**Technical Paper**
BR-1960

# Combustion Optimization at Longview Power Reduces Emissions While Achieving Improved Heat Rate and Efficiency

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Presented to:
*47th International Technical Conference on Clean Energy*

Date:
*July 23-27, 2023*

Location:
*Clearwater, Florida, U.S.A.*

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# COMBUSTION OPTIMIZATION AT LONGVIEW POWER REDUCES EMISSIONS WHILE ACHIEVING IMPROVED HEAT RATE AND EFFICIENCY

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## Abstract

Emissions control and reduction remain a large part of power plant operations. From selective catalytic reduction (SCR), wet and dry scrubber technology to electrostatic precipitators (ESP) and fabric filter baghouses, power plants continue to allocate large capital and operating expenses to reduce their emissions footprint. Another strategy that has become a cost-effective means of reducing emissions is optimization of the combustion process. The FocalPoint® optimization system from Babcock & Wilcox (B&W) is a leading technology that has proven to be a cost-effective means to achieve further carbon monoxide (CO) and nitrogen oxides ($NO_x$) emissions reduction while also lowering $O_2$ to achieve better unit heat rate and efficiency.

This paper discusses how B&W's FocalPoint optimization system was utilized on Longview Power's 700-megawatt (MW) Foster Wheeler boiler in Maidsville, West Virginia. It describes the successful implementation of optimization logic that biases air flow to the burners, overfire air (OFA) ports, and windboxes as well as reducing overall $O_2$ to control emissions and improve heat rate. This paper presents specific results showing how the combustion optimization project achieved and, in many aspects, surpassed its goals.

## Introduction

### *Unit History*

The Longview power plant was one of the last coal-fired plants built in the 13-state PJM interconnection. The plant began commercial operation in December of 2011. The boiler is a first-of-a-kind Foster Wheeler once-through Benson low mass flux vertical tube advanced supercritical boiler. A side view of the Longview unit is shown in Figure 1.

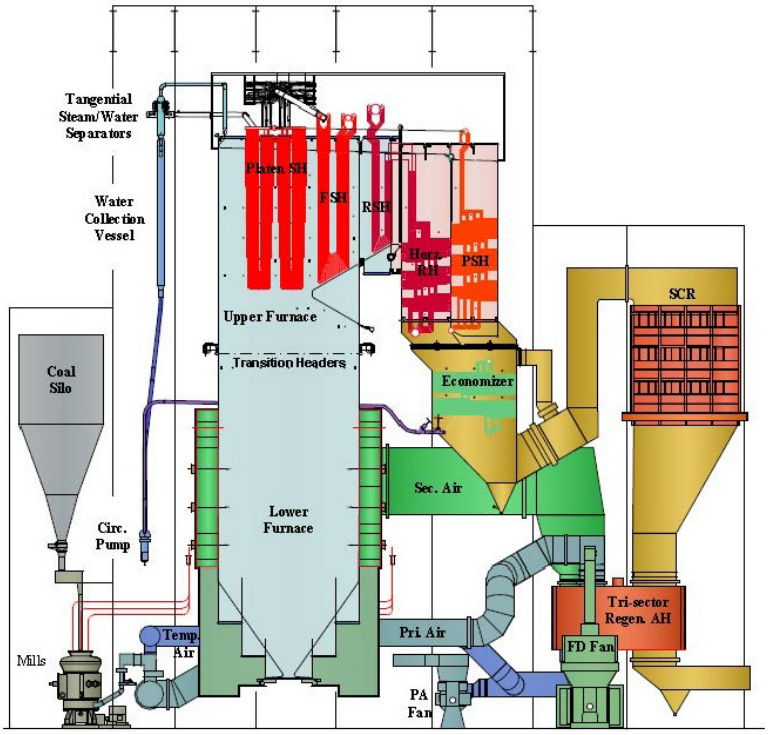


Figure 1 – Longview Unit 1 Side View

The plant had some issues during initial startup and commissioning that kept the unit from operating reliably. Modifications were completed during the outages in the Spring and Fall of 2015. Today, Longview unit 1 is one of the most efficient coal-fired plants in the United States with a best in class heat rate of 8,750 Btu/kWh (9,232kJ/kWh).

Despite the improvements made with the unit modifications, Longview still had issues with slag control. In 2014, Longview installed B&Ws Power Clean® intelligent sootblowing (ISB) system to help with the slagging issues. In 2016 the Power Clean system was upgraded to B&W's latest software, Titanium® ISB. Commissioning of the ISB system occurred in late 2016. The ISB system uses a detailed boiler performance model to intelligently operate sootblowers based on actual heat transfer in each of the heat traps. The ISB allowed the plant to better control slag buildup and eliminate the large slag falls that would occur, as well as control other variables affecting heat rate such as reheat spray flow.

After the successful implementation of the Titanium ISB system, B&W approached Longview about optimizing the combustion to reduce emissions and further improve heat rate. Longview agreed to the combustion optimization project and B&W installed its FocalPoint Optimization system on the same computer as the Titanium ISB system. This paper describes the combustion optimization project, the FocalPoint system, and the results achieved to date.

### *Unit Description*

The Longview Power unit is a Foster Wheeler vertical tube, wall-fired, advanced supercritical boiler with a net rating of 700 MW. The unit is located in Maidsville, West Virginia, and burns a high-sulfur bituminous coal from a local mine. The boiler is paired with a high-efficiency Siemens steam turbine and generator set which has a rating of 803.6 MW/hr. A selective catalytic reduction (SCR) system is used for

primary $NO_x$ control and a wet flue gas desulfurization (FGD) system is used for sulfur dioxide ($SO_2$) control. Particulate emissions are controlled with a pulse jet fabric filter (PJFF).

The Longview boiler has six (6) Foster Wheeler MBF pulverizers feeding coal to 36 low-$NO_x$ burners. The burners are in an opposed wall firing configuration with three (3) elevations of six (6) burners on each wall. Each elevation of burners has its own dedicated secondary air windbox. Air enters each windbox from both ends where it is measured and controlled by the distributed control system (DCS) using an air flow damper. Each burner has a secondary air flow damper with drive so the position can be adjusted from the unit's control system. The unit has 16 overfire air (OFA) ports above the top elevation of burners with eight (8) ports located on each wall. The middle six (6) OFA ports are in line with the burner columns with the two remaining ports located outside of the outermost burner columns. Like the burners, each set of eight (8) OFA ports is fed secondary air from a dedicated windbox with flow measurement and control dampers on each end of the windbox. Each OFA port has a flow control damper with drive so the position of the damper can be adjusted from the unit's control system. The layout of the burners and OFA ports is shown in Figure 2.

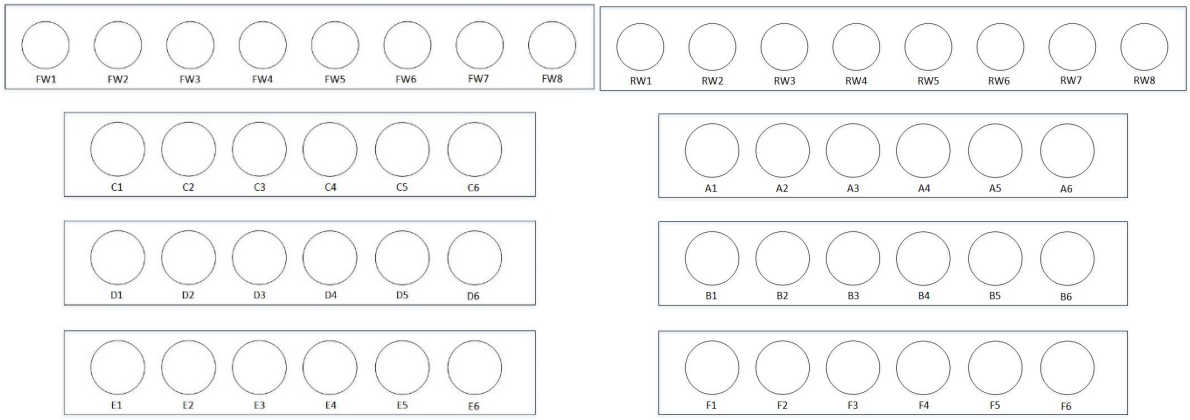


Figure 2 – Longview Burner and OFA Layout

The Longview unit is well instrumented for monitoring the combustion process. In addition to the normal $O_2$, CO, and $NO_x$ measurements at the stack, Longview has additional $O_2$, CO, and $NO_x$ probes installed in the flue after the economizer. There are 16 in situ $O_2$ probes aligned with the 16 OFA ports. Eight (8) $O_2$ probes extend about 1/3 of the way into the flue to represent the conditions near the front wall. The remaining eight (8) $O_2$ probes extend about 2/3 of the way into the flue to represent conditions near the rear wall. There are six (6) close-coupled extractive CO probes. The CO probes are aligned between OFA ports with no CO probe between the middle two OFA ports. The CO probes extend approximately half way into the flue to be representative of the flue gas in the middle of the unit. The unit has six (6) close-coupled extractive $NO_x$ probes installed adjacent to the CO probes.

## Combustion Optimization Project

### *FocalPoint System Description*

The FocalPoint system is B&W's general-purpose process optimization software. The system provides a wide array of performance models, general calculational functions, logic functions, knowledge-based decision algorithms, and optimization algorithms which can be combined as needed to create a customized optimization solution. The FocalPoint system contains several B&W proprietary first-principles performance models and provides tools such as neural networks and fuzzy logic for the generation of data-driven performance models. The system allows for the optimization solution to be broken down into smaller units with each unit operating under its own timing but interacting with the other units. The system also provides fully configurable models which describe the physical devices being adjusted and how the optimizer interacts with them.

The FocalPoint system operates on a Windows platform and is composed of two main software pieces: the engine/server and the client/HMI. The engine/server performs all the calculations, interacts with the FocalPoint system's own historian, and communicates with the plant's existing control systems using industry standard protocols like OPC. The client/HMI connects to the engine/server and provides screens for configuring the system, for monitoring system status, and for displaying optimization results.

### *Project Goals and Optimization Approach*

The combustion optimization project had the following main goals:

- Reduce the frequency, severity, and duration of CO spikes
- Keep CO below permit limits and reduce if possible
- Reduce the $NO_x$ level entering the SCR to reduce ammonia usage
- Balance the $O_2$ across the unit
- Reduce the overall $O_2$ set point

To achieve these goals, the FocalPoint optimizer was given access to the biases on the following DCS control loops:

- Burner secondary air flow dampers
- Burner windbox flow dampers
- OFA flow dampers
- OFA windbox flow dampers
- $O_2$ set point

B&W created an optimization solution for Longview using a combination of fuzzy logic models and customized decision logic. The fuzzy logic models describe the relationships between each of the measured emissions ($O_2$, CO, and $NO_x$) and the controllable parameters. The customized decision logic accounts for the relationships (complementary and competing) between the $O_2$, CO, and $NO_x$ as well as the constraints on the optimization problem. The optimization logic not only considers current operating conditions, but also looks at recent operational history. Additionally, the optimizer logic communicates with the Titanium ISB system to retrieve and use the current state of sootblowing on the unit. The main

optimizer calculations run every two (2) minutes and calculate a new set of control parameter biases which are sent to the plant's control system.

## Results

The plant operators and engineers have noticed several improvements since the FocalPoint system has been in service. The system is kept in automatic nearly 100% of the time and the plant operates at steady state a majority of the time. Operators indicate they no longer must be concerned with trying to control CO spikes by manually biasing OFA or burner sleeves, allowing them to focus their attention on other operational matters.

The following results and comparisons are based on months of operational data; not just a few hours or weeks. Because of this, the results show the combustion optimizer's ability to deliver consistent performance improvements over a range of operating conditions. Additionally, unless otherwise noted, no filtering has been applied to the data used.

### *CO Emissions*

A goal of the FocalPoint combustion optimization system was to reduce CO emissions. As part of the plant's permitting for operation, CO must be kept below 673 lb/hr on a 24-hour rolling average. Prior to the FocalPoint system, the average CO emissions was around 362 lb/hr. Since implementation of the FocalPoint system, CO emissions are now around 195 lb/hr. This is a reduction of 167 lb/hr, or a 46% reduction. The results can be seen in Figure 3. The 2017 data is the baseline without the optimizer in operation. The data for 2020 has the optimizer in automatic operation 98.5% of the time.

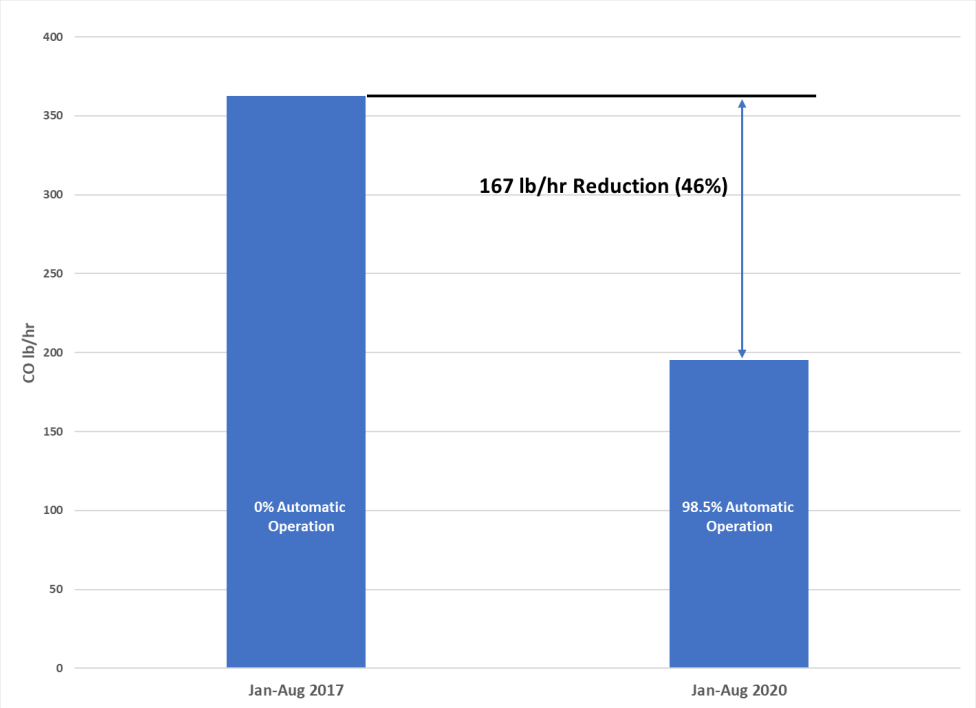


Figure 3 – CO Reduction with the FocalPoint Optimizer

Another goal of the system was to reduce the frequency and severity of CO spikes. Figure 4 shows the FocalPoint optimizer has been successful at doing this. The vertical bars are the amount of time the instantaneous stack CO was above the annual average permit limit of 673 lb/hr. The optimizer reduced the amount of time from about 13% to about 4%. The solid line in the graph is the standard deviation of the stack CO. The standard deviation is a measure of the CO variability. The optimizer reduced the CO variability by 27%.

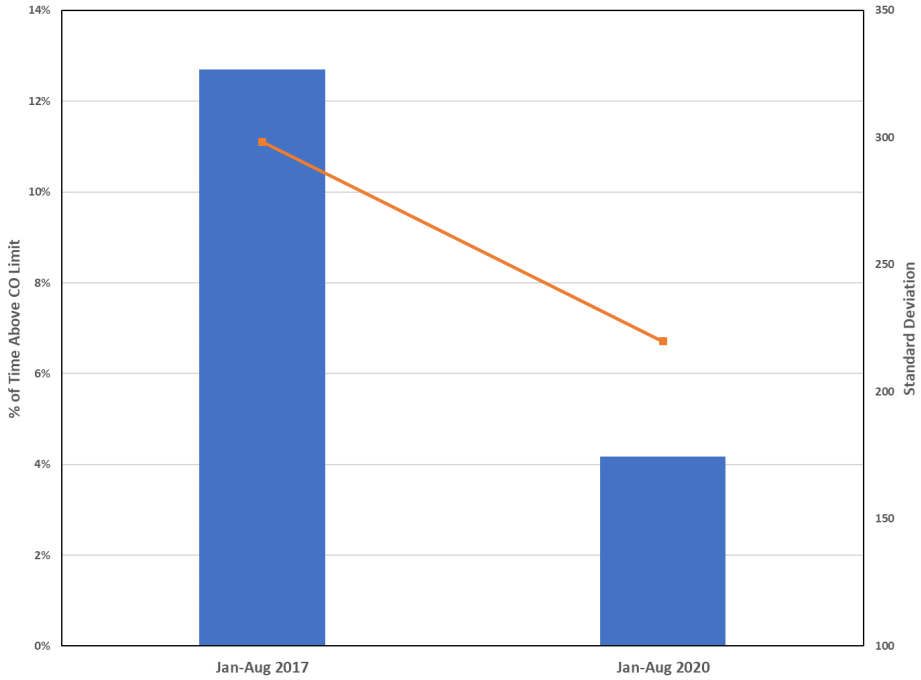


Figure 4 – CO Spike Reduction with the FocalPoint Optimizer

### *$NO_x$ Emissions*

The complete logic for $NO_x$ reduction has not yet been implemented, but with the biasing of the burner and OFA ports to balance $O_2$ and reduce CO, a reduction in overall $NO_x$ was realized.

This unit is subject to an ozone season from May to September and there are multiple limits included in the permit. The permit limits of note are 489 lb/hr on a 24-hour rolling average, 428 lb/hr on a 30-day rolling average, and 397 lb/hr annually. During ozone season the target $NO_x$ is 330 lb/hr on a 24-hour average.

In January of 2020, the engineers at Longview modified the $NO_x$ logic in the DCS which allowed the ammonia ($NH_3$) spray to remain in automatic mode. This had the effect of reducing $NH_3$ consumption. To determine the optimizer's impact on $NO_x$, the SCR Inlet $NO_x$ was analyzed for improvements before and after the optimizer was placed in service. The data in Figure 5 is for the period of May to July 2019 and

May to July 2020. As can be seen, there was a 5.3% reduction in SCR inlet $NO_x$. While the FocalPoint optimizer was in operation during the May to July 2019 period, it was only in service 31.8% of the time. During May to July 2020, the FocalPoint optimizer was in automatic mode 98.8% of the time.

Because of the combustion balancing with the FocalPoint system, there was also a balancing of the $NO_x$ emissions measured across the flue. The 2019 data in Figure 5 has a 5.3% deviation between the A and B SCR Inlet $NO_x$ probes while the 2020 data has a 0.6% deviation.

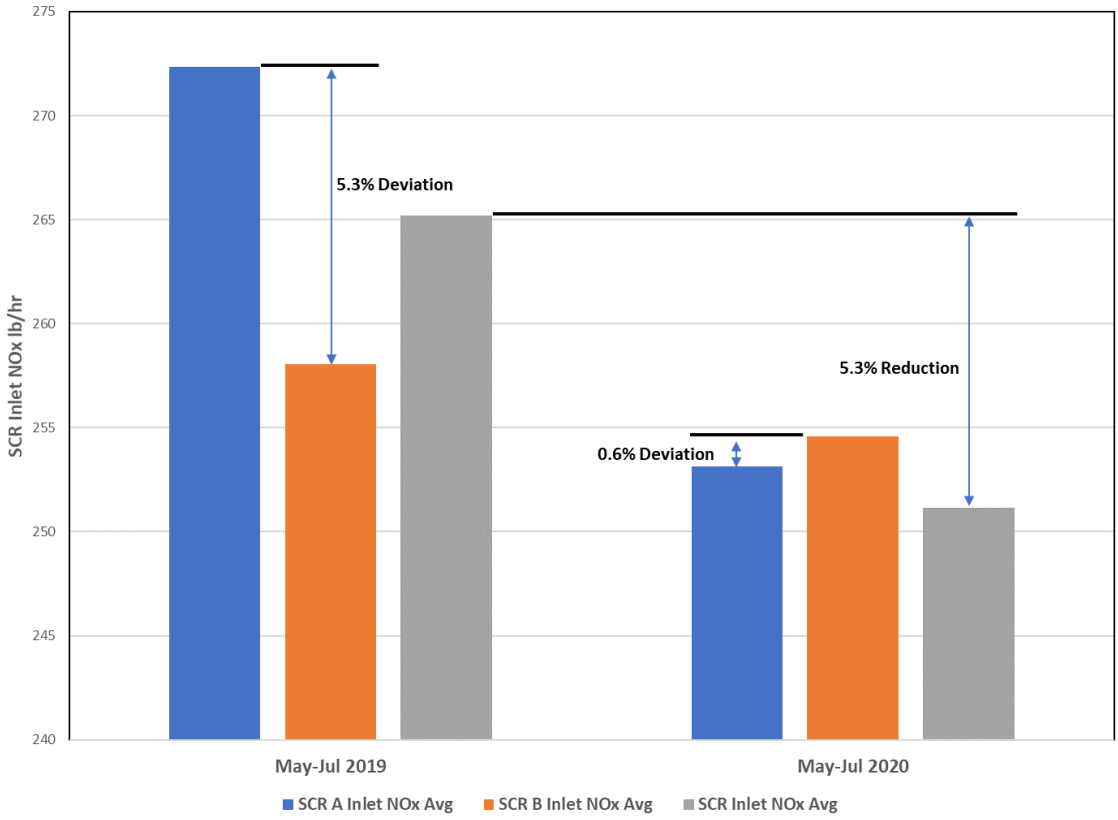


Figure 5 – $NO_x$ Emission Reduction

### *Furnace Exit Gas Temperature*

Another secondary effect of staging combustion is a change in furnace exit gas temperature. Prior to the installation of the FocalPoint system, the unit had a history of imbalance between the right and left furnace exit gas temperature probes. In January and February of 2017, there was a 76° F deviation between the right and left FEGT probes. In the corresponding months for 2020, there was only a 35° F deviation between the right and left probes. There was also an overall average reduction in FEGT of over 200° F. These results are shown in Figure 6. The data in Figure 6 was filtered to only include operational data for loads greater than 700 MW.

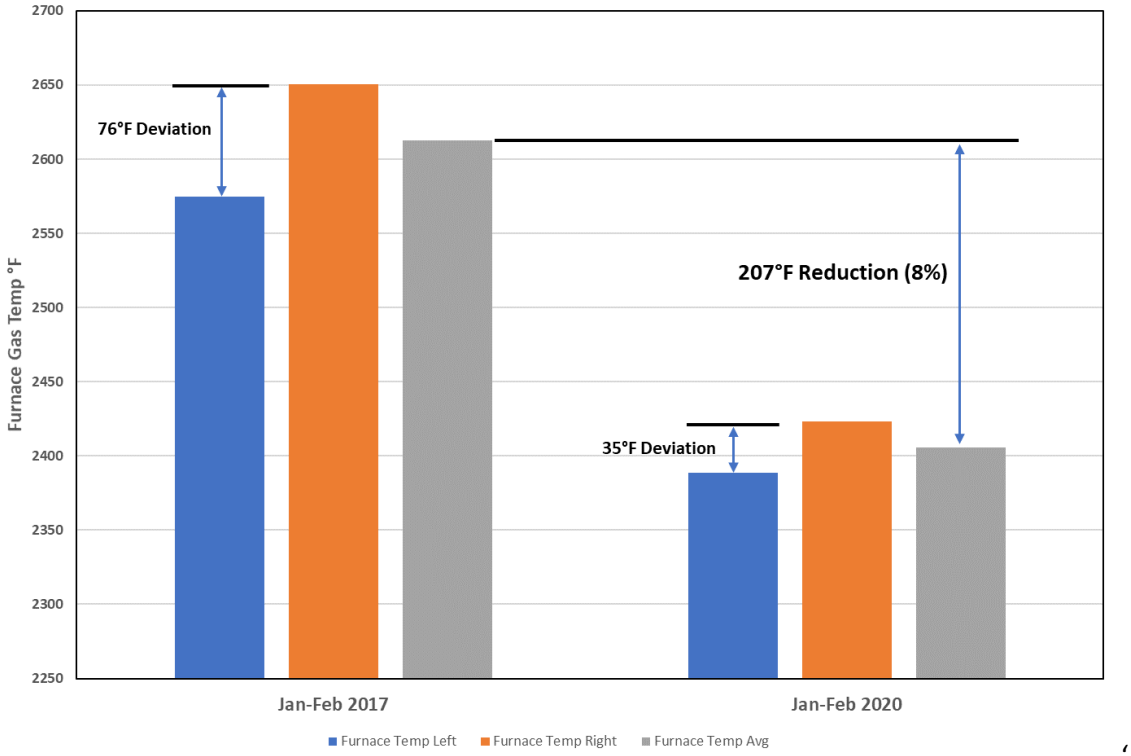


Figure 6 – Furnace Exit Gas Temperature

### *$O_2$*

One of the biggest improvements realized from the implementation of the FocalPoint system at Longview is the decrease in operating $O_2$. This is a result of balancing the $O_2$ and reducing the CO spikes and average value; which allowed the optimizer to lower the overall $O_2$ setpoint.

The design $O_2$ set point for the Longview unit is 3.29%. Using manual adjustments, the operators were able to keep the $O_2$ average around 3 to 3.1%. With the FocalPoint system in service, the $O_2$ now averages around 2.5%. This is a decrease of more than 0.5% in $O_2$. The automatic $O_2$ adjustments made by the FocalPoint optimizer also provides an extra layer of safety when CO excursions occur. The $O_2$ set point is increased automatically to coincide with higher CO, providing protection to the unit. The unit was previously unable to operate at an average $O_2$ below 3% without significant CO spikes. *[Note: at the time this paper was written, the plant allowed the FocalPoint system to operate the $O_2$ at 2.4%.]*

The decrease in operating $O_2$ alone attributes to a significant Improvement in unit heat rate and boiler efficiency. The $O_2$ reduction is shown in Figure 7. The data in Figure 7 was filtered to only include operational data for loads greater than 700 MW.

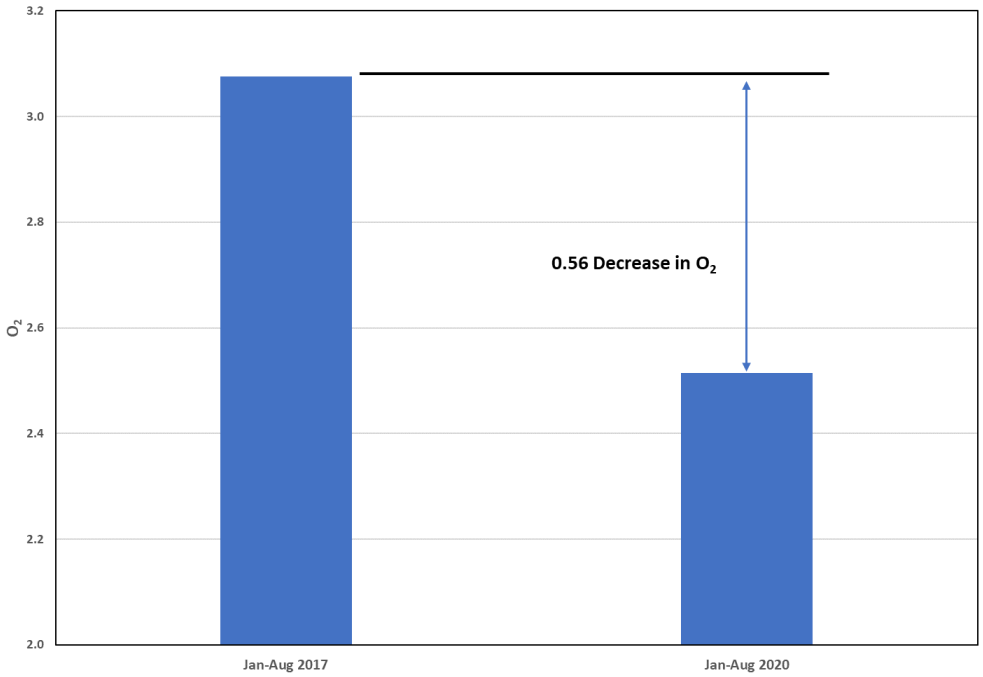


Figure 7 – Overall $O_2$ Reduction

### *Heat Rate and Efficiency*

Two important metrics for power plant operation are heat rate and efficiency. These values are typically the best way to evaluate thermal performance and cost efficiency for a plant. The Titanium ISB software calculates gross heat rate and boiler efficiency as part of the boiler model calculations it runs in real-time on the operating unit. Since both the Titanium ISB and FocalPoint systems have been operating for the same time period, the gross heat rate and efficiency values calculated from the Titanium ISB were evaluated. *[Note: the gross heat rate and boiler efficiency values presented here may differ slightly from the official values reported by the plant in their public filings.]*

In Figure 8, gross heat rate was averaged from January to August of 2017 and from January to August of 2020. As can be seen, the calculated gross heat rate from the Titanium ISB was reduced by 213 Btu/kWh, which is a 2.6% improvement.

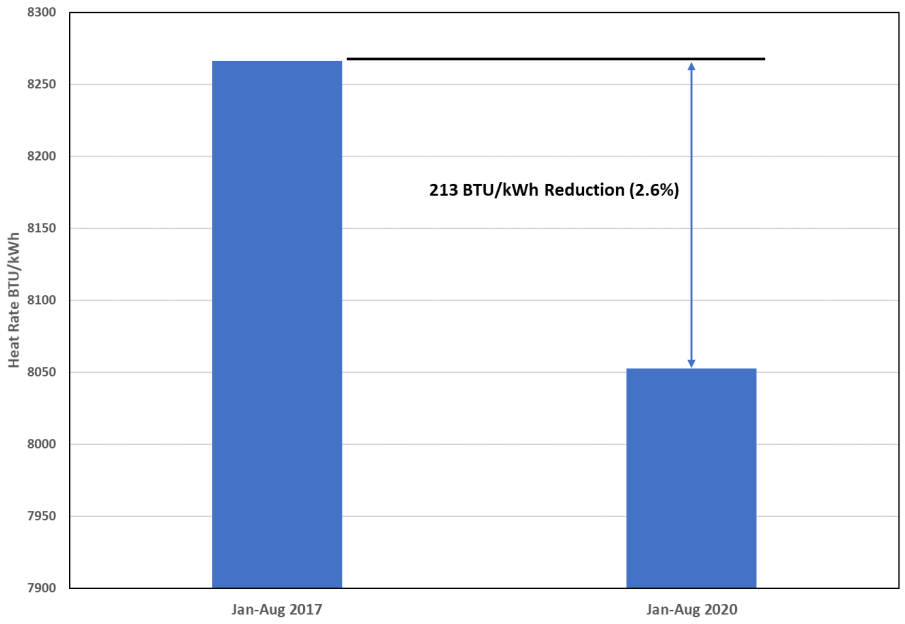


Figure 8 – Gross Heat Rate

The same data and time frame for the heat rate was used for the evaluation of boiler efficiency. The percent efficiency as calculated by the Titanium ISB increased by 0.58%. This is a significant increase in efficiency for any boiler. This result is shown in Figure 9.

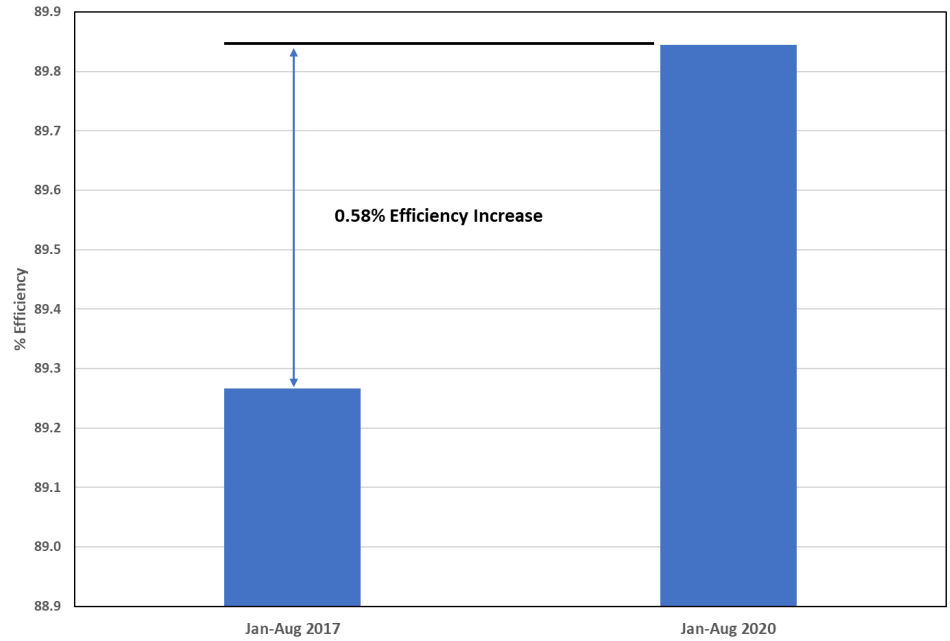


Figure 9 – Longview Boiler Efficiency

## Conclusion

The FocalPoint optimization system was installed on Longview Power's 700 MW advanced supercritical boiler to help control CO, reduce $NO_x$, and balance and reduce $O_2$. The data in this paper show the FocalPoint system has succeeded in these goals. The $O_2$ reduction alone equates to fuel savings, reduced maintenance costs, and unparalleled thermal efficiency. The FocalPoint system offers the benefits of continually monitoring combustion and emissions performance while leveraging that analysis to make consistent adjustments to the process. This allows operators to confidently focus on other plant processes based on the measured results of the FocalPoint optimizer system as it runs in automatic operation nearly 100% of the time.