LG&E/KU – Ghent Station

Phase II Air Quality Control Study

Unit 2 Cooling Tower Impacts

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1.0 Introduction

The Ghent Station is located in Carroll County, approximately 9 miles northeast of Carrolton, Kentucky, on an approximately 1,670 acre site. Ghent Station includes four pulverized coal fired electric generating units with a gross total generating capacity of 2,107 MW. Ghent Station began commercial operations in 1973.

All four steam generators (boilers) at Ghent Station fire high sulfur bituminous coal. Two of the boilers are manufactured by Combustion Engineering and two by Foster Wheeler. The Combustion Engineering boilers are tangential-fired, balanced draft forced circulation boilers, and Foster Wheeler boilers are balanced draft natural circulation boilers. Unit 1 has a gross capacity of 541 MW and is equipped with low NO_x burners (LNBs) and selective catalytic reduction (SCR) for nitrogen oxide (NO_x) control; cold-side dry electrostatic precipitator (ESP) for particulate matter (PM) control; wet flue gas desulfurization (WFGD) for sulfur dioxide (SO_2) control, and lime injection system for sulfuric acid (H_2SO_4) and/or sulfur trioxide (SO_3) control. Unit 2 has a gross capacity of 517 MW and is equipped with LNBs and overfire air (OFA) for NO_x control; hot-side dry ESP for PM control; and WFGD system for SO_2 control, and lime injection system for H_2SO_4/SO_3 control. Units 3 and 4 have a gross capacity of 523 MW and 526 MW, respectively, and are equipped with LNBs, OFA, and low-dust SCR for NO_x control; hot-side dry ESP for PM control; wet FGD system for SO_2 control, and trona injection system for H_2SO_4/SO_3 control.

As part of the AQC upgrades, Pulse Jet Fabric Filters (PJFF) will be installed on each unit. Installation of the Unit 1 PJFF may impact the performance of the existing Unit 2 cooling tower. This document summarizes the investigation that was performed to determine the performance impact of the Unit 2 Cooling Tower.

2.0 Arrangement

This section describes the details of existing Unit 2 Cooling Tower arrangement and the proposed arrangement of the Unit 1 PJFF installation.

2.1 Unit 2 Cooling Tower

The Unit 2 Cooling Tower is a linear crossflow mechanical draft arrangement which was originally designed and furnished by Marley. Marley has been acquired and is now under the SPX family of companies. The tower was originally installed in 1975.

2.1.1 Tower Arrangement

The tower is a twelve (12) cell Marley Class 600 crossflow tower with splash type fill. The side of the tower is open from the base of the tower to the hot water basin with a sloping louver face. The tower is approximately 55'-5" wide at the base and approximately 72’-0” wide at the top of the hot water basin level. The tower has a fill height of approximately 36'-0”. Each cell is 40 feet wide and includes a 200 horsepower motor and fan. The fill, drift eliminators, louvers, water distribution system, and hot water deck were replaced by International Cooling Tower (ICT) in 2008.

The water distribution system includes dual distribution headers above the hot deck on each side of the tower for the first 6 cells then reduced to a single distribution header on each side of the tower for the remaining 6 cells. The distribution headers range in size from 48” to 24” in diameter.

2.1.2 Tower Performance

The original tower performance was based on the criteria indicated in Table 2-1.

Table 2-1
Ghent Unit 2 Cooling Tower Performance

Item	Value
Site Elevation	489’-0”
Wet Bulb Temperature	30^oF to 85^oF
Approach Temperature	5^oF to 25^oF
Heat Load Range	1,265 million BTU/Hr to 350 million BTU/Hr
Water through circuit	197,600 gpm
Water Inlet Temperature	115.6 F (Guarantee Point)
Water Outlet Temperature	90 F (Guarantee Point at WBT = 76.0^oF)
Air Flow	1,409,135 ft^3/min (Design)
Fan Blade Pitch	20.5^o (At Design Air Flow)
Motor Horsepower	180 (At Design Pitch)
Maximum Motor Horsepower	200 (With 22^o Fan Blade Pitch)

2.2 Unit 1 PJFF Arrangement

This section describes the proposed arrangement of the Unit 1 PJFF installation.

2.2.1 Unit 1 PJFF Arrangement

The proposed Unit 1 AQC arrangement is shown on Site Arrangement Drawing 168908-GCDS-1001.

The existing flue gas exhaust system downstream of the Unit 1 economizer outlet consists of an electrostatic precipitator (ESP), two parallel air heaters, an SCR, sorbent injection system, and two parallel ID fans, with ductwork downstream of the ID fans combined upstream of the inlet to the wet scrubber. Ductwork downstream of the ID fans is elevated and supported by exposed above-grade steel framing and individual concrete foundations.

The AQC technology addition proposed for Unit 1 consists of two 50 percent PJFFs, two 50 percent VFD booster fans, PAC injection system, and the associated ductwork and ancillary equipment required to tie this equipment into the exhaust gas air stream. The major equipment is proposed to be located immediately south of the southwest end of Unit 2 mechanical draft cooling tower, and west of the Unit 1 WFGD. The PJFF equipment will be located above, and straddle, the existing Unit 1 WFGD inlet duct. The new booster fans will be located below (west fan) or just south of (east fan) the existing inlet duct and new PJFFs adjacent to the existing Unit 2 ID fans. Refer to Site Arrangement 168908-GCDS-1001 for more information. This arrangement minimizes obstruction to cooling tower inlet air flow, but places the PJFFs above the outlet stacks of the cooling tower draft fans. This may create icing conditions on the PJFFs during certain weather events.

2.2.2 Unit 2 Cooling Tower Arrangement Impacts

With installation of the proposed Unit 1 PJFF, a portion of the two most western cells (Cell # 12 and #11) south side air inlets will be partially blocked. Figure 2-1 below shows the partially blocked west end of the cooling tower. The PJFF and associated ductwork is located approximately 16 to 20 feet from the south side of the cooling tower and extends across the face of cells #12 and #11.

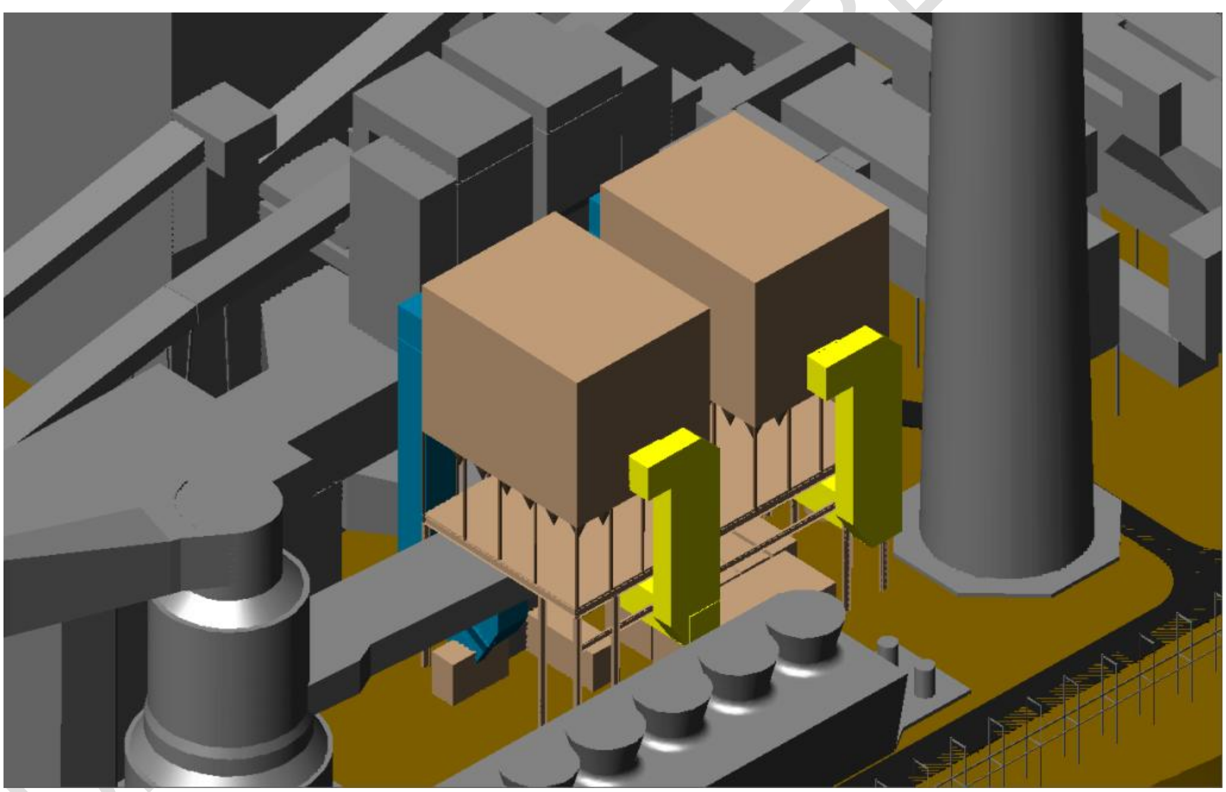

Figure 2-1
Ghent Unit 1 PJFF 3-D Model Screenshot

3.0 Performance Impacts

3.1 Performance Impacts Estimates

Three major cooling tower manufacturers (SPX, GEA, and Midwest Towers) were contacted to review the proposed installation and offer estimates of the potential performance impacts for the cooling tower. The following discussion summarizes the results of their review.

3.1.1 SPX (Marley)

SPX indicated that considering that the cooling tower has 12 cells and each cell has two air inlet openings, there are a total of 24 air inlet openings. If 2 of the 24 inlets were totally blocked it is estimated that would be equal to a reduction of approximately 8% of the total tower performance. After review of the proposed arrangement, SPX estimated that, based on their experience and judgment, the tower performance would be impacted in the range of 2% to 4%. They noted that the important fact is that the new equipment is close enough to the existing equipment that they believe there will be a performance impact. SPX estimated this performance impact as approximately 0.3^{o}F (2%) to 0.56^{o}F (4%) in cold water temperature. It is possible this small impact would not be significant to the plant but that is for LG&E/KU to determine. Optionally, to gain the performance or most of the performance back, they noted that the existing tower was originally designed and based on 180 bhp usage on each fan. The existing fans are equipped with 200 hp motors. If the fan blades are still pitched to utilize 180 bhp, the fan pitch can be increased to draw more air. SPX estimated an increase of 3% is possible if the fans are re-pitched. (200/180 to the 0.3 root).

SPX also indicated that if re-pitching the fan blades could not sufficiently recover the performance, another option would be to add a cell to the north end of the existing tower. For this size tower, they estimated an additional cell would cost approximately $550,000 on a furnished and erected basis. An additional $500,000 is estimated for basin construction, distribution header extensions and electrical/control requirements. The estimated cost of an additional cell would be approximately $1 to $1.1 million.

3.1.2 GEA

GEA reviewed the proposed installation and completed preliminary modeling. For thermal modeling purposes, three (3) cases were modeled in order to determine potential thermal impact and the severity of any performance impacts.

- Case 1: Assumes no obstruction. Tower performance was modeled as it exists today based upon the new fill configuration installed by ICT. Total fan efficiency = 75%.
- Case 2: Conservative: Assumes 100% obstruction/restriction on (1) one side across 14 of 216 total bays. Reduces effective bays for fan draw to 202. Calculated total fan efficiency = 70.125%.
- Case 3: Practical: Assumes 50% obstruction/restriction on one (1) side across 14 of 216 total bays. Reduces effective bays for fan draw to 209. Calculated total fan efficiency = 72.56%.

Modeled output is based on the design flow of 197,600 GPM, 25.6^{o}F Range, and 76.0 degree F inlet wet bulb temperature:

Case	Fan bhp Required	Total Fan Efficiency %	Approach Temp°F
1 – As is	191.0	75.00	15.0
2 - Conservative	200.8	70.13	15.28
3 - Practical	199.7	72.56	15.0

GEA summary comments:

- The original design approach of 14^{o}F indicated in the supplied data sheets appears to be overly optimistic. This is not uncommon for the Class 600 Marley towers that were built in the 1970's and 1980's. The modeled as-is approach temperature at the design temperature range with the new fill configuration is actually 15^{o}F at a calculated fan bhp of 191.0 per cell.
- The conservative Case 2 thermal model results in a 0.2^{o}F increase in the approach temperature. However this is based on assuming solid/complete blockage of air at the affected bay of the end cells. This will likely not be the case based on the sketch and description of the equipment to be installed.
- The practical Case 3 thermal model indicates the 15^{o}F approach is obtainable by simply re-pitching the fans in all cells to draw 199.7 bhp per cell. This can be accomplished at little cost. It is possible that the fans were already re-pitched very close to the 200 nominal HP when the fill modification was completed.

GEA did not indicate the addition of cooling tower cells as an option to regain performance.

3.1.3 Midwest Towers

Midwest Towers reviewed the proposed installation. They estimated the performance of the existing cooling tower may be impacted slightly, but since the new structures below the hot deck level were primarily open structural steel supports, they didn't think the impact would be significant. At the most, they estimated maybe a total of ½ cell would be blocked which normally would not cause a significant decrease in overall tower performance.

Midwest Towers also indicated if the performance of the tower was impacted significantly that another cell could be added to the existing tower. For this size tower, they estimated an additional cell would cost approximately $500,000 on a furnished and erected basis. They typically double this cost to account for basin extensions, and mechanical/electrical additions. The estimated cost of an additional cell would be approximately $1,000,000.

4.0 Summary and Conclusions

Based on the proposed installation of the Unit 1 PJFF, associated ductwork and support steel, as part of the AQC upgrades, it has been determined that there will most likely be a slightly negative impact on the Unit 2 cooling tower. The air flow into two cells of the tower will be partially blocked which will reduce the tower performance. The predicted performance impact has been estimated by cooling tower manufactures to be in the 2% to 4% (0.3^{o}F to 0.56^{o}F) impact on cold water temperature or a corresponding reduction in total fan efficiency.

The predicted reduction in the cooling tower performance may or may not be significant to the operation of Unit 2. Therefore, it has also been estimated that most or all of the estimated performance reduction could be recovered by re-pitching the fan blades and increasing air flow up to the limit of the existing 200 hp motors. This change can typically be accomplished by plant maintenance personnel and is typically relatively inexpensive. This option is what has been assumed for the basis of the project cost estimate.

If the performance impacts are more significant than estimated and re-pitching fan blades do not recover sufficient performance, then a cell could be added to the existing cooling tower. The estimated cost of adding another cell to regain performance is approximately $1,000,000.