WV ACE Partial State Plan

Appendix J

Black & Veach “Longview Unit 1 Heat Rate Study”

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FINAL

LONGVIEW UNIT 1 HEAT RATE STUDY

B&V PROJECT NO. 406009
B&V FILE NO. 14.410

PREPARED FOR

Longview Power

11 AUGUST 2020

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1.0 Executive Summary

1.1 INTRODUCTION

Longview Power LLC asked Black & Veatch to support its efforts to analyze the potential response to the United States Environmental Protection Agency (EPA) Docket ID No. EPA-HQ-OAR-2017-0355, "Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units; Revisions to Emission Guideline Implementing Regulations; Revisions to New Source Review Program. Proposed Affordable Clean Energy (ACE) rule." Longview Power operates Longview Unit 1, which is a coal fired electric generating unit (EGU), and specifically requested that Black & Veatch develop a high-level assessment report regarding four specific items:

- Variable frequency drive deployment for induced draft fans.
- Variable frequency drive deployment for boiler feed pumps.
- Potential internals upgrades for boiler feed pumps.
- Variable frequency deployment for forced draft fans (considered to be "targeted heat rate assessments" under ACE and a potential method for complying with CO_2 standards of performance).

To meet these goals, Black & Veatch prepared a high-level analysis of these heat rate improvement (HRI) projects that have been proposed by the EPA as the best system of emissions reduction (BSER). Estimates of HRI, annual carbon dioxide (CO_2) reduction, and a rough order of magnitude capital cost estimate have been developed for each alternative.

A comprehensive assessment of the technical and economic feasibility will not be provided in this effort but should be considered in a follow-on effort under a separate phase. Follow-on studies would consist of conceptual engineering to develop more accurate performance and cost estimates for the system(s) to better determine feasibility of the options evaluated at a high level in this study.

2.0 Existing Plant Characteristics

Table 2-1 shows the existing baseline full-load efficiency parameters for Longview Unit 1, along with net plant heat rate (NPHR) and CO_2 emissions rates. These data were gathered from the Longview Unit 1 PI Data and performance calculations and adjusted based on standard equations for consistency. The actual performance data is from June 25, 2019, from 13:00 to 17:00.

Table 2-1 Longview Unit 1 Baseline Actual Full Load Data

Unit	Gross/ Net (MW)	Net Turbine Heat Rate (NTHR) (Btu/kWh), Actual	Boiler Efficiency, HHV Basis (%)	NPHR (Btu/kWh)	Coal Burn Rate (ton/h)	Coal HHV (Btu/lbm)	CO_2 Emissions (ton/h)
Longview Unit 1	781.9/ 706.2	6,955	89.90	8,566	236.5	12,789	601.6

Btu/kWh: British thermal unit per kilowatt hour.
Btu/lbm: British thermal unit per pound-mass.
HHV: higher heating value.
ton/h: tons per hour.

The unit consists of a Foster Wheeler supercritical pulverized coal boiler with single reheat stage. Six pulverizers supply the boiler with coal, and combustion air is supplied by two forced draft (FD) fans. Two Ljungström combustion air heaters are used to heat primary and secondary air. Nitrogen oxides (NOx) control systems installed at the unit include low-NOx burners and a selective catalytic reduction (SCR) system. Particulate control is by a pulse jet fabric filter (PJFF). Sulfur dioxide (SO_2) control is by a wet flue gas desulfurization (WFGD) system. The baseline coal quality was based upon the weighted average of coal deliveries from January 2019 through March 2020 from the Cumberland FOB point.

3.0 Description of Heat Rate Improvement Alternatives

This preliminary heat rate project screening was based on a high-level analysis of Longview Unit 1, as well as Black & Veatch's experience with similar projects. The projects depicted herein were selected from heat rate improvement (HRI) projects detailed by the EPA in its ACE proposal as BSER projects.

3.1 VARIABLE FREQUENCY DRIVE UPGRADES

VFDs function by controlling electric motor speed by converting incoming constant frequency power to variable frequency, using pulse width modulation. VFD upgrades for large electrically-driven rotating equipment provide many co-benefits, the largest of which is improved part-load efficiency and performance. This benefit is greatest at low load, and the more part-load and unit cycling that is done, the greater the benefit.

In addition to the reduced auxiliary power consumption, other benefits that are gained from the installation of VFDs on rotating equipment are as follows:

- Reduced noise levels around the equipment.
- Lower in-rush current during startups.
- Decreased wear on existing auxiliary power equipment.

Disadvantages of the installation of VFDs include the high capital cost plus a minimal amount of increased electrical equipment maintenance associated with the VFD system.

Output power signal quality and reliability of VFD equipment has increased significantly in the last 10 to 15 years, to the point that equipment from some manufacturers are approved for use, and have been installed, in nuclear power plants for critical equipment such as reactor coolant and recirculation pumps. Part of this increased reliability comes from the development of technology to allow the VFD equipment to remain in operation if one or multiple insulation gate bipolar transistor power cells fail by automatically bypassing the bad cell, or cell(s), until an outage when repairs can be made. Additionally, output power signals meet Institute of Electrical and Electronics Engineers (IEEE) 519 1992 requirements eliminating the need for harmonic filters.

VFD installation steps are typically as follows:

- Replace the existing rotating equipment coupling with resilient elastomeric block-shaft couplings to ensure no electrically induced torsional forces are transferred to the fan rotor. This means the existing equipment must be de-coupled from the motor and then realigned with the new coupling.
- Make upgrades to the lube oil system as necessary.
- Install new VFD enclosure foundations.
- Install new VFD enclosures and heat exchangers.
- Replace the power supply cables between existing switchgear to the new VFD enclosure. Install new cables from the VFD enclosure to the motor.

- For smaller units, the VFD control enclosure and cabinets will also be smaller with reduced pre-outage time requirements. The air-cooled VFD equipment can further reduce equipment installation and maintenance costs.

The logistics of these types of upgrades are typically as follows:

- Engineering design and specification development: 2 months.
- Bid process: 1.5 months.
- Contract negotiations: 1.5 months.
- Drawing submittal and reviews: 2 months.
- Lead time for equipment: 6 to 12 months.
- Outage time: approximately 1 month.

The rotating equipment evaluated for the possible addition of VFD systems in this study include the boiler feed pumps and the large draft fans for handling combustion air and flue gas (forced draft and induced draft fans).

3.1.1 Boiler Feed Pumps

Based on available information, Longview boiler feed pumps (BFP) auxiliary power consumption benefit is estimated to be negligible at full load (782 MW gross) and 3.8 MW at low load (475 MW gross).

Refer to Figures 3-1 and 3-2, which illustrate the current BFP train operation and future variable speed operation with the addition of VFDs. The VFD analysis allowed a reduction of pump speeds by 4 percent at full load and 29 percent at low load. These pumps operate near their highest efficiency point at full load, thus there is only savings potential at low load, even with the fluid drives still in place. Given the high capacity factor of the unit, the practical annual potential heat rate improvement is low (0.19 percent), especially given the high cost of the VFDs.

The estimated furnish and erect price for a VFD system for the Longview BFPs includes VFD, VFD enclosure, enclosure foundations, coupling, new power cabling and any new raceway required, engineering, installation, and contingency. Limited available space immediately around the rotating equipment would not affect the installation of VFD systems as the equipment can be placed virtually anywhere on the plant site and still provide adequate, clean power to the VFD.

VFD Deployment for BFPs

Total Installed Capital Cost:	$9.9 million for three pumps
Auxiliary Power Reduction:	Full load (782 MW gross): Negligible Low load (475 MW gross): 3.9 MW
Heat Rate (Efficiency) Improvement:	Full Load (782 MW gross): Negligible Low Load (475 MW gross): 0.5 percent
Estimated Additional Annual O&M Cost:	$9,000 for three pumps

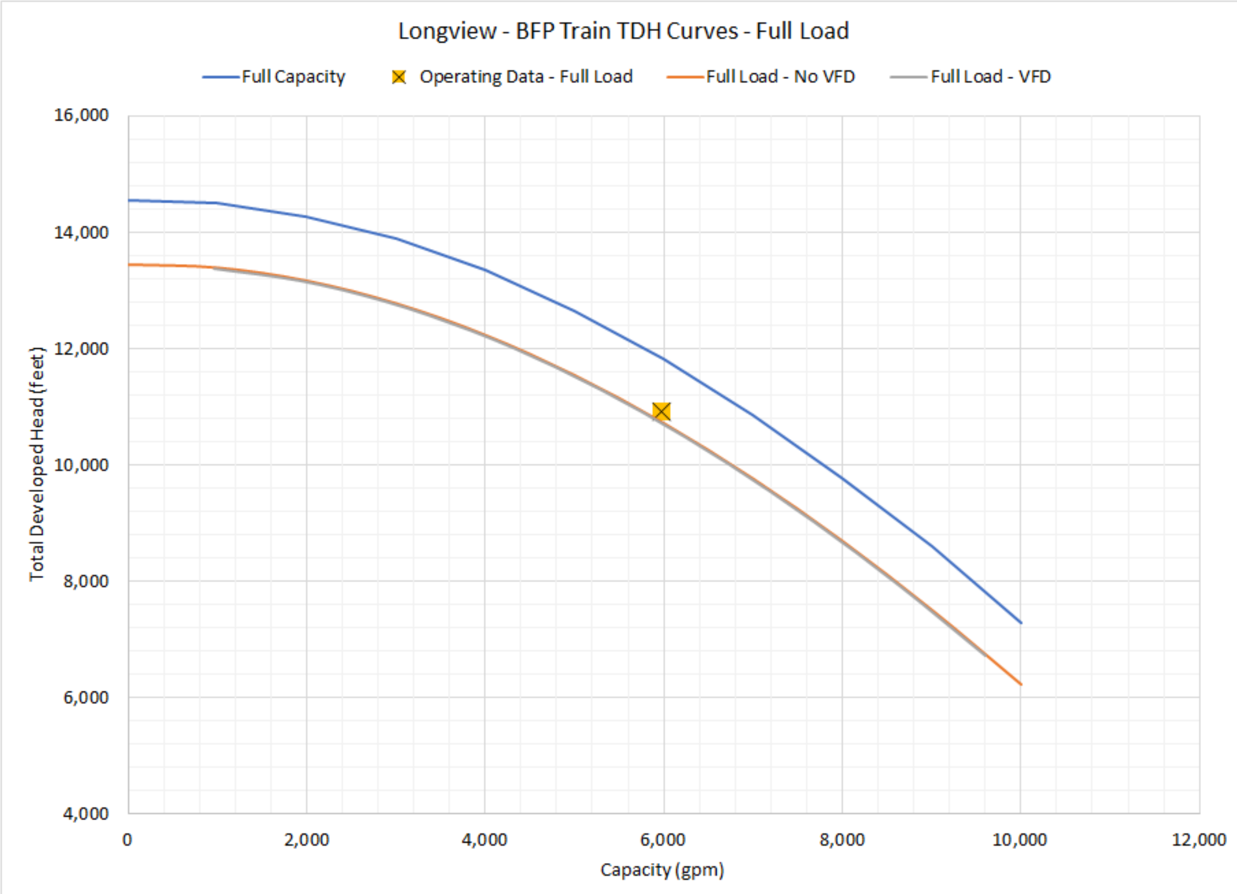

Figure 3-1 Boiler Feed Pump Train Curves - Full Load Variable Frequency Speed Comparison

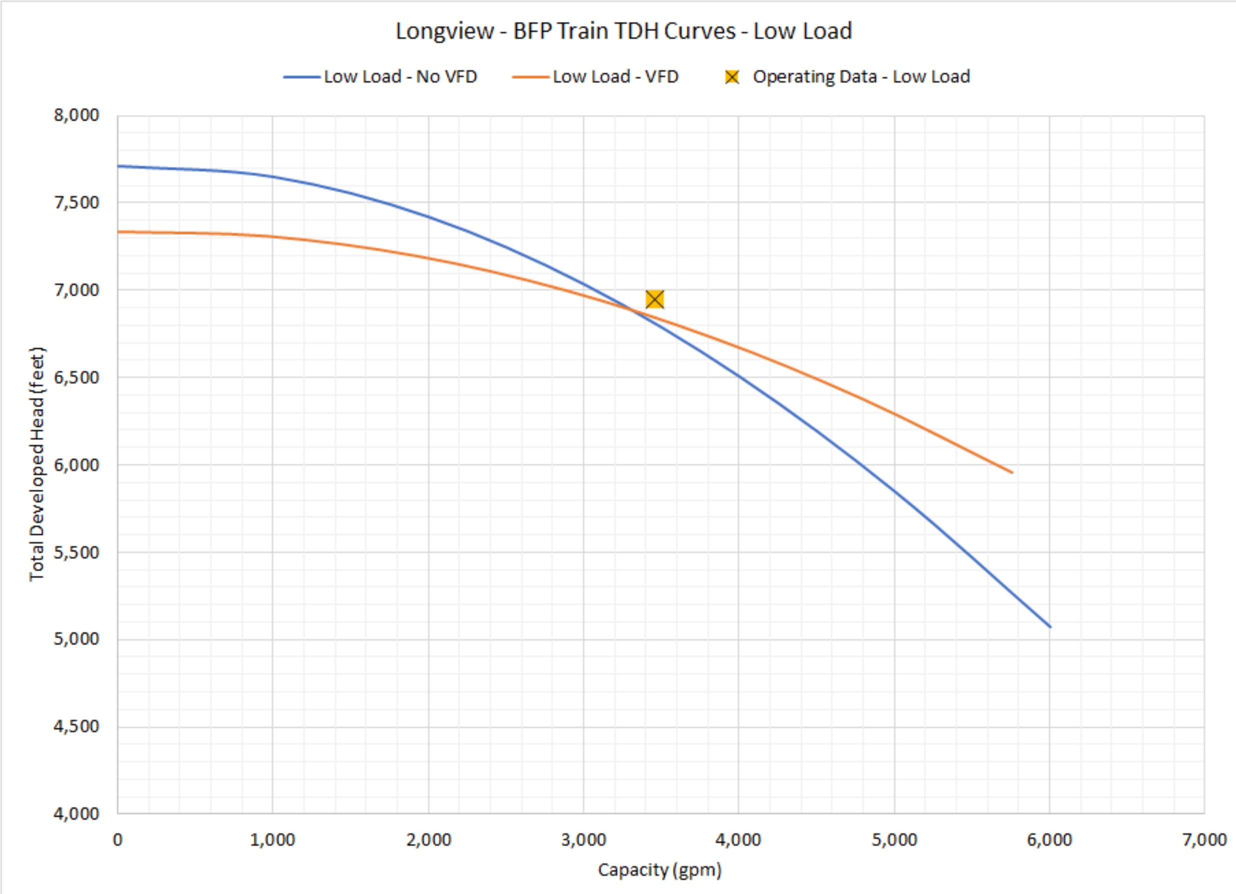

Figure 3-2 Boiler Feed Pump Train Curves - Low Load Variable Speed Comparison

Note as well that no analysis was conducted on the potential for utilizing the booster pump in any auxiliary manner to improve BFP utilization, as that was outside the scope of this study.

Overall, the estimated benefit from implementing VFD drives on the boiler feed pumps, compared to the estimated cost, indicates that from the standpoint of implementing the BSER for Longview this option does not have statistically significant merit. Therefore, this option is not recommended for compliance.

3.1.2 Large Draft Fans

Longview Unit 1 has forced and induced draft air fans that will be evaluated in this study. The forced draft and induced draft fans are currently axial-type with single speed motors and controlled by modulating blade position (variable blade pitch controls).

3.1.2.1 Forced Draft Fans

According to the available information and operating data the Longview Unit 1 forced draft (FD) fan, auxiliary power consumption would be estimated to decrease by 410 kW for two fans at full load (782 MW gross) and 220kW at low load (475 MW Gross). Refer to Figure 3-3 and Figure 3-