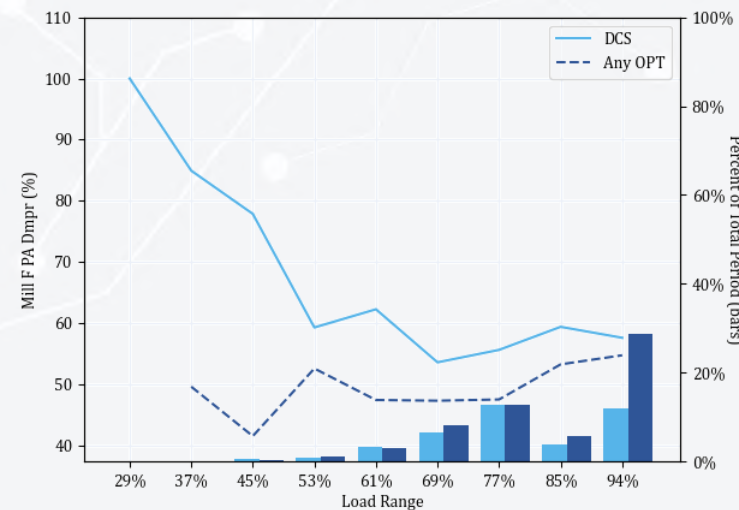
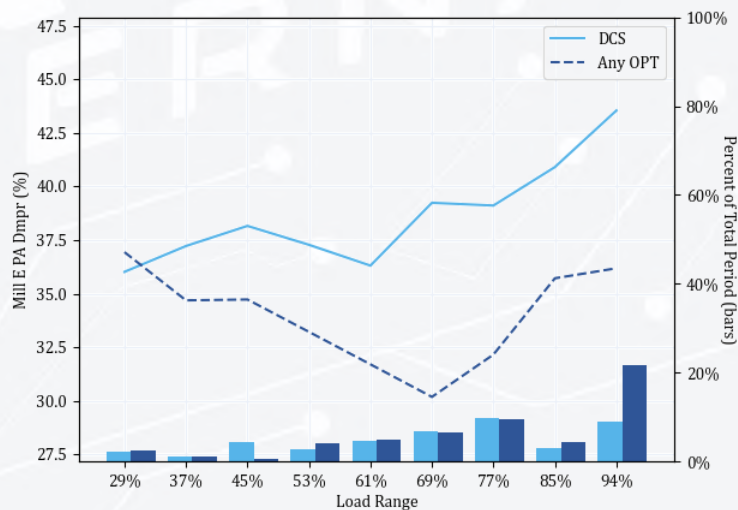
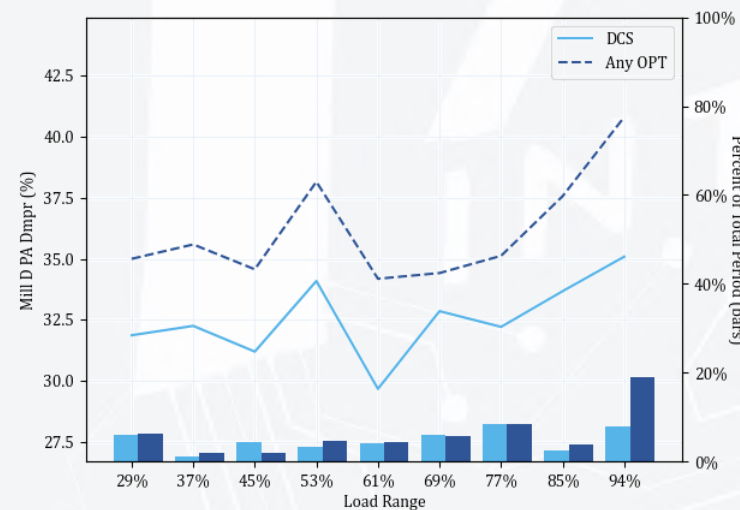
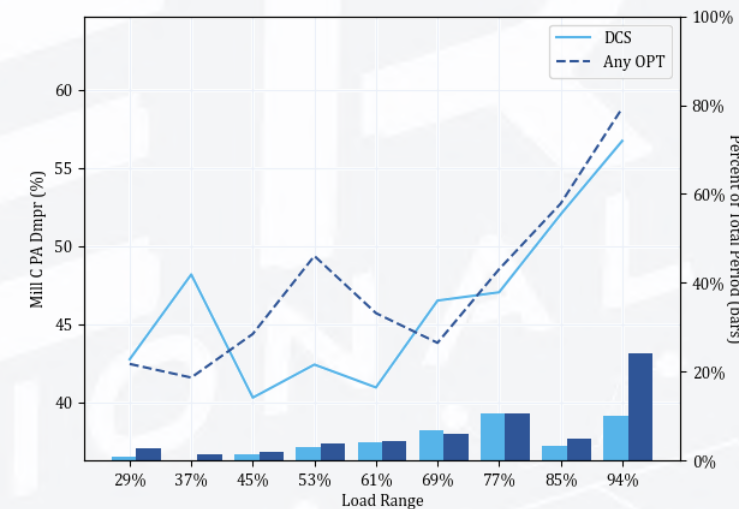
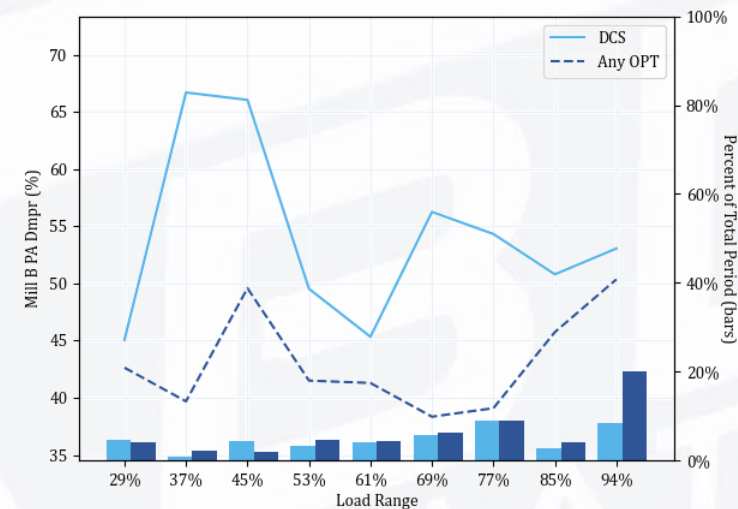
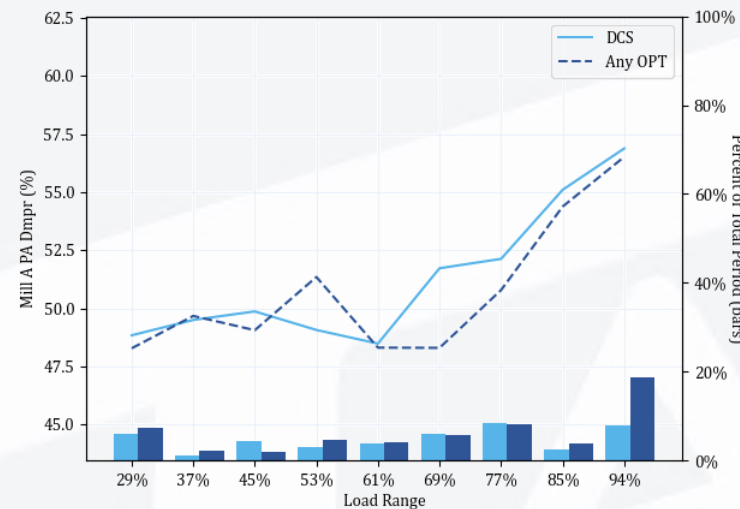
ONLINE EXAMPLES - MILL FUEL, AIR, & TEMPERATURE



ONLINE EXAMPLES - MILL FUEL, AIR, & TEMPERATURE



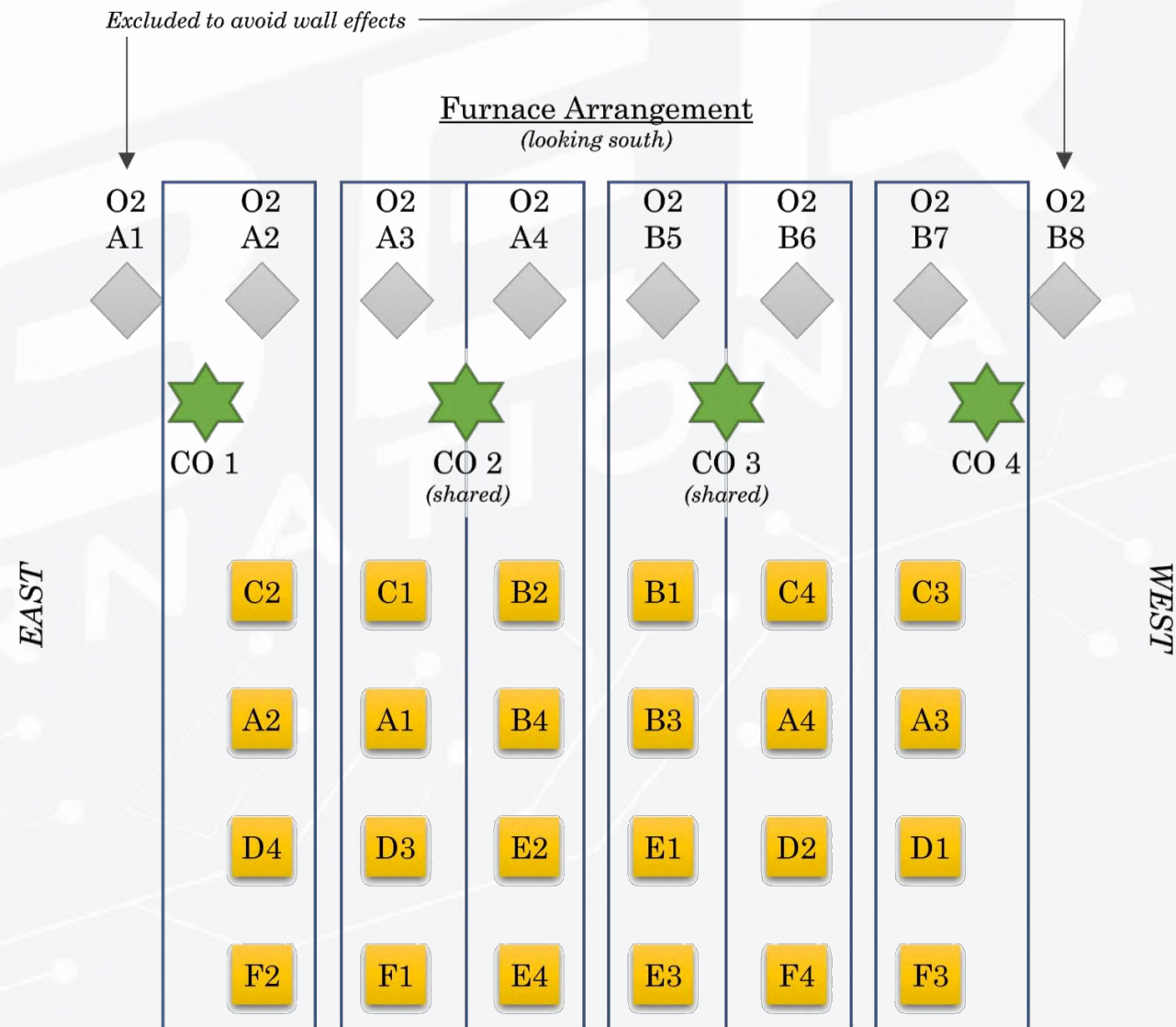
ONLINE EXAMPLES - MILL FUEL, AIR, & TEMPERATURE



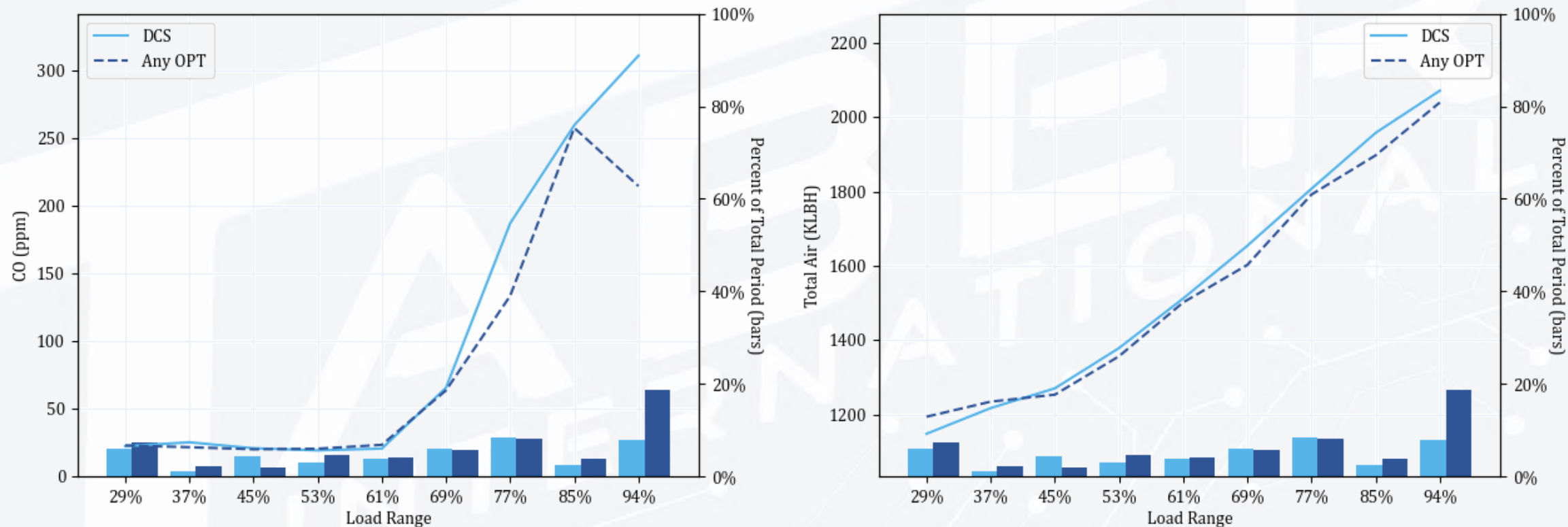
COMBUSTION CONTROL

GUIDED AI OPTIMIZATION USING PHYSICS-BASED CRITERIA

- Furnace arrangement and sensor locations are used in customization process for targeted control
- Direct indications are used within a hybridized control architecture to bound AI model solution space
- Allows for simultaneous improvements in combustion efficiency and emission control



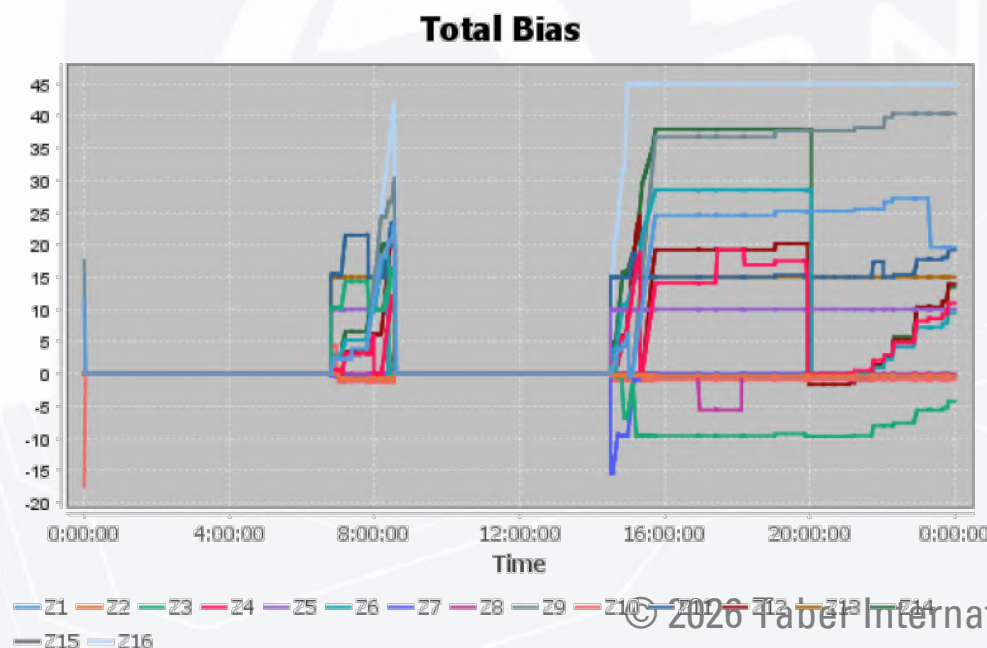
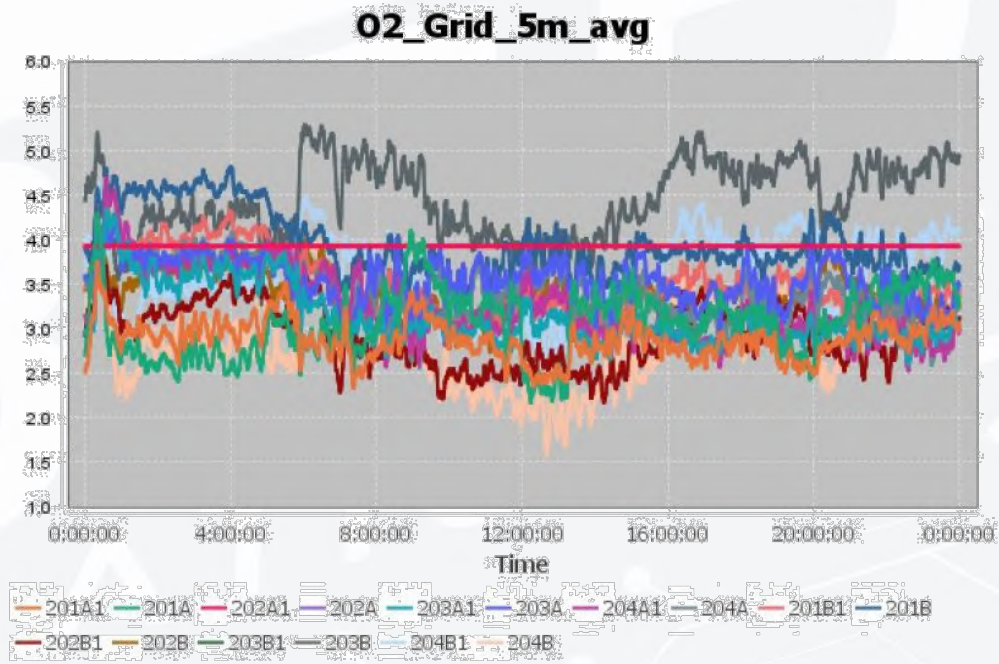
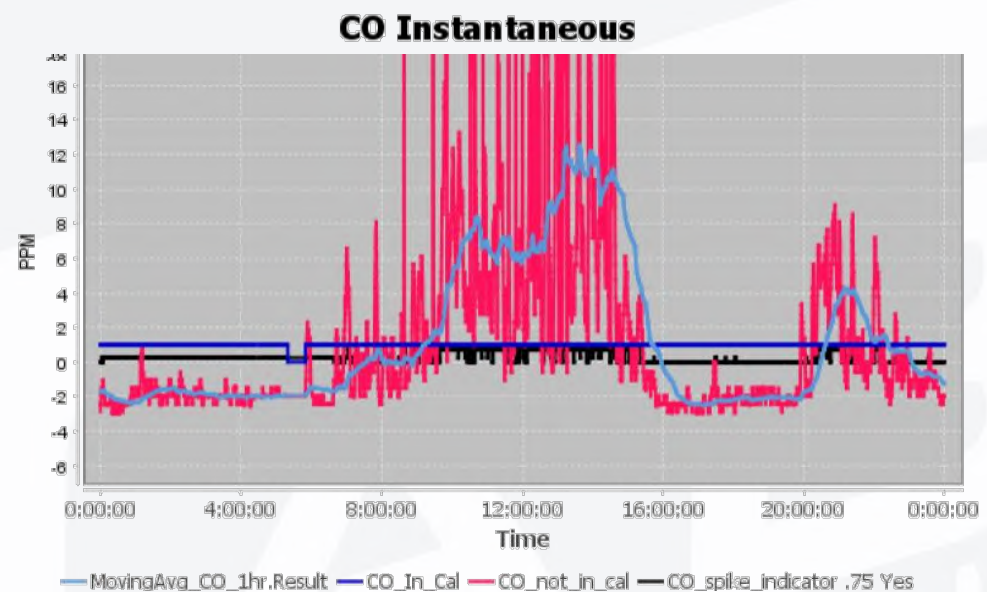
GUIDED AI OPTIMIZATION USING PHYSICS-BASED CRITERIA



Utilization of Delta CO/CO₂ probes, together with the guided AI approach, enabled lower total air flow, while simultaneously improving CO emission rates

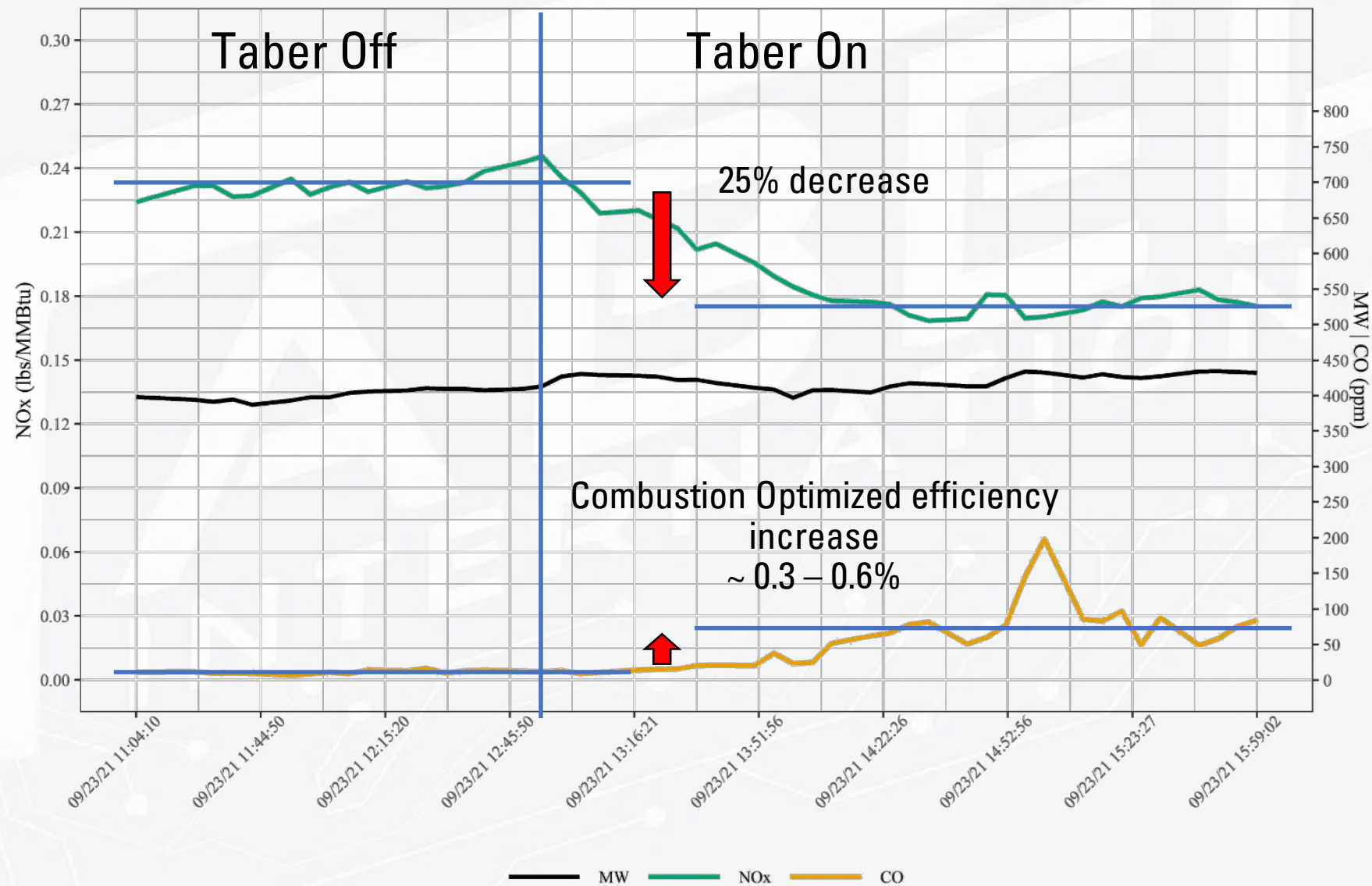


GUIDED AI OPTIMIZATION USING PHYSICS-BASED CRITERIA

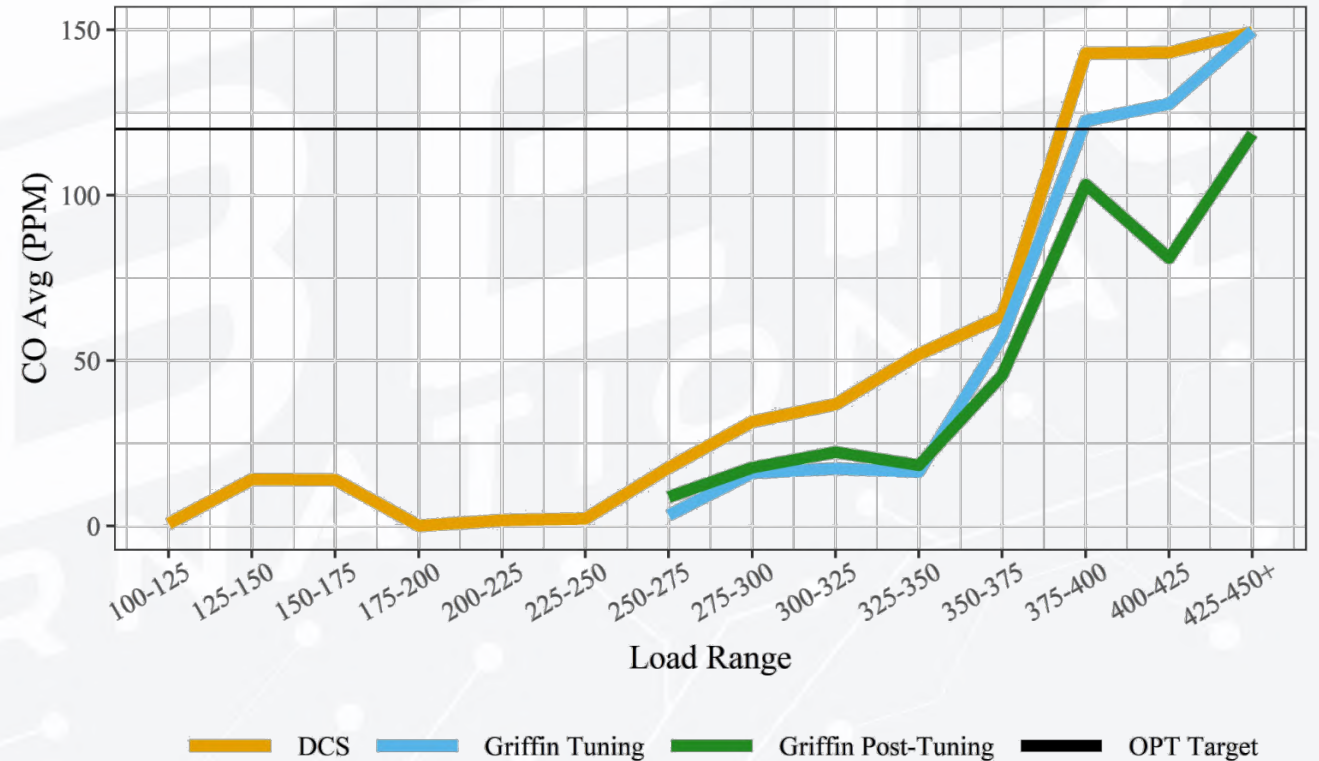
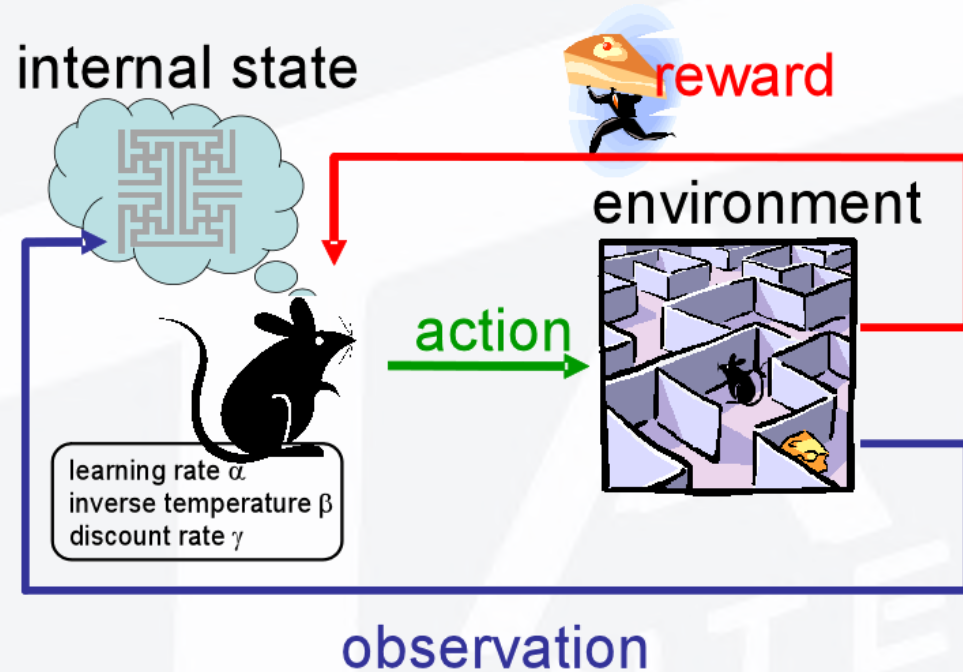


With COS active, CO is maintained at/near zero without air increase, O2 profile is better managed, realizing overall more efficient operation and reduced slagging potential.

EMISSIONS CONTROL – ON/OFF TEST



EMISSIONS CONTROL – REINFORCEMENT LEARNING

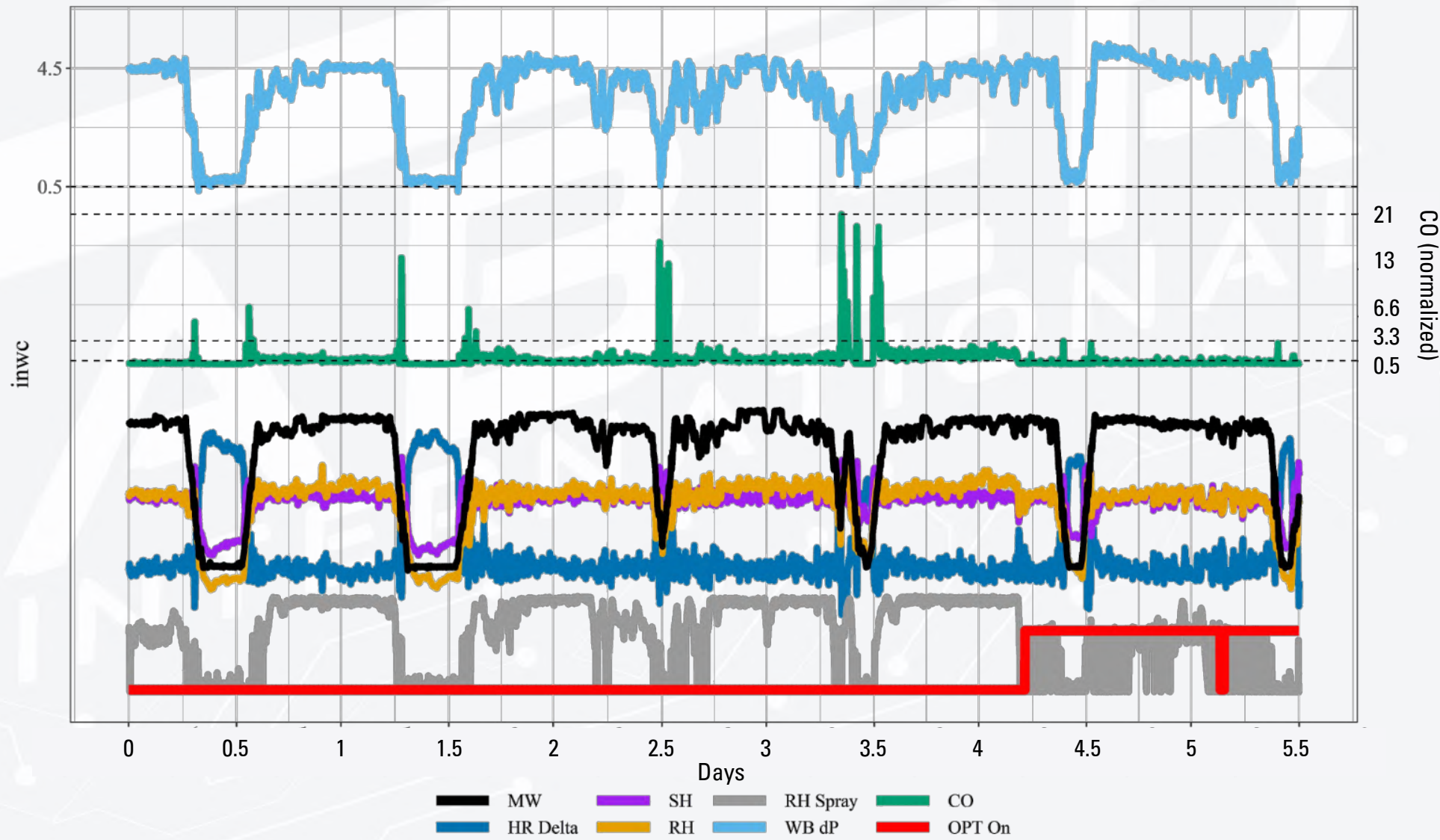


Reinforcement learning provides the added benefit of the system being cognizant of the “path” taken to arrive at the system’s current state. In the manner, it recognizes that at any given moment, the same reading don’t mean the same performance, and can respond accordingly.

LOW-LOAD STABILITY

LOW LOAD & RAMPING BEHAVIOR

Demonstrated ability to better control WB_dP at low load (avoid going too low), significantly improved CO control, similar to improved heat rate indicators, and better temperature setpoint realization during ramping and afterward.



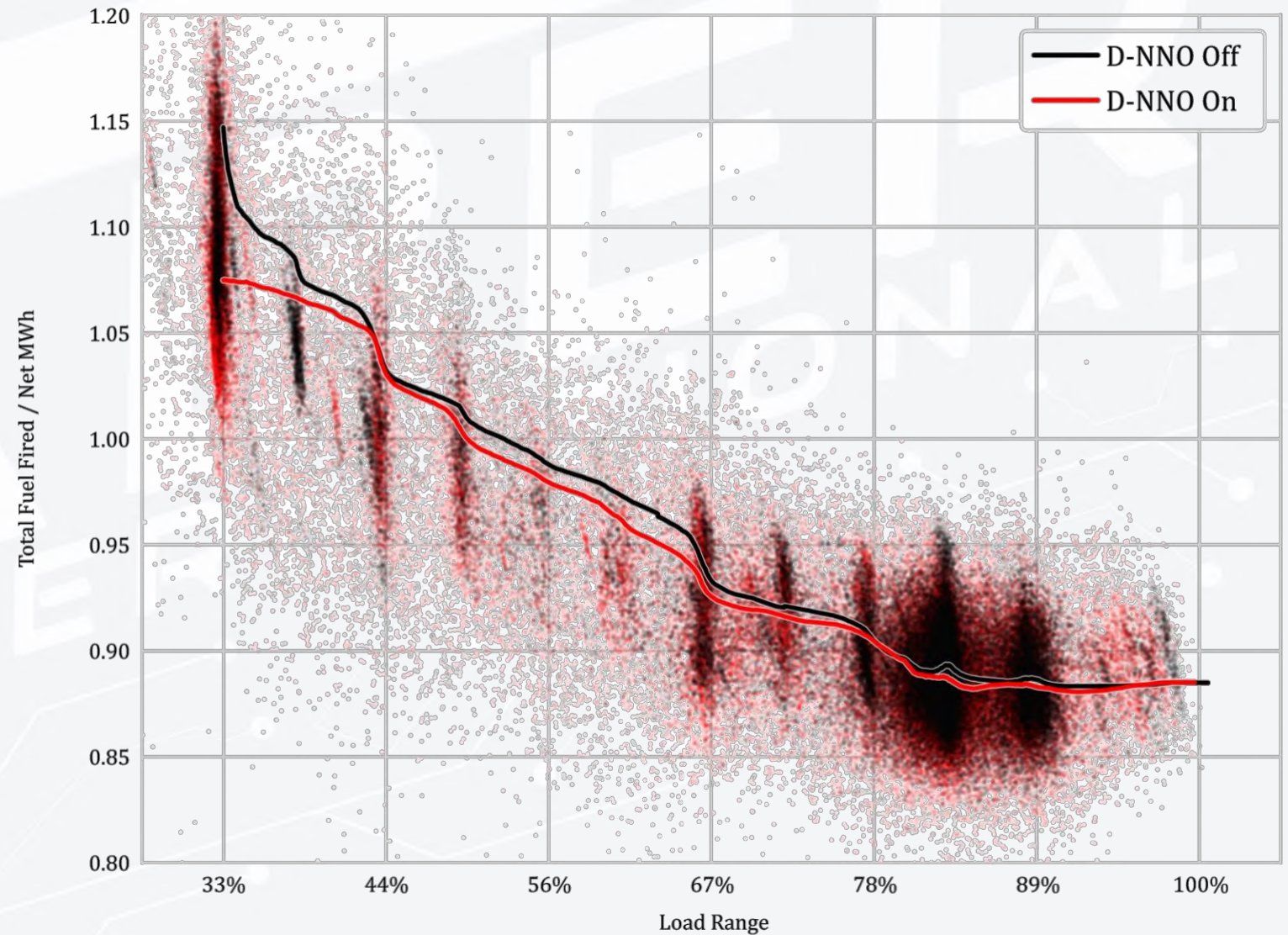
HEAT RATE IMPROVEMENTS



HEAT RATE OPTIMIZATION CONSISTENCY

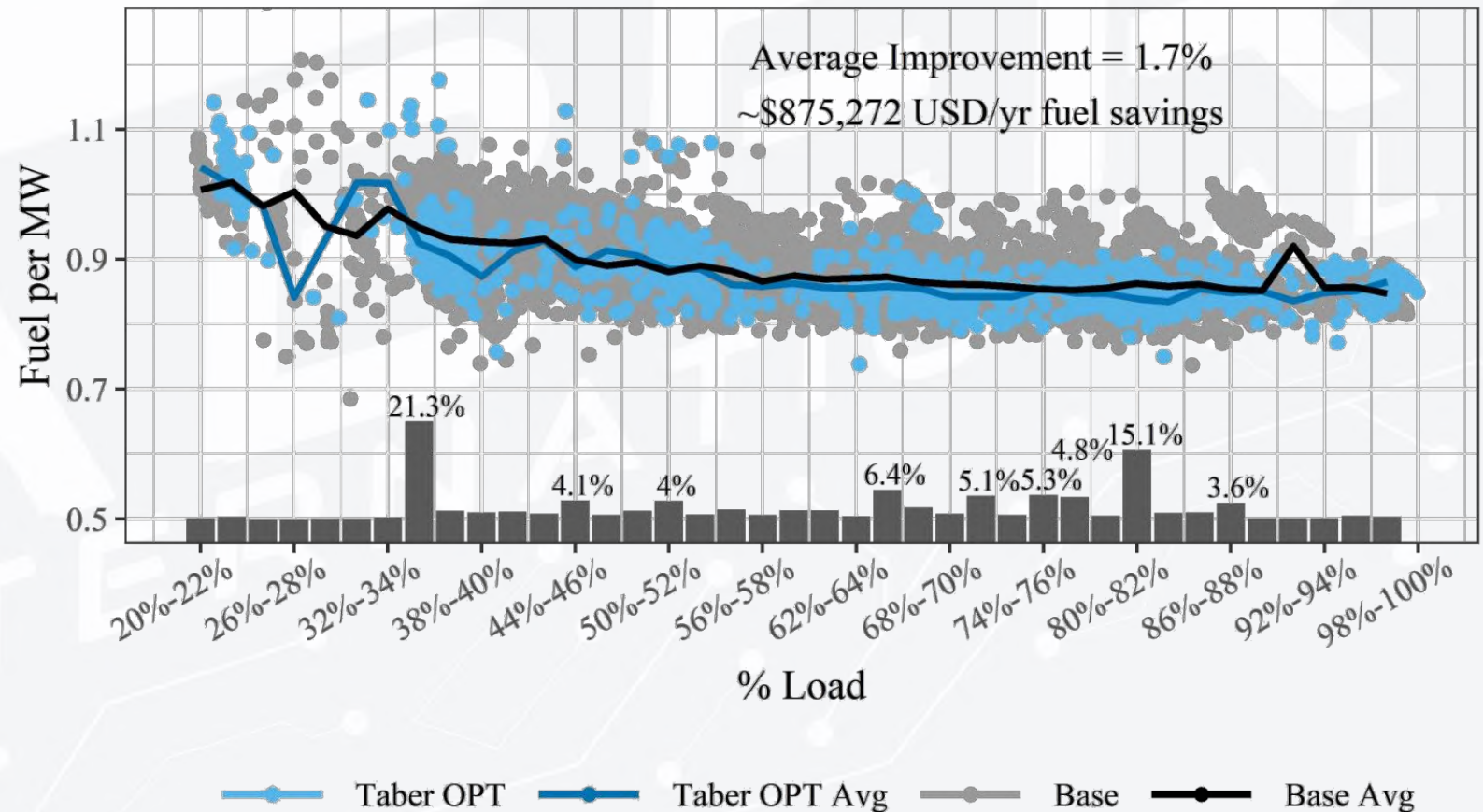
The resulting effects of this system operating in closed-loop control for 2-years show consistent improvement operating efficiency improvement through use of the system.

- 2% average operating efficiency improvement
- Improvements observed across the load range, 20% - 100% MCR
- Accomplished using only control improvements and operating practice adjustments
- Utilized an advanced recurrent neural network utilizing novel Transformer formulations to fully identify and generate the process model used in closed-loop control



OVERALL IMPROVED SYSTEM FLEXIBILITY AND PERFORMANCE

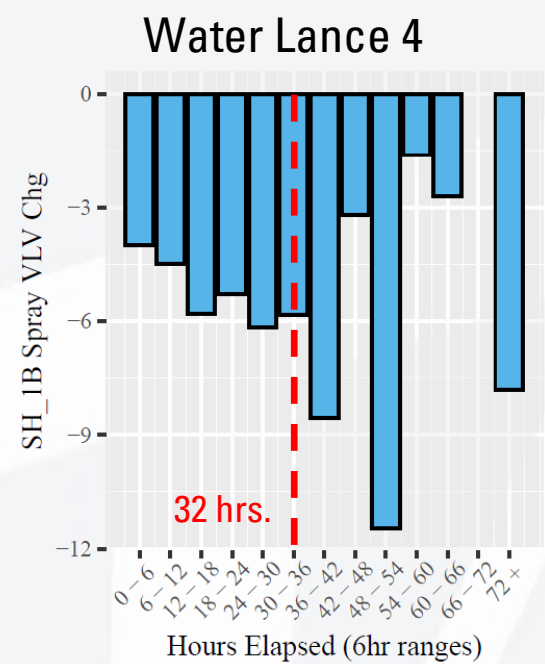
The culmination of advanced, dynamic AI systems and optimization with expert knowledge capture and automated responses is a robust system capable of enhanced flexible operation and stability, meeting the challenging demands of the future energy grid reliably and cleanly.



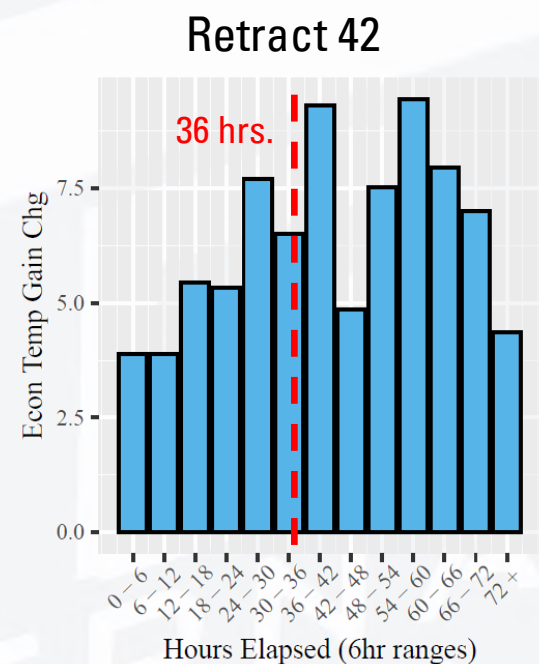
KNOWLEDGE BASED SOOTBLOWING



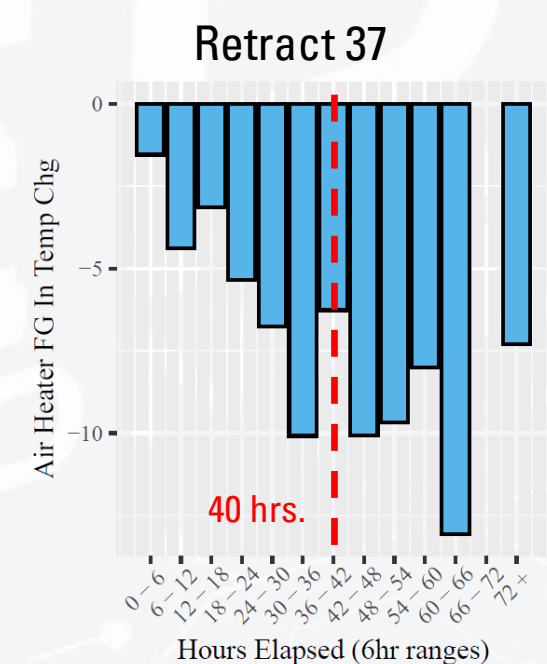
PROCESS-DRIVEN INTELLIGENT SOOTBLOWING



Greater energy absorption in water walls, reducing necessary attemperator flow



Economizer build-up removed increasing efficiency

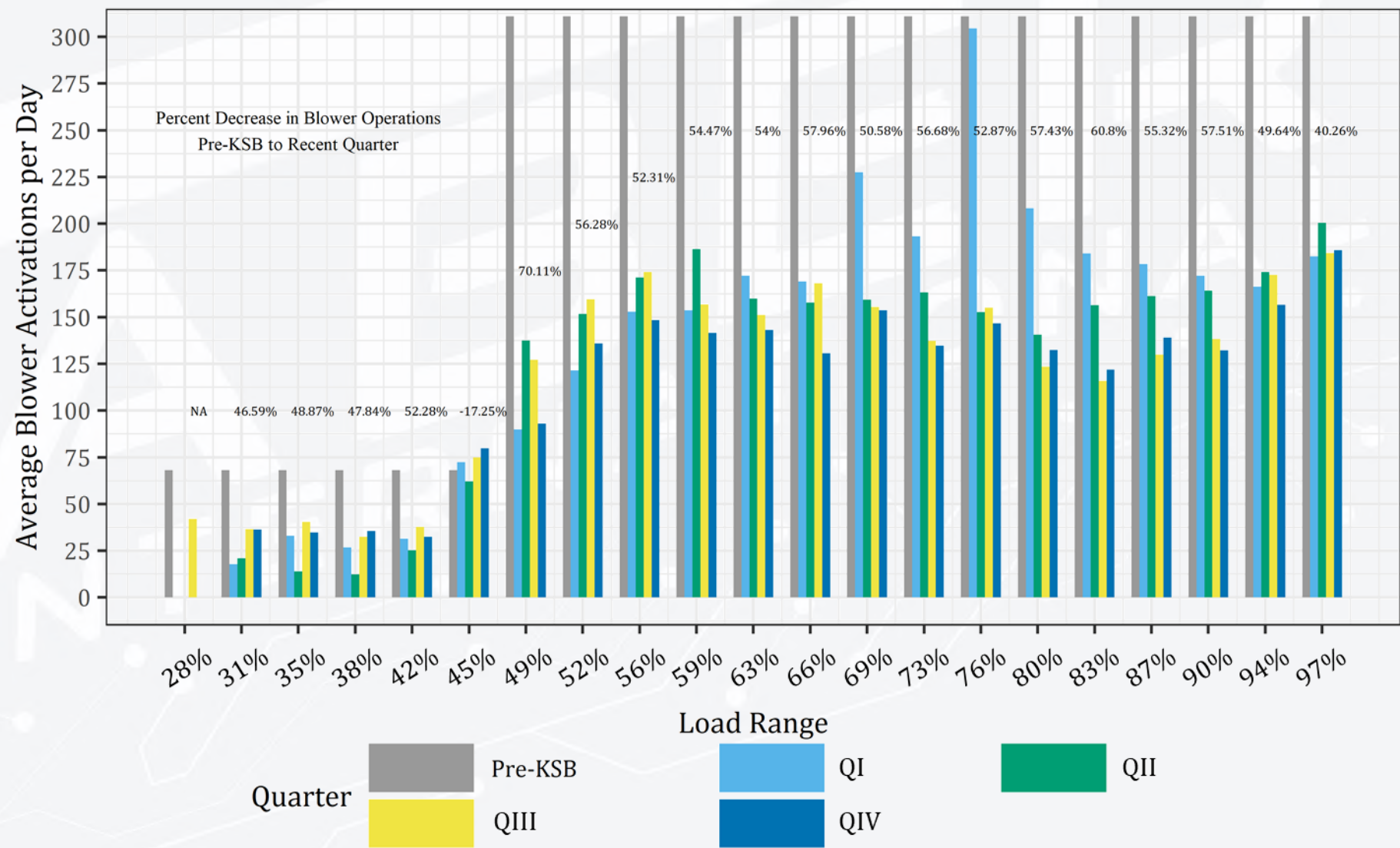


Greater energy absorption in SH panels, reducing flue exit gas temperatures

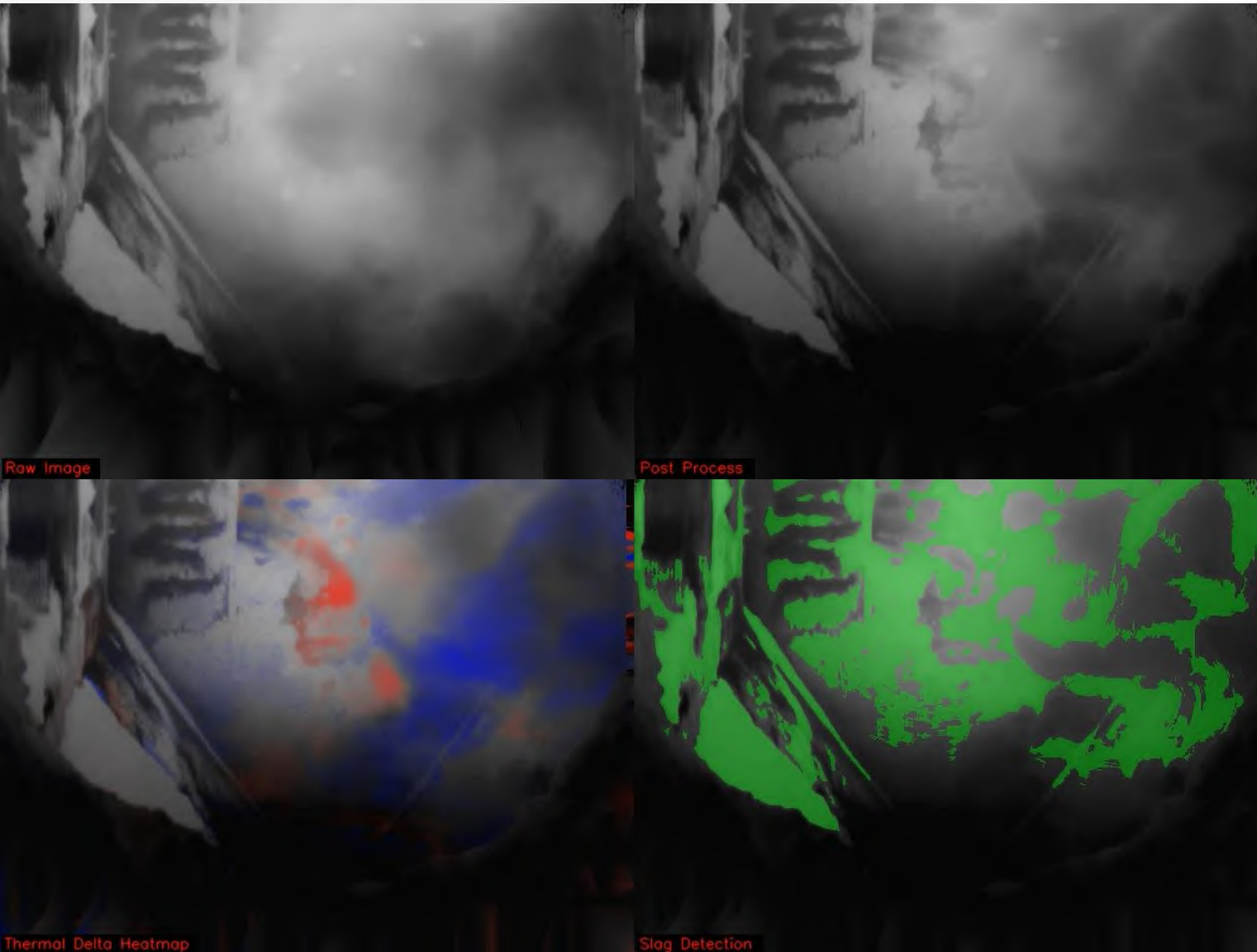
Data analytics, expert knowledge, and AI are developed to identify and understand the effects of individual sootblower activations and other parameters of interest on the overall process, and the effects of time and multiple outside contributors on system performance reported through an automated reporting system.

PROCESS-DRIVEN INTELLIGENT SOOTBLOWING

Intelligent sootblowing can dramatically reduce overblowing and provide confidence to operations to step back from conservative approaches, significantly reducing steam usage, as well as avoiding tube erosion and other wear and tear.

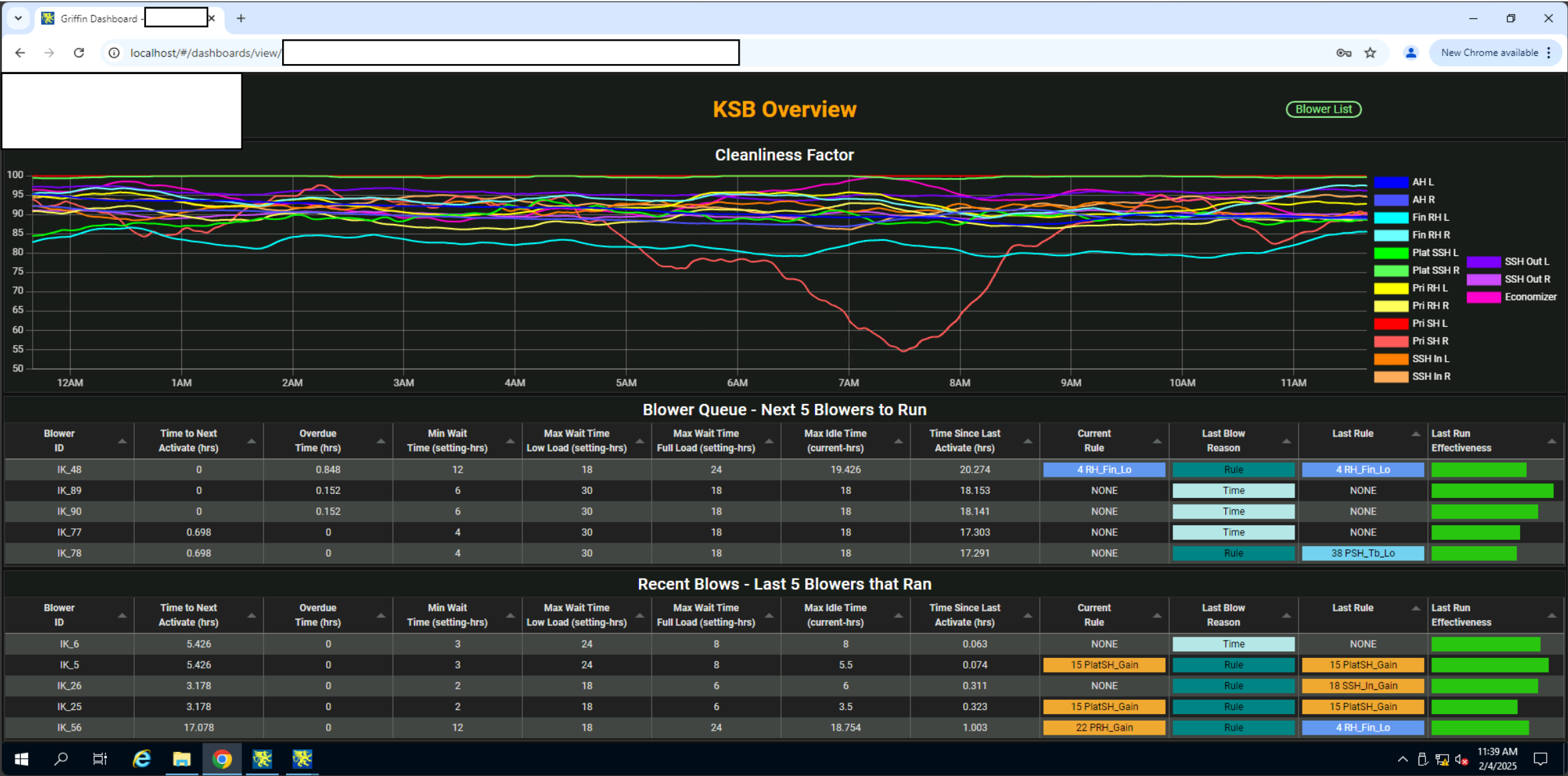


ENHANCING SYSTEMS WITH THE LATEST TECHNOLOGIES

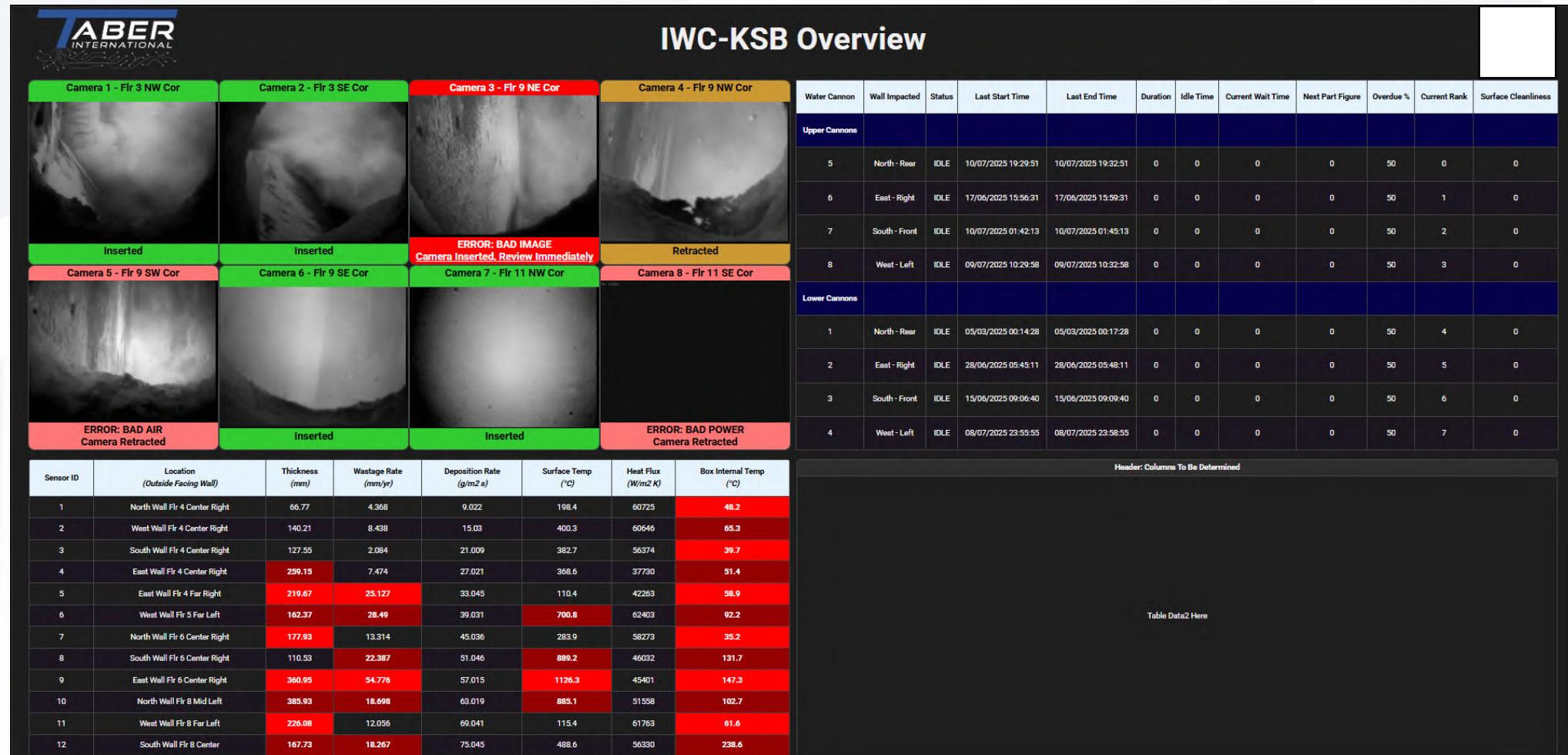


- Using all data at our disposal is key to optimization
- New approaches to utilizing data in more less traditional formats can create new opportunities for optimization
- We're moving toward a point with technology that we can enable machines with many of the same "data collection" methods as humans (the 5 senses)

SYSTEM VISIBILITY DRIVES ADOPTION



SYSTEM VISIBILITY DRIVES ADOPTION



Web-based interfaces and data visualization tools can also be created to increase system visibility and interactivity across a site or corporate entity.

PROJECT TESTIMONIALS

[We] started load cycling and low load operation back in the 2016-17-time frame. Our current load range capability is from 15% minimum MDC to 100% maximum MDC.

Flexibility is our current reality and maintaining stability during load ramps takes continuous monitoring and adjustments. The inherent problems associated with load ramping and cycling (pressure swings, temperature swings, and low total air flow at lower loads) have been minimized to certain extent, by the optimizer.

In our system load ramps are almost never continuous. There may be 2-3 interruptions or pauses in the total ramp. For example, an afternoon peak load ramp may be from 15% MDC to 80% MDC with a 15-minute pause at 40% and the same at 60%. At each of these pauses is where we have seen the worst pressure and temp swings. **The optimizer can anticipate these excursions and utilize the sprays and/or burner tilts to minimize the effects of the event.**

I think one of the best indicators of this application is operator acceptance. Anyone who has worked at a power plant and has anything to do with operations knows “without operator by-in” the program will fail. **Here our operators have seen positive results and are willing to work to make it better, which makes their life better.**

– Asst. Operations Manger, Coal-Fired Power Plant, Western United States

PROJECT TESTIMONIALS

“[Taber’s] KSB enabled us to break away from sequence blowing [and] got rid of 25+ operator-based sequences that were overkill. Blowers run more as needed now, with roughly 20-30% aux steam savings. We’ve been able to tune KSB rules and holds on blowers such that our units are as efficient and as clean as needed for baseload, as well as being inefficient and as dirty as needed to keep exit temps up at low loads for best ESP and SCR operation, the latter of which has made for **better flexibility and turndown.**”

– Doug Sturm, Sr. Engineer, CGS Operations

“Our previous system was sequence based [over which] Griffin is a huge improvement, and it is maintaining [unit] cleanliness very well. We’ve had a few short boiler outages on our unit where Griffin is installed. I make it a point to check the reheater for slag when the unit is off. I haven’t seen any issues. Before Griffin, I was walking the unit down easily once a week, sometimes more. Usually we asked Operations to blow certain lances, which required verification and a physical check to make sure it achieved the level of cleanliness that we wanted. Sometimes I would change sequences to get the boiler clean...which usually required a week or so to [do]. Before Griffin, boiler cleanliness consumed 30% of my day. Now with Griffin, I don’t do any of the tweaking anymore. Griffin does it for us. As pleased as I am with Griffin, what amazed me most was how smoothly and effectively Griffin was rolled out. It was almost seamless and very professionally done. I’ve never been involved, at any place I’ve ever worked, where a change of this magnitude was rolled out so smoothly and seamlessly across multiple shifts.”

– Ben Hanneken, Engineering, Labadie Energy Center

CONCLUSIONS

- Providing grid stability and sufficient generation is a complicated problem and is only becoming more complex with greater penetrations of variable generation sources.
- With control and operating modifications (stretches), the existing thermal fleet is capable of stretching to act as the balancing agent, and there is great value in their flexible and variable operation.
- Specialized machine learning and other data-driven models which incorporate and learn system dynamics can be more effective in optimizing systems in the midst of transients and dynamic operation than traditional approaches or static optimization.
- These types of approaches are further enhanced and made robust when they are encapsulated within domain expertise “guardrails”.
- Operational improvements to both efficiency (heat rate) and emission rates have been demonstrated both in single events and over extended periods of time.
- Instructing operators and engineers on flexible operation best-practices is critical to achieving unit reliability and overall flexibility. By automating many portion of this process, greater consistency and robustness is achieved.
- As a more integrated approach is realized where upcoming events can be better prepared for and the future load demands predicted with more accuracy, further benefits and gains can be expected through dynamic optimization and trajectory planning.

TOTAL PLANT INNOVATION

COMBUSTION OPTIMIZATION

FLEXIBILITY & RAMPING

MODEL PREDICTIVE CONTROL

ELECTRONIC LOGGING
& REPORTING

PREDICTIVE MAINTENANCE

PERFORMANCE MONITORING
& DASHBOARDS

VIRTUAL SENSORS



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