

LG&E/KU – Ghent Station

Phase II Air Quality Control Study

Operations and Maintenance Cost Estimate (Without SCR)

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1.0 Operations and Maintenance Cost Estimate

The levelized annual incremental Operations and Maintenance (O&M) cost estimates for the LG&E/KU Ghent Station Phase II Air Quality Control Study were derived from proprietary Black & Veatch O&M estimating tools and representative estimates for similar projects. Costs were based on vendor estimates and recommendations; estimated performance information; typical costs for materials, supplies, consumables and chemicals; and input from LG&E/KU for existing plant staffing and labor rates. Black & Veatch has summarized these costs into two primary categories: fixed costs and variable costs. Fixed costs, expressed as dollars per unit of net capacity per year (\$/kW-yr), do not vary directly with plant power generation and consist primarily of wages and wage-related overheads for the permanent plant staff and routine equipment maintenance. This is in contrast to the variable costs, expressed as dollars per unit of net generation (\$/MWh), which tend to vary in nearly direct proportion to the output of the unit. Variable O&M includes costs associated with ash disposal, chemicals, reagents, utilities, and other consumables.

An electricity cost due to increased plant auxiliary power was estimated by Black & Veatch with input from LG&E/KU for the cost per unit of generation in 2011. The cost of lost revenue due to increased auxiliary power requirements is not included in the fixed or variable O&M cost in Table 1-2, but is listed separately and added to the total variable costs for budgetary uses in Table 1-3.

Fuel costs are determined separately and not included in either fixed or variable O&M costs.

1.1 Fixed Costs

A major element in the estimate of incremental fixed O&M is the cost of wages for the additional labor to staff the facility. Increased staffing was estimated for the plant as a whole, not on an individual unit basis. It was estimated that the plant would require one additional operator per shift to support the additional Air Quality Control (AQC) equipment at the site. Ghent currently has four distinct operating crews which would result in a total of 4 additional operators. It was also estimated that the plant would need additional maintenance support at the site. The maintenance craft personnel would consist of a total of one mechanical maintenance person and one instrument and control (I&C) technician in order to ensure the reliability of the additional plant systems.

Table 1-1 shows the estimated incremental staffing plan and associated salaries. The salaries for each added position were based on an average rate of \$58.17/hour and 2,080 hours per year. It was understood that the rate of \$58.17/hour, provided by LG&E/KU, is a fully-loaded labor rate.

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Other incremental fixed O&M costs include routine maintenance for the additional AQC equipment on each unit. The routine maintenance costs for the ash handling systems for all four units were increased based on the added equipment and additional byproduct being captured. A Pulse Jet Fabric Filter (PJFF) is being added to each unit while keeping the existing Electrostatic Precipitators (ESP) in operation. It is expected that each unit will continue to have its own dedicated ash handling system and all fly ash collected will be considered waste and will be land filled. In addition, due to the location of the Unit 3 PJFF, a new ash handling system will be added to transfer ash from the PJFF directly to the common ash handling facility.

The incremental routine maintenance costs for the particulate control systems on each unit were determined by including maintenance expenses for the PJFF.

On Units 1 and 2, two new centrifugal booster fans with Variable Frequency Drives (VFD) are being added to the existing ID fans, resulting in additional maintenance cost. On units 3 and 4 four new centrifugal ID fans with VFDs are replacing the existing axial fans. Based on previous Black & Veatch studies, it is estimated that the maintenance cost for centrifugal fans, even with VFDs for flow control, are less than half the maintenance cost for axial fans. As a result it was estimated that the difference in annual maintenance cost for the four new centrifugal ID fans versus the two exiting axial fans would be negligible.

Additional maintenance costs were added to cover a new Powdered Activated Carbon (PAC) injection system on each of the four units and a new sorbent (lime or trona) injection system on Unit 2.

The estimate of annual fixed O&M costs in 2011 US \$/kW-yr is shown in Table 1-2.

1.2 Variable Costs

The major elements of the expected incremental variable costs include ash disposal, reagents, and other consumables. Ash disposal costs include the additional byproduct being generated due to added AQC equipment. It was assumed that all existing fly ash collected as well as the additional fly ash being generated and collected at the facility will be landfilled.

Reagents and other consumables costs are based upon unit price input from LG&E/KU to the extent available, selected vendors, and Black & Veatch's past project experience for the selected technology, given the expected fuel constituents and the respective emissions limits.

The estimate of annual variable O&M costs in 2011 US \$/MWh is included in Table 1-2. The total net generation (in MWh) is based on the estimated capacity factor provided and rated net capacity for each respective unit. Rated net capacity was

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calculated using the gross unit capacity and an average auxiliary power rate of 8.25 percent for each unit based on information provided by LG&E/KU.

Variable O&M costs are based on the following assumptions:

- Annual reagent and consumables usage and ash generation are based on full load unit operation and each unit's respective capacity factor
 - Unit 1: 81.00%
 - Unit 2: 71.00%
 - Unit 3: 78.00%
 - Unit 4: 77.00%
- Ash disposal cost is \$15/ton
- Limestone cost is \$8.22/ton
- Pulse jet fabric filter bag replacement cost is \$100/bag
- Pulse jet fabric filter cage replacement cost is \$50/cage
- Pulse jet fabric filter bags and cages are replaced every three years
- Halogenated PAC cost is \$1.10/lb
- Trona cost is \$200/ton
- Incremental water usage, water disposal, and water treatment costs are considered to be negligible

The incremental auxiliary power increase for each unit was estimated by Black & Veatch while the auxiliary power cost for each unit was provided by LG&E/KU. Incremental auxiliary power use and costs are listed in Appendix A.

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Table 1-1. Incremental O&M Staffing Plan and Labor Expenses

	Per Shift	Shifts	Total	Annual Base Wages ¹	Over Time %	Payroll	Burden %	Total Annual Expense
OPERATIONS								
Operator	1	4	4	\$120,994	0	\$483,974	0	\$483,974
						Operations Subtotal		\$483,974
MAINTENANCE								
Mechanic	1	1	2	\$120,994	0	\$120,994	0	\$120,994
I&E Technician	1	1	2	\$120,994	0	\$120,994	0	\$120,994
						Maintenance Subtotal		\$241,987
	Total Staff		8	Grand Total Annual Labor Expenses				\$725,962
Notes:								
1. Based on fully loaded labor rate.								

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Table 1-2. Annual Incremental Fixed and Variable O&M Costs

(all costs in \$1000)

	Unit 1	Unit 2	Unit 3	Unit 4	Total Plant
Labor¹					
Operations	\$121	\$121	\$121	\$121	\$484
Maintenance	\$60	\$60	\$60	\$60	\$242
Labor Subtotal	\$181	\$181	\$181	\$181	\$726
Maintenance					
Ash Handling System	\$66	\$83	\$93	\$64	\$306
Particulate Control System (PJFF)	\$53	\$51	\$52	\$52	\$208
ID/Booster Fans	\$47	\$47	\$0	\$0	\$94
PAC Injection System	\$13	\$13	\$13	\$13	\$52
Sorbent Injection System (Trona)	\$0	\$35	\$0	\$0	\$35
Maintenance Subtotal	\$179	\$229	\$158	\$129	\$695
FIXED COSTS	\$360	\$410	\$339	\$310	\$1,421
Ash Disposal	\$71	\$303	\$79	\$70	\$523
PJFF Bag & Cage Replacement	\$787	\$787	\$787	\$787	\$3,146
Mercury Control (PAC Injection)	\$9,928	\$8,497	\$10,229	\$9,631	\$38,286
SO ₃ Control (Sorbent Injection)	\$0	\$3,841	\$0	\$0	\$3,841
Neural Network Support	\$50	\$50	\$50	\$50	\$200
VARIABLE COSTS²	\$10,836	\$13,478	\$11,145	\$10,538	\$45,997
Net Capacity (MW)³	496	474	480	483	1,933
Net Generation (MWh)	3,522,025	2,950,252	3,278,736	3,255,267	13,006,280
Fixed Costs, \$/kW-yr	\$0.73	\$0.87	\$0.71	\$0.64	\$0.74
Variable Costs, \$/MWh	\$3.08	\$4.57	\$3.40	\$3.24	\$3.54

Notes:

1. Staffing and associated costs shown for total plant, but divided up equally among the four units.
2. Variable Costs in this table do not include Auxiliary Power Costs.
3. Calculated using rated gross capacity and average of 8.25% auxiliary power per unit.

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Table 1-3. Summary O&M Costs					
	Total Fixed Costs	Variable Costs	Auxiliary Power Costs	Total Variable Costs	Total O&M Costs
Unit 1					
PJFF ¹	\$347,500	\$858,000	\$1,122,798	\$1,980,798	\$2,328,298
PAC Injection	\$13,000	\$9,928,000	\$7,800	\$9,935,800	\$9,948,800
Neural Network	\$0	\$50,000	\$0	\$50,000	\$50,000
Unit 1 Subtotal	\$360,500	\$10,836,000	\$1,130,598	\$11,966,598	\$12,327,098
Unit 2					
PJFF ¹	\$362,500	\$1,090,000	\$1,310,540	\$2,400,540	\$2,763,040
PAC Injection	\$13,000	\$8,497,000	\$6,760	\$8,503,760	\$8,516,760
Sorbent injection	\$35,000	\$3,841,000	\$9,091	\$3,850,091	\$3,885,091
Neural Network	\$0	\$50,000	\$0	\$50,000	\$50,000
Unit 2 Subtotal	\$410,500	\$13,478,000	\$1,326,391	\$14,804,391	\$15,214,891
Unit 3					
PJFF ¹	\$326,500	\$866,000	\$1,090,995	\$1,956,995	\$2,283,495
PAC Injection	\$13,000	\$10,229,000	\$7,683	\$10,236,683	\$10,249,683
Neural Network	\$0	\$50,000	\$0	\$50,000	\$50,000
Unit 3 Subtotal	\$339,500	\$11,145,000	\$1,098,679	\$12,243,679	\$12,583,179
Unit 4					
PJFF ¹	\$297,500	\$857,000	\$952,061	\$1,809,061	\$2,106,561
PAC Injection	\$13,000	\$9,631,000	\$7,424	\$9,638,424	\$9,651,424
Neural Network	\$0	\$50,000	\$0	\$50,000	\$50,000
Unit 4 Subtotal	\$310,500	\$10,538,000	\$959,485	\$11,497,485	\$11,807,985
TOTAL	\$1,421,000			\$50,512,153	\$51,933,153
Notes:					
1. PJFF Total O&M includes labor costs, ash handling, fabric filter and miscellaneous auxiliary power costs for Units 1, 2, 3, and 4.					

Appendix A
Auxiliary Power Costs

The table below is a summary of the Ghent differential auxiliary power costs.

Ghent Differential Auxiliary Power Costs					
Units	Differential Aux	Capacity	Annual Diff.	Aux Power	Annual Aux
	Operating (kW)	Factor	Aux (MWh)	Cost (\$/MWh)	Power Cost
Unit 1	6,407	81%	45,460	\$24.87	\$1,130,598
Unit 2	8,673	71%	53,940	\$24.59	\$1,326,391
Unit 3	6,321	78%	43,187	\$25.44	\$1,098,679
Unit 4	5,713	77%	38,534	\$24.90	\$959,485
Total	27,113		181,121		\$4,515,153

Units	Differential Aux	Capacity	Annual Diff.	Aux Power	Annual Aux
	Operating (kW)	Factor	Aux (MWh)	Cost (\$/MWh)	Power Cost
PJFF	6,363	81%	45,147	\$24.87	\$1,122,798
PAC Injection	44	81%	314	\$24.87	\$7,800
Total Ghent 1	6,407				1,130,598
PJFF	8,569	71%	53,296	\$24.59	\$1,310,540
PAC Injection	44	71%	275	\$24.59	\$6,760
Sorbent Injection	59	71%	370	\$24.59	\$9,091
Total Ghent 2	8,673				1,326,391
PJFF	6,276	78%	42,885	\$25.44	\$1,090,995
PAC Injection	44	78%	302	\$25.44	\$7,683
Total Ghent 3	6,321				1,098,679
PJFF	5,669	77%	38,235	\$24.90	\$952,061
PAC Injection	44	77%	298	\$24.90	\$7,424
Total Ghent 4	5,713				959,485

Notes:

1 For all units PJFF includes loads from PJFF, draft fans, ash handling, enclosures, and miscellaneous.

The tables below are a detailed breakdown of the differential auxiliary power use for each Ghent unit.

Ghent Unit 1					
List of Items	Normal Quantity	Normal	Normal	Normal	Total
	Operating	Operating HP	Operating Time	Operating kW	Operating kW
ID FANS					
BOOSTER FANS	2.0	4000.0	24.0	3510.6	7,021
MISC BOOSTER FAN LOADS (lube oil pumps, heater, cooling fans, louvers)	2.0	15.0	24.0	12.0	24
CURRENT EXISTING ID FANS	2.0	-6600.0	24.0	-5792.5	-11,585
FUTURE EXISTING ID FANS	2.0	5400.0	24.0	4739.3	9,479
MISC ID FAN LOADS CANCEL OUT	2.0	0.0	24.0	0.0	0
ID FAN SUBTOTAL					4,939
PULSE JET FABRIC FILTER (PJFF)					
PJFF SUBTOTAL					660
POWDER ACTIVATED CARBON (PAC) INJECTION					
PAC INJECTION SUBTOTAL					44
ENCLOSURE LOADS					
ENCLOSURE LOADS SUBTOTAL					360
MISCELLANEOUS LOADS					
MISC LOADS SUBTOTAL					404
TOTAL					6,407

Notes:

Motor Efficiencies were assumed at 93% except for compressors and ID fan drivers including 1 VFDs which were assumed at 85%

Ghent Unit 2					
List of Items	Normal Quantity	Normal	Normal	Normal	Total
	Operating	Operating HP	Operating Time	Operating kW	Operating kW
ID FANS					
BOOSTER FANS (NOTE 2)	2.0	4000.0	24.0	3510.6	7,021
MISC BOOSTER FAN LOADS (lube oil pumps, heater, cooling fans)	2.0	15.0	24.0	12.0	24
CURRENT AND FUTURE EXISTING ID FAN LOADS CANCEL OUT	0.0	0.0	24.0	0.0	0
ID FAN SUBTOTAL					7,045
PULSE JET FABRIC FILTER (PJFF)					
PJFF SUBTOTAL					660
POWDER ACTIVATED CARBON (PAC) INJECTION					
PAC INJECTION SUBTOTAL					44
SORBENT INJECTION					
SORBENT INJECTION SUBTOTAL					59
ENCLOSURE LOADS					
ENCLOSURE LOADS SUBTOTAL					360
MISCELLANEOUS LOADS					
MISC LOADS SUBTOTAL					504
TOTAL					8,673

Notes:

1	Motor Efficiencies were assumed at 93% except for compressors and ID fan drivers including VFDs which were assumed at 85%
2	Booster fan horsepower is the same with or without an SCR.

Ghent Unit 3					
List of Items	Normal Quantity	Normal	Normal	Normal	Total
	Operating	Operating HP	Operating Time	Operating kW	Operating kW
BOOSTER FANS					
ID FANS	4.0	5600.0	24.0	4914.8	19,659
MISC ID FAN LOADS (lube oil pumps, heater, cooling fans)	4.0	20.0	24.0	16.0	64
CURRENT EXISTING ID FANS	2.0	-8800.0	24.0	-7723.3	-15,447
APPROX. MISC ID FAN LOADS	2.0	-20.0	24.0	-16.0	-32
BOOSTER FAN SUBTOTAL					4,245
PULSE JET FABRIC FILTER (PJFF)					
PJFF SUBTOTAL					1,087
POWDER ACTIVATED CARBON (PAC) INJECTION					
PAC INJECTION SUBTOTAL					44
ENCLOSURE LOADS					
ENCLOSURE LOADS SUBTOTAL					540
MISCELLANEOUS LOADS					
MISC LOADS SUBTOTAL					404
TOTAL					6,321

Notes:

1	Motor Efficiencies were assumed at 93% except for compressors and ID fan drivers including VFDs which were assumed at 85%
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Ghent Unit 4					
List of Items	Normal Quantity	Normal	Normal	Normal	Total
	Operating	Operating HP	Operating Time	Operating kW	Operating kW
BOOSTER FANS					
ID FANS	4.0	5600.0	24.0	4914.8	19,659
MISC ID FAN LOADS (lube oil pumps, heater, cooling fans)	4.0	20.0	24.0	16.0	64
CURRENT EXISTING ID FANS	2.0	-8800.0	24.0	-7723.3	-15,447
APPROX. MISC ID FAN LOADS	2.0	-20.0	24.0	-16.0	-32
BOOSTER FAN SUBTOTAL					4,245
PULSE JET FABRIC FILTER (PJFF)					
PJFF SUBTOTAL					660
POWDER ACTIVATED CARBON (PAC) INJECTION					
PAC INJECTION SUBTOTAL					44
ENCLOSURE LOADS					
ENCLOSURE LOADS SUBTOTAL					360
MISCELLANEOUS LOADS					
MISC LOADS SUBTOTAL					404
TOTAL					5,713

Notes:

	Motor Efficiencies were assumed at 93% except for compressors and ID fan drivers including 1 VFDs which were assumed at 85%
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