

LG&E/KU – Ghent Station

Phase II Air Quality Control Study

Fly Ash and Landfill Waste Disposal

March 21, 2011

Revision B – Client Review

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DRAFT - CLIENT REVIEW

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 (SO₂) control, and lime injection system for sulfuric acid (H₂SO₄) and/or sulfur trioxide (SO₃) 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 SO₂ control, and lime and trona injection systems for H₂SO₄/SO₃ control. Units 3 and 4 have a gross capacity of 523 MW and 526 MW, respectively, and are equipped with LNBS, OFA, and SCR for NO_x control; hot-side dry ESP for PM control; WFGD system for SO₂ control, and trona injection system for H₂SO₄/SO₃ control.

The following Air Quality Control (AQC) technologies were evaluated to ensure that there is compliance with the emissions reductions that are required to meet future regulations:

- Pulse Jet Fabric Filter (PJFF) on Units 1-4.
- Selective Catalytic Reduction (SCR) on Unit 2.
- Sorbent (Trona/Lime) injection on Unit 2.
- Powdered activated carbon (PAC) injection on Units 1-4.

Based on the previously listed AQC technologies, the purpose of this study is to evaluate the physical and chemical composition of the fly ash material removed by the new PJFF on Units 1-4. This study will not discuss any potential impact of disposal of fly ash in the existing landfill. The potential impact analysis on the existing landfill is by others.

2.0 Composition of Fly Ash

Fly ash is one of the solid waste items produced directly from the combustion of coal. The burning of harder, older anthracite and bituminous coals produces fly ash which is pozzolanic in nature, and usually contains less than 10 percent lime (CaO). Fly ash with pozzolanic properties means that it reacts with calcium hydroxide in the presence of water to form compounds possessing cementitious properties at room temperature. Most of the fly ash produced from coal-fired power stations is captured in particulate removal equipment like PJFFs or ESPs and safely disposed off in landfills. This section describes the production and composition of the fly ash removed by PJFFs from Units 1-4.

Additionally, Units 1-4 would utilize a PAC injection system for control of mercury and sorbent injection system (lime or trona) for control of sulfuric acid mist upstream of the PJFF. The byproducts from the PAC and sorbent injection system would be collected in the PJFF and would be removed with the fly ash for disposal in a landfill.

2.1 Units 1, 3 and 4 Fly Ash

Currently Ghent Unit 1 has an existing cold side electrostatic precipitator (CS-ESP) and Units 3 and 4 have existing hot side electrostatic precipitator (HS-ESP) with the majority of the fly ash being removed by the existing ESPs. The existing sorbent injection system injects sorbent upstream and downstream of the existing ESPs. The byproducts from new PAC injection and existing sorbent injection as well as finer combustion particulate not collected in the ESP would be collected in new PJFFs for Units 1, 3 and 4. Due to significantly lower amounts of fly ash in the flue gas stream entering the new PJFFs on Units 1, 3 and 4, sorbent and PAC may blind the bags of new PJFFs which may cause increase in operational issues. Additionally, a high rate of pre-filtration would reduce the amount of nonflammable fly ash available to be mixed with the PAC injected upstream of and collected by the PJFF. The higher ratio of flammable PAC to nonflammable fly ash collected in the PJFF could present a potential fire hazard.

Due to the differing amounts of sorbent usage rates between lime and trona, tables have been created to show the differences. Tables 2-1, 2-2 and 2-3 provide the estimated quantity and composition of fly ash and byproducts removed from the PJFFs for Unit 1, Unit 2 and Unit 3 respectively when trona is used as a sorbent in addition to PAC injection. Tables 2-4, 2-5 and 2-6 provide the estimated quantity and composition of fly ash and byproducts removed from the PJFFs for Unit 1, Unit 2 and Unit 3 when lime is used as a sorbent in addition to PAC injection. For conservatism, it has been assumed that all of the sorbent will be collected by the PJFF system for Units 1, 3 and 4.

Table 2-1		
Unit 1 PJFF - Composition of Fly Ash and Byproduct for Trona Sorbent		
Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	69	1.09%
Unreacted Trona (Na ₂ CO ₃ .NaHCO ₃ .2H ₂ O)	2,895	45.56%
Na ₂ SO ₄	2,117	33.33%
Powdered Activated Carbon	<u>1,272</u>	<u>20.02%</u>
Total	6,353	100.00%

Table 2-2		
Unit 3 PJFF - Composition of Fly Ash and Byproduct for Trona Sorbent		
Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	186	2.84%
Unreacted Trona (Na ₂ CO ₃ .NaHCO ₃ .2H ₂ O)	2,895	44.13%
Na ₂ SO ₄	2,117	32.28%
Powdered Activated Carbon	<u>1,361</u>	<u>20.75%</u>
Total	6,559	100.00%

Table 2-3		
Unit 4 PJFF - Composition of Fly Ash and Byproduct for Trona Sorbent		
Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	78	1.22%
Unreacted Trona (Na ₂ CO ₃ .NaHCO ₃ .2H ₂ O)	2,895	45.31%
Na ₂ SO ₄	2,117	33.15%
Powdered Activated Carbon	<u>1,298</u>	<u>20.32%</u>
Total	6,388	100.00%

Table 2-4		
Unit 1 PJFF - Composition of Fly Ash and Byproduct for Lime Sorbent		
Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	69	0.87%
Unreacted Lime (CaO)	4,535	57.36%
CaSO ₄	2,029	25.67%
Powdered Activated Carbon	<u>1,272</u>	<u>16.09%</u>
Total	7,905	100.00%

Table 2-5		
Unit 3 PJFF - Composition of Fly Ash and Byproduct for Lime Sorbent		
Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	186	2.29%
Unreacted Lime (CaO)	4,535	55.91%
CaSO ₄	2,029	25.02%
Powdered Activated Carbon	<u>1,361</u>	<u>16.78%</u>
Total	8,111	100.00%

Table 2-6		
Unit 4 PJFF - Composition of Fly Ash and Byproduct for Lime Sorbent		
Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	78	0.98%
Unreacted Lime (CaO)	4,535	57.11%
CaSO ₄	2,029	25.56%
Powdered Activated Carbon	<u>1,298</u>	<u>16.35%</u>
Total	7,940	100.00%

2.2 Unit 2 Fly Ash

Currently Unit 2 has an existing HS-ESP and the majority of the fly ash is removed by the existing HS-ESP. The byproducts from PAC and sorbent (lime or trona) injection as well as finer combustion particulate not collected in the HS-ESP would be collected in new PJFF for Unit 2. Due to significantly lower amounts of fly ash in the flue gas stream entering the new PJFF on Units 2, sorbent and PAC may blind the bags of new PJFF which may cause increase in operational issues. Additionally, a high rate of pre-filtration would reduce the amount of nonflammable fly ash available to be mixed with the PAC injected upstream of and collected by the PJFF. The higher ratio of flammable PAC to nonflammable fly ash collected in the PJFF could present a potential fire hazard.

Due to the differing amounts of sorbent usage rates between lime and trona, tables have been created to show the differences. Furthermore, the fly ash quantities in these tables represent the fly ash that would be captured in the new PJFF assuming greater than 99% particulate capture efficiency in the HS-ESP. Tables 2-7 provide the estimated quantity and composition of fly ash and byproducts removed from the PJFF for Unit 2 when trona is used as a sorbent in addition to PAC injection. Tables 2-8 provide the estimated quantity and composition of fly ash and byproducts removed from the PJFF for Unit 2 when lime is used as a sorbent in addition to PAC injection. For conservatism, it has been assumed that all of the sorbent will be collected by the PJFF system for Units 1, 3 and 4.

Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	246	3.78%
Unreacted Trona (Na ₂ CO ₃ ·NaHCO ₃ ·2H ₂ O)	2,895	44.53%
Na ₂ SO ₄	2,117	32.57%
Powdered Activated Carbon	<u>1,242</u>	<u>19.11%</u>
Total	6,500	100.00%

Table 2-8		
Unit 2 PJFF - Composition of Fly Ash and Byproduct for Lime Sorbent		
Byproduct Composition	lb/hr	Percentage
Fly ash from coal combustion	246	3.06%
Unreacted Lime (CaO)	4,535	56.32%
CaSO ₄	2,029	25.20%
Powdered Activated Carbon	<u>1,242</u>	<u>15.42%</u>
Total	8,052	100.00%

One way to reduce the fire hazard concern and also reduce the potential of blinding PJFF bags is to de-energize some of the fields of existing ESPs for Units 1-4 to the point where some fly ash would be carried to the new PJFF to mix with the injected PAC. Hence it is recommended that some of the existing fields of the ESPs for Units 1-4 be de-energized to the point where approximately 75% of the fly ash would be removed by the existing ESPs. The remaining fly ash would be collected in the new PJFFs along with byproducts from PAC and sorbent injection. The fly ash would provide a more useful coating of particulate on the bags for filtration. However, the drawback to this philosophy would be that the existing ID fans would experience increased particulate loading which would likely decrease the expected operating life of the rotors and other ID fan related equipment. To alleviate this risk, ductwork would need to be rerouted to allow the existing ID fans to be downstream of the PJFFs or the existing ID fans would need to be bypassed. All draft fans would need to be placed downstream of the new PJFFs.

If the existing ESPs on Units 1, 3 and 4 are bypassed completely all the fly ash and byproduct which includes lime/trona and PAC would be captured in the new PJFFs for Units 1, 3 and 4. However, as previously discussed, the drawback to this philosophy would be that the existing ID fans would experience increased particulate loading. In this case, the existing ID fans would experience 100% of the particulate posing a significant risk to their longevity. To alleviate this risk, the same steps would need to be taken with the existing ID fans as previously discussed.

The proposed flue gas flow path of Ghent Unit 1 requires addition of a new PJFF with booster fans downstream. To eliminate ID fan wear concerns with Ghent Unit 1 and PJFF fire hazards it would be recommended that four new centrifugal ID fans be installed downstream of the new PJFF system and with the existing ID fans being abandoned.

However, the basis of the cost estimate will be to keep Units 1 ESP and ID fans fully operational and in service.

Ghent Unit 2 draft system layout is different from Unit 1 in that there is no SCR system and particulate control is accomplished with a hot-side ESP (HS-ESP) system. To allow for the partial or full deenergization of the HS-ESP system to eliminate PJFF fire hazards, the ductwork to the existing ID fans would be rerouted or the fans would be bypassed. The new SCR system would then be designed for a high-dust application. This, along with the use of existing or installation of new ID fans located downstream of the new Unit 2 PJFF system would avoid fire hazard concerns. Four new centrifugal ID fans could be used here as well, though the existing ID fans would have enough capacity with reduced margins to operate Unit 2 with new SCR and PJFF systems. However, the basis of the cost estimate will be to keep Units 2 HS-ESP and existing ID fans fully operational and in service.

The layout of the Ghent Units 3 and 4 draft system is similar to Unit 2 with the addition of SCR systems downstream of the HS-ESP systems. Again, fire hazards could exist in the new PJFF systems due to the HS-ESP systems pre-filtering ash. To alleviate this concern the HS-ESP systems would be bypassed or partially utilized to accommodate PAC and sorbent injection. However, the basis of the cost estimate will be to keep Units 3 and 4 HS-ESP fully operational and in service.

Based on conversation with Babcock Power Environmental Inc (BPEI), the SCR on Ghent Units 3 and 4 are designed as a high-dust SCR with adequate sonic horns/sootblowers in place. Hence, if the HS-ESP systems are completely bypassed or only partially utilized, the existing SCR design would be adequate to handle the higher dust conditions. As is currently the plan, four new centrifugal ID fans would be installed downstream of each new PJFF on Ghent Units 3 and 4 to replace the existing axial ID fans currently installed. Decreased life of the ID fans from limited use of or bypassed HS-ESP systems would not be a concern with Units 3 and 4.

3.0 Summary

The information provided in this study may be utilized by LG&E/KU in addressing the transport and final disposal of the byproducts. However, this study does not discuss any potential impact of disposal of fly ash on the existing landfill. Additional review regarding expansions of existing landfills may also be required to meet the stricter design requirements.

LG&E/KU has requested that the potential for sale of fly ash be reflected in the overall conceptual design. The captured PAC in the fly ash collected by the PJFF makes that ash unacceptable for most products where reused fly ash is incorporated. Only the ash captured by the ESP, upstream of PAC injection, can be expected to be suitable for beneficial reuse. Although it is outside the scope of this document, the conceptual design of the fly ash transfer systems includes separate handling systems for the “clean” and PAC-contaminated fly ash to ensure the potential of ash reuse where practical.

For fly ash containing activated carbon (used for mercury control at power plants), the physical and engineering performance of the material is expected to be similar to that of fly ash without activated carbon. However, it may have some potential handling issues, such as increased dusting. Therefore, the disposal requirements are expected to be the same as fly ash without activated carbon. A detailed landfill study may be required to address the potential impact of disposal of fly ash in existing or new landfill.