LG&E/KU – Ghent Station

Phase II Air Quality Control Study

Project Design Memorandum

December 16 , 2010
Revision C – Issued For Project Use

B&V File Number 22.1000

Black & Veatch Corporation ▪ 11401 Lamar ▪ Overland Park, KS 66211
Tel: (913) 458-2000
www.bv.com

Table of Contents

Appendices

Tables

Figures

1.0 Project Description

1.1 Introduction

1.1.1 Purpose

This site-specific Project Design Memorandum document defines the technical and functional requirements on which the Ghent Phase II Air Quality Control Study will be based. The stated functional and technical requirements include LG&E/KU requirements and are applicable to the Ghent portion of the overall project. Separate PDMs will be developed for other stations included in the overall project.

1.1.2 Organization of the Document

This Project Design Memorandum document is organized into various sections covering scope of work, environmental, and engineering criteria and requirements. Additional sections may be added during other phases of the project.

1.1.3 Revisions

The Project Design Memorandum document is dynamic in nature. Black & Veatch (B&V) controls this document and is thus responsible for updates and revisions. It is anticipated that this document will be periodically updated and potentially expanded during the life of the project as additional data and specific design criteria become available.

1.2 Overview

The purpose of this Phase II air quality control study is to build upon the previous fleet-wide, high-level air quality technology review and cost assessment conducted for six LG&E/KU facilities (Phase I) in order to develop a facility-specific project definition consisting of a conceptual design and a budgetary cost estimate for selected air quality control technologies (Phase II) for three different facilities, including Ghent. Similar studies will be performed for the Mill Creek and E.W. Brown facilities. Each facility will have a specific project design memorandum.

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) 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. 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.

Gypsum, a scrubber by-product, produced at Ghent is either stored in the on-site landfill or sold for use in manufacture of wall board for the home construction industry. Fly ash and bottom ash is sluiced to on-site storage ponds. Black & Veatch is also involved in a separate study for the transportation of coal combustion products. Layouts developed for the alternative transport systems will be taken into account during the Phase II Air Quality Control Study. All four units are cooled using mechanical draft cooling towers.

The following is a summary of basic project information.

• Project Name:	Phase II Air Quality Control Study – Ghent
• Client/Owner:	LG&E/KU
• Operator:	Kentucky Utilities (KU)
• Engineer & Regulatory Consultant	Black & Veatch Corporation (B&V)
• Project Site Location:	Ghent, Kentucky (refer to Figure 1-1 and Figure 1-2)
• Project Type/Size:	Retrofit of Environmental/Air Quality Control equipment for existing units.
• On-Site Work:	Start Construction – [LATER]
• Target In Service Date:	2013 to 2017
• Fuel	High Sulfur Western Kentucky Bituminous Coal from Illinois Basin, Fuel Oil for startup
• Water Source:	Well Water, City Water, Ohio River Water

North

South

Figure 1-1
Ghent Power Plant Site

North

South

Figure 1-2
Ghent and Surrounding Area Map

Existing Facilities:

• Existing On Site Generation Units:	• Unit 1 - 541 gross MW (in-service date 1973) • Unit 2 - 517 gross MW (in-service date 1977) • Unit 3 - 523 gross MW (in-service date 1981) • Unit 4 - 526 gross MW (in-service date 1984)
• Existing Air Quality Control Equipment:	• Unit 1 - Low NO_x Burners (LNBs), Selective Catalytic Reduction (SCR), Cold-side Dry Electrostatic Precipitator (ESP), Wet Flue Gas Desulfurization (WFGD), Lime Injection System • Unit 2 - LNBs, Overfire Air System (OFA), Hot-side Dry ESP, WFGD • Unit 3 - LNBs, OFA, Low -dust SCR, Hot-side Dry ESP, WFGD, Trona Injection System • Unit 4 - LNBs, OFA, Low -dust SCR, Hot-side Dry ESP, WFGD, Trona Injection System
• Site Access:	Site is located in Carroll County, Ghent, Kentucky, on the southeast side of the Ohio River, approximately 9 miles northeast of Carrolton, KY and 35 miles southwest of Cincinnati, OH with access off of Hwy 42.

1.3 Scope of Work

A summary of the current scope of work is provided below. Refer to Appendix A for the complete scope of work. Project scope items provided by others, but requiring technical interface, are also listed below.

- Project Kick-off Meeting & Site Visit
- Environmental Regulatory Considerations
- Develop Project Instruction Memorandum
- Project Management
- Develop Project Design Memorandum

- AQC Technology Validation and Selection
- Develop Preliminary Conceptual Design
- Project Cost Estimate
- Implementation Schedule
- Constructability Plan
- Evaluation Report

Project Elements being provided by others:

- Permitting – LG&E/KU Environmental Affairs Department
- Coal Combustion Products Transport Project study – Black & Veatch under separate assignment

1.4 Governing Building Code

The governing local building code is the Kentucky Building Code, Ninth Edition (2006 International Building Code (IBC), as specifically amended).

1.5 Design and Performance

This section summarizes major plant and scope of work interfaces. When fuel or utilities are considered, the following defined properties shall be used as the design basis.

1.5.1 Unit Performance

Plant design is based on the criteria listed in Table 1-1.

Table 1-1
Performance Design Basis

Parameter	Basis Value
Ambient Temperature	75 °F Dry Bulb
Ambient Pressure	29.09 in Hg
Ambient Humidity	60.0 % Relative Humidity
Fuel Analysis	Refer to Subsection 1.5.2

1.5.2 Fuel Specifications

All four Ghent units burn high sulfur, western Kentucky, bituminous coal from the Illinois Basin. Refer to Appendix B, Design Basis, for main fuel specifications.

Startup fuel is fuel oil.

1.5.3 Water

1.5.3.1 Quality Requirements. Water quality characteristics for water to be used as the source for the AQC systems are listed in Table 1-2.

Table 1-2
Design Basis Water Analysis

Constituent	Well Water	City Water	Ohio River Water
	mg/L as such	mg/L as such	mg/L as such
Calcium	152	115	48
Magnesium	27.4	35.1	18
Sodium	28	11.8	23
Potassium	Unavailable	3.44	Unavailable
Total Cations, mg/L as $CaCO_3$	Unavailable	Unavailable	Unavailable
M-alkalinity, mg/L as $CaCO_3$	232	355	108
Sulfate	480	48.9	105
Chloride	59	14.7	48
Nitrate	Unavailable	42.5	Unavailable
Silica	10	Unavailable	10
Total Anions, mg/L as $CaCO_3$	Unavailable	Unavailable	Unavailable
pH (range)	7.4 – 8.2	7.14	7.5 – 8.6
Specific Conductance, µS/cm	1040	796	576
Temperature (range), ºF	60 – 65	Unavailable	50 – 88
Total Suspended Solids	19	Less than MDL	30*
Total Dissolved Solids	566	496	434
Turbidity, NTU	Unavailable	Unavailable	Unavailable

Table 1-2 (continued)

Design Basis Water Analysis			
Constituent	**Well Water**	**City Water**	**Ohio River Water**
	mg/L as such	mg/L as such	mg/L as such
Color, PCU	Unavailable	Unavailable	Unavailable
Total Phosphate, mg/l as PO_4	0.5	0.206	0.5
Aluminum	Unavailable	0.119	Unavailable
Barium	Unavailable	0.049	Unavailable
Boron	Unavailable	Unavailable	Unavailable
Cadmium	Unavailable	ND @ 0.001	Unavailable
Chromium	Unavailable	ND @ 0.001	Unavailable
Copper	Unavailable	0.002	Unavailable
Iron	0.85	ND @ 0.005	2.0
Manganese	0.07	0.024	0.1
Nickel	Unavailable	0.004	Unavailable
Strontium	Unavailable	Unavailable	Unavailable
Zinc	Less than 0.01	0.014	0.01
Notes: *River suspended solids can vary drastically during times of high rain occurrences in the watershed			

1.5.4 Emissions

Plant design is based on the primary target emissions criteria defined in Table 1-3.

Table 1-3
Primary Design Emission Targets

Pollutant	Unit 1	Unit 2	Unit 3	Unit 4
NO_x	N/A[b]	0.041 lb/MBtu	N/A[b]	N/A[b]
SO_2	N/A[b]	N/A[b]	N/A[b]	N/A[b]
Sulfuric Acid Mist (SAM)	2-10 ppm[a] TBD	2-10 ppm[a] TBD	2-10 ppm[a] TBD	2-10 ppm[a] TBD
Mercury (Hg)	90% control or 0.012 lb/GWh	90% control or 0.012 lb/GWh	90% control or 0.012 lb/GWh	90% control or 0.012 lb/GWh
HCl	0.002 lb/MBtu	0.002 lb/MBtu	0.002 lb/MBtu	0.002 lb/MBtu
Particulate Matter[d],[e]	0.03[c] lb/MBtu	0.03[c] lb/MBtu	0.03[c] lb/MBtu	0.03[c] lb/MBtu
Arsenic (As)[f]	0.5×10^{-5} lb/MBtu	0.5×10^{-5} lb/MBtu	0.5×10^{-5} lb/MBtu	0.5×10^{-5} lb/MBtu
CO	0.10 lb/MBtu	0.10 lb/MBtu	0.10 lb/MBtu	0.10 lb/MBtu
Dioxin/Furan	15×10^{-18} lb/MBtu	15×10^{-18} lb/MBtu	15×10^{-18} lb/MBtu	15×10^{-18} lb/MBtu

Data from LG&E/KU Ghent Station kickoff meeting October 6, 2010 (Gary Revlett handouts and meeting notes) unless noted otherwise.
[a] Units provided in ppmvd at 3% O_2 as indicated in the draft H_2SO_4 BACT analysis dated September 30, 2010.
[b] Not applicable for this Phase II study.
[c] Emission rate target is higher than what can typically be achieved with chosen technology; a lower emission target may be possible.
[d] Particulate matter control limits for $PM_{2.5}$ or $PM_{condensable}$ have not been determined for this project.
[e] Particulate matter assumed to be the surrogate for emissions of certain non-mercury metallic HAP (i.e., antimony (Sb), beryllium (Be), cadmium (Cd), cobalt (Co), lead (Pb), manganese (Mn), and nickel (Ni)).
[f] Arsenic assumed to be the surrogate for non-mercury metallic HAP (i.e., arsenic (As), chromium (Cr), and selenium (Se)).

1.5.5 Bulk Material

The following bulk materials may be associated with this project:

- Limestone is currently being used as a reagent in the WFGD systems.
- Lime and trona are already used on site to support SO_3 control and there use or that of another reagent would be continued.
- Powder Activated Carbon (PAC) will be used for Hg control
- Fly ash will be collected dry from the precipitator and fabric filter.

1.5.5.1 Pebble Lime Handling and Storage. Refer to Table 1-4 for the pebble lime properties.

Table 1-4
Pebble Lime Properties

Proximate Analysis, Dry Basis, Percent (%) by Weight	Nominal	Range
Available Calcium Oxide (CaO) Content	90.00	90% minimum
Magnesium Oxide (MgO) Content	0.00	0 – 5%
Inert	10.00	5 – 10%
Total	100.00	--
Bulk Density Design Basis		
Volumentric Sizing	55	pcf
Structural Loading	110	pcf
Angle of Repose	30	degree
Surcharge Angle	25	degree
Maximum lump size	3/4	inch

1.5.5.2 Powdered Lime Handling and Storage. Refer to Table 1-5 for the powdered lime properties.

Table 1-5
Powdered Lime Properties

Bulk Density Design Basis		
Volumentric Sizing	60	pcf
Structural Loading	85	pcf

1.5.5.3 Powdered Activated Carbon (PAC) Handling and Storage. Refer to Table 1-6 for the powdered activated carbon properties.

Table 1-6
Powdered Activated Carbon Properties

Bulk Density Design Basis		
Volumentric Sizing	15	pcf
Structural Loading	35	pcf

1.5.5.4 Fly Ash from Precipitator/Fabric Filter Handling and Storage.

Refer to Table 1-7 for the fly ash properties.

Table 1-7
Fly Ash Properties

Bulk Density Design Basis		
Volumentric Sizing	65	pcf
Structural Loading	90	pcf

1.5.6 Classification of Hazardous Areas

Electrical equipment, materials, raceway and wiring will be selected, designed, and installed in accordance with NFPA-70 [NEC].

1.5.7 Future Expansion Considerations

The arrangement of the facility will be based on the configuration of the existing units. No additional units or future expansion is planned. Equipment layouts of the air quality control options must leave room for the modification or addition of gypsum fines and dry ash conversion equipment as identified in the recently completed Black & Veatch Conceptual Engineering for Coal Combustion Products Transport Project dated April 23, 2010.

1.6 Permits and Licenses

1.6.1 Permits

The Environmental Affairs Department of LG&E/KU is responsible for identifying and obtaining the necessary Federal, State and Local permits required to construct and operate the facility and associated equipment. B&V is contracted to coordinate with the environmental counterpart at LG&E/KU, and provide guidance relevant to regulatory scenario planning to ensure project conceptual design is compliant with applicable federal, state, and local statutes and regulations.

1.7 Site Investigations

1.7.1 Surveys and Topography

The general area of the Ghent site under consideration for siting the AQC equipment has been developed as part of the existing plant installation and additional improvements. General site arrangement drawings covering the existing site were developed previously and are available for use in this study. However, several subsequent improvements have been completed in the area and the data on some of the older drawings may not be up to date. The existing drawings are sufficient for purposes of this study with regard to available space and topography, but a full survey of the as-built conditions is recommended before start of detailed design to ensure the latest information is used.

1.7.1.1 Underground Utilities. Relatively extensive existing underground utilities are located in the general area under consideration for the AQC improvements. The expected locations of underground utilities are documented on existing drawings, but again the degree of completeness and accuracy may be suspect. The existing drawings are adequate for purposes of the AQC study, but a survey of existing underground utilities should be completed prior to detailed design.

1.7.2 Geology and Seismology

Significant large modifications have previously been completed at the site since original construction, resulting in several detailed geotechnical investigations at various locations on the site. Specifically, the following four investigations were completed and reviewed for applicability to the study.

- Report of Geotechnical Exploration, Unit 1 SCR Addition, KU Ghent Generating Station; MACTEC, Inc.; August 9, 2002
- Report of Geotechnical Exploration, Unit 1 Stack and FGD Additions, KU Ghent Generating Station; MACTEC, Inc.; January 18, 2007
- Report of Geotechnical Exploration, Unit 3 FGD Absorber Addition, Ghent Generating Station; MACTEC, Inc.; September 14, 2005
- Report of Geotechnical Exploration, Unit 4 FGD and Exhaust Stack Additions, KU Ghent Generating Station; MACTEC, Inc.; March 27, 2006

The areas investigated in the above three explorations include the general areas under consideration in the study. Moreover, the general geotechnical data and results of the investigation as documented in the three documents are relatively consistent, leading to the assumption that the information is applicable to all new construction across the four units to be considered as part of this study.

In general, the existing documentation noted indicated the following subsurface conditions.

- During original construction portions of the area received significant amount of fill material varying from soft silty clay to sand and gravely sand. Fill depth varied from 0 to 12 feet in depth.
- Below the fill, a natural firm to very dense noncohesive (sand and gravely sand) stratum exists to an approximate depth of 40 to 60 feet.
- Below the first stratum of natural material, the natural soil consists of very firm to very dense noncohesive materials (sands, gravely sand, and gravels) to the depth investigated (approximately 100 feet).
- Groundwater elevation was relatively constant as documented in each investigation at approximately 55 to 60 feet below grade.

The investigations noted that the existence of significant underground foundations and utilities made soil-supported shallow foundations difficult to install without impacting existing facilities. For that reason, and due to small areas of softer fill near the surface, all investigations recommended auger-cast pile deep foundations for new structures carrying significant load. For purposes of the study, foundations for structures with significant concentrated loads, tensile loads, and significant overturning and lateral loads will be assumed as founded on reinforced-throughout concrete augered cast-in-place (ACIP) friction piles. High capacity piles will be assumed as 18 inches in diameter by 50 feet long with a 150 ton capacity in compression. Lower capacity piles, such as those required for piperacks and other more lightly loaded structures, will be assumed as 18 inch by 40 feet ACIP piles with a 100 ton capacity. Due to the expected significant congestion, both overhead and below grade, the ACIP piles assumed will be of the low overhead installation type.

Light structures not subject to significant overturning can be assumed to be supported on shallow footing or raft foundations extending below the frost line where conditions allow their installation. Shallow foundations extending to at least 3 feet below the surface will be designed based on an allowable bearing pressure of 4.0 thousand pounds per square foot (ksf). Excavations are not expected to be either large or deep enough to warrant special consideration to prevent groundwater intrusion during construction, noting the low groundwater level expected.

The above assumptions will form the basis of the conceptual design of foundations for the AQC structures in the study. However, prior to start of detailed design, additional geotechnical investigation should be completed to more exactly determine the geotechnical design parameters in the immediate area of the proposed improvements.

1.7.3 Hydrology

The site in the area of the AQC improvements is fully developed. Hydrology and storm event design have previously been established and will not be modified unless required. The addition of runoff volume due to any increase in impermeable surfaces resulting form the AQC modifications, although expected to be minimal, will be evaluated and the impact to existing stormwater systems estimated as a part of the study. Modifications to existing stormwater systems, if any, deemed necessary by the improvements proposed by the study will be recommended. Due to the congestion above and below grade in the areas where new foundations are expected, some rerouting of existing storm sewers piping is likely, but the overall function of the existing systems is expected to remain for the most part unchanged.

1.7.4 Noise

The project's conceptual engineering for noise control will be based on compliance with OSHA requirements and local noise restrictions, as applicable.

1.8 Environmental Design Criteria

1.8.1 Meteorology

Table 1-8 summarizes the meteorological data applicable to plant design. Wind data for the indicated location have been analyzed to develop the wind roses which are included in Appendix C.

Table 1-8 Meteorological (Ambient and Extreme) Data		
Design Parameter	**Design Value**	**Units**
Rainfall – 24 Hour, 10 Year Event (Design rainfall parameter may vary depending on local codes or agencies.)	4.13(A)	inches
Rainfall – 24 Hour, 25 Year Event (Design rainfall parameter may vary depending on local codes or agencies.)	4.81(A)	inches
Rainfall – Average Annual Total	42.60(B)	inches
Design Rain Rate (100 year recurrence)	3.0(C)	inches per hour
Evaporation Rate – Annual Average NWS Penman Equation	49.34*(D)	inches
Design Wind Speed (Chapter 6)	90**(C)	mph
Structural Occupancy Category for Wind (Table 1-1)	III(E)	
Wind Importance Factor, I_w (Table 6-1)	1.15(E)	
Wind Design Exposure (Chapter 6)	Category C(E)	N/A
Average Wind Speed	8.3***(F)	mph
Prevailing Wind Direction (from)	South-southwest*** (G)	
Frost Depth (50 Year Recurrence)	38(C)	Inches
Snow Load – Ground, p_g	20(I)	lb/ft^2
Snow Importance Factor, I_s (Table 7-4) Refer to Table 1-1	1.1(E)	
Open Structure Icing Design Conditions	0.75 inches ice thickness with 30 mph concurrent wind speed(I)	
Freeze Protection Design Conditions	-29.6°F (H) DB with 8.3*** (F) mph coincident wind	
Annual Barometric Pressure, adjusted to site elevation	29.09(C)	in. Hg
Design Ambient Temp (Extreme High)	104.0 DB(H)	°F
Design Ambient Temp (Extreme Low)	-29.6 DB(H)	°F
Design Annual Average Ambient Temp	54.2(B)	°F
Winter Design (Dec-Feb) Ave Temp	32.8(B)	°F
Summer Design (Jun-Aug) Ave Temp	74.3(B)	°F
Space Conditioning Ambient Design Temps (ASHRAE Fundamentals, 1.0%)	88.9 DB(H) 73.8 MCWB(H)	°F °F
Space Conditioning Ambient Design Temps (ASHRAE Fundamentals, 2.0%)	86.5 DB(H) 72.5 MCWB(H)	°F °F
Space Conditioning Ambient Design Temps (ASHRAE Fundamentals, 99.0%)	10.2 DB(H) 9.0 MCWB(C)	°F °F

Notes: Design conditions based on ASHRAE 2009 data for: Cincinnati, OH Approximate Location (Google Earth): Latitude: 39.04N Longitude: 84.67W Elevation: 867 ft MSL * Dayton Weather Service Office Substituted for Cincinnati. **3-second gust at 33 ft. above ground ***Wind data is for Louisville, KY. References: [A]National Weather Service - Hydrometeorological Design Studies Center. [B]National Climatic Data Center (NCDC) Climate 20-Climate Normals; Cincinnati, OH. [C]Engineering Weather CD, "Summary for Cincinnati, OH 1973-1996," Engineering Weather Data, 2000 Interactive Edition, 2001, Version 1.0, [CD]. [D]Technical Memorandum No. 34 from NWS, 1982. Dayton, OH Weather Service Office Substituted for Cincinnati. [E]ASCE 7-05. [F]NCDC United States Average Wind Speeds for US cities; Louisville, KY. Based upon 55 years of data, through 2002. [G]Wind roses from Integrated Surface Hourly Data (ISH) 1995-2008 data for Louisville, KY. [H]National Climatic Data Center (NCDC), "2009 ASHRAE Handbook Annual Summary with Comparative Data for Cincinnati, OH." [I]Kentucky Building Code, Ninth Edition

1.8.2 Site Seismicity

Table 1-9 summarizes Seismicity parameters applicable to plant design. Table references are to ASCE 7 as referenced by the Kentucky Building Code.

Table 1-9
Seismicity Data

Design Parameter	Value
Building Code	Kentucky Building Code (IBC 2006 as specifically amended)
Building Use/Occupancy Category (main plant structures)	III
Seismic Importance Factors	1.25
Site Class (based on the existing geotechnical investigations listed in Section 1.7.2)	D
Spectral Response Accelerations: 0.2 second response (S_s) 1.0 second response (S_1)	 Ss = 0.204 S1 = 0.089
Adjusted maximum considered earthquake response acceleration parameters: F_a (site coefficient from Table 11.4-1) F_v (site coefficient from Table 11.4-2)	 Fa = 1.6 Fv = 2.4
Maximum considered spectral response accelerations: S_{MS} (short periods; Fa * Ss) S_{M1} (1-second period; Fv * S_1)	 SMS = 0.326 SM1 = 0.214
Design spectral response acceleration parameters: S_{DS} = 2/3 (SMS) S_{D1} = 2/3 (SM1)	 SDS = 0.218 SD1 = 0.142
Seismic Design Category (SDC) (from Table 11.6-2)	C

1.8.3 Site Elevation

Site Elevation: Existing at-grade floor of plant is 489 feet above Mean Sea Level (MSL).

1.8.4 Soil Resistivity

Minimal existing electrical soil resistivity information was available from the various geotechnical investigations previously noted (none was documented in the geotechnical investigations listed in Section 1.7.2). Resistivity data in the Unit 4 area was documented in another source at approximately 5,200 ohm-cm with probes at 5 foot spacing and 7,600 ohm-cm for a 10 foot spacing. For purposes of this study, these values will be assumed as representative and will be utilized to estimate material requirements The electrical soil resistivity profile used for future grounding design will need to be determined from additional geotechnical investigations to be completed prior to detailed design.

The previous geotechnical investigations did address thermal resistivity in the soils at the site. The investigations recommended using a thermal resistivity value ranging from 70 to 80 ^{o}C-cm/watt throughout the area under consideration.

1.9 Electrical Data

The electrical power system conceptual configuration shall be based on the project's one-line diagram which will be provided separately. Table 1-10 includes electrical parameters to be considered in the plant configuration.

Table 1-11 lists prevailing voltages and frequencies to be considered in the plant configuration.

Table 1-10
Electrical Design Data

Design Parameter	Maximum	Units
Available system fault current at electrical system interface point.		
• 345 KV System (Bus 2010)	33,567	Amps
• 25 KV System (Bus 2295 165 TRA)	18,412	Amps
• 25 KV System (Bus 2292 165 TRB)	18,590	Amps
• 18 KV System (GH1)	195,000	Amps
• 22 KV System (GH2)	205,700	Amps
• 22 KV System (GH3)	226,749	Amps
• 22 KV System (GH4)	238,900	Amps

Table 1-11
Electrical Equipment and System Voltages
(New AQC Auxiliary Electrical System Design Basis)

Power Supply Code	**Continuous Voltage (Volts)** Nom Max Min	**Momentary Voltage Dip** % of Nominal	**Frequency (Hz)** Nom Max Min	**Configuration**	**System Neutral Grounding** Type	**Transfer to Alternate Source** Method	**Max Sym Short-Circuit at Max Voltage (Amps)** 3-Phase Phase –Ground
MV-1 Medium Voltage (>5,000 hp)	13,800 14,500 11,000	80	60 60 60	3-phase, 3-wire, Wye	Resistance (IT)	Manual	48,500 2,000
MV-2 Medium Voltage	4,160 4,400 3,744	80	60 60 60	3-phase, 3-wire, Wye	Resistance (IT)	Manual	48,500 1,500
LV-1 Low Voltage (Power)	480 504 432	80	60 60 60	3-phase, 3-wire, Delta - Delta	High Resistance (IT)	Manual	65,000 10
LV-2 Low Voltage (Lighting)	480Y/277 504Y/292 432Y/249	80	60 60 60	3-phase, 4-wire, Wye	Solidly Grounded (TN)	N/A	10,000 10,000
LV-3 Low Voltage (Power)	208Y/120 220Y/127 187Y/108	80	60 60 60	3-phase, 4-wire, Wye	Solidly Grounded (TN)	N/A	10,000 10,000
UPS-1 UPS Power	120 126 108	95	60 60 60	Single phase, 2-wire	Solidly Grounded (TN)	Static ½ Cycle	N/A 10,000
DC-1 DC Power	125 140 100	70	0 0 0	Two-Pole	Ungrounded	N/A	N/A N/A
CP-1 Control Power (AC)	120 126 108	80	60 60 60	Single-Phase, 2-Wire	Solidly Grounded (TN)	N/A	N/A N/A

1.10 Temporary Facilities

Construction support services will be required by all onsite contractors, subcontractors, and their personnel. These support services and facilities, depending on contract requirements, may be provided by LG&E/KU and the Contractor(s), and/or their subcontractors. The following list summarizes construction facilities that will be estimated in this phase of the project:

- Field Office(s): B&V will estimate size and location of field offices and construction trailers.
- Material Lay-Down Area(s): B&V will estimate size of area needed for material lay-down during construction.
- Project Parking Requirements: B&V will estimate size and location of temporary parking facilities needed during construction.

1.11 Fire Protection Design Data

Fire protection systems design will be based on NFPA requirements. Details of planned fire protection design will be provided later.

1.12 Economic Evaluation Criteria

1.12.1 Economic Evaluation Factors

Table 1-12 lists economic criteria to be considered in the project cost estimate.

Table 1-12
Economic Criteria

Economic Parameters[a]	2010 Costs			
Unit Identification	**1**	**2**	**3**	**4**
Remaining Plant Life (years)	30			
Capacity Factor (percent)	81.00	71.00	78.00	77.00
Auxiliary Power Cost ($/MWh)	24.87	24.59	25.44	24.90
Limestone Cost ($/ton)	8.22			
Lime Cost ($/ton)	131.78			
Ash Disposal Cost ($/ton)	15[b]			
SCR Catalyst Replacement Cost ($/m^3)	6,500[b]			
Ammonia Cost for SCR ($/ton)	517.55			
Trona Cost ($/ton)	200.42			
Halogenated PAC Cost ($/lb)	1.10[b]			
Water Cost ($/1,000 gal)	2[b]			
Fully-Loaded Labor Rate ($/year)	121,000			
Fully-Loaded Labor Rate ($/hr)	58.17[c]			
Capital Escalation Rate (%)	2.5			
O&M Escalation Rate (%)	2			
Levelized Fixed Charge Rate or Capital Recovery Factor (%)	12.17			
Interest During Construction (%)	4.5			

Data from "Table 3-3 Economic Evaluation Parameters" of the Phase I Air Quality Control Technology Cost Assessment report.
[a]Utilities costs are as delivered costs.
[b]Economic variable was not provided by LG&E/KU and are assumed data based on similar economic data for other LG&E/KU plants.
[c]Based on Fully-Loaded Labor Rate ($/year) value and 2080 hours per year.

1.12.2 Load Model

Table 1-13 displays the average annual unit load model used for economic evaluations based on unit operation.

Table 1-13
Load Model

Unit #	Unit Load, Rating	Unit Gross Output MW[(a)]	Operating Hours Hours/year[(b)]	Gross MW-Hours/year
Unit 1	High	545	5,099.3	2,780,693
	Medium	394	1,531.8	604,268
	Low	280	372.2	104,394
	Offline	0	1,756.7[(c)]	0
	Total		8,760.0	3,489,355[(d)]
Unit 2	High	508	4,095.0	2,078,603
	Medium	366	885.0	324,090
	Low	252	1,603.7	404,414
	Offline	0	2,176.0[(c)]	0
	Total		8,760.0	2,807,108[(d)]
Unit 3	High	481	6,976.0	3,357,213
	Medium	349	307.6	107,338
	Low	235	428.0	100,537
	Offline	0	1,048.4[(c)]	0
	Total		8,760.0	3,565,088[(d)]
Unit 4	High	474	4,389.4	2,079,203
	Medium	343	2,390.5	820,610
	Low	229	1,092.0	250,311
	Offline	0	888.1[(c)]	0
	Total		8,760.0	3,150,124[(d)]

Notes:
[(a)] Unit Gross Output is a representative point estimated from within the LG&E/KU provided range of unit gross outputs per load rating (low, medium, and high). The point was selected so that when multiplied by the respective operating hours and summed per unit, the total would equal the Gross MW-Hours/Year[(d)].
[(b)] Hours based on 2009 Operating Load Analysis reports for each unit.
[(c)] Offline hours include all hours below the specified lower operating boundary including hours not in operation (e.g., on Units 1 and 2, any operating point below the lower operating boundary of 170 MW gross.)
[(d)] Average of 2008 & 2009 Ghent gross generation data (based on 365 days per year).
[(e)] Gross MW Capacities are on average 510 MW, 510 MW, 515 MW, and 515 MW for Units 1, 2, 3, and 4, respectively based on information provided by Ghent operations.

2.0 Design Codes and Standards

2.1 Project Specifications

B&V's scope includes development of technical specifications for the purchase and erection of Fabric Filters for the various units requiring Fabric Filters as part of the AQC Study. Specifications will include technical specifications developed by B&V along with Front End Documents and General Conditions as developed by LG&E/KU. Technical specifications are expected to be letter form in B&V standard format.

2.2 Codes and Standards

The design and specification of work shall be in accordance with applicable state and federal laws and regulations and local codes and ordinances. The codes and industry standards which will be the basis for design, fabrication, and construction are listed below and will be the editions in effect, including all addenda, as stated in equipment and construction purchase or contract documents. Other recognized standards may also be used as design, fabrication, and construction guidelines when not in conflict with the listed standards. Applicable codes will be as established based on consideration of applicable laws and regulations:

- American Association of State Highway and Transportation Officials (AASHTO)
- American Concrete Institute (ACI).
- American Institute of Steel Construction (AISC).
- American Iron and Steel Institute (AISI).
- American National Standards Institute (ANSI).
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
- American Society of Civil Engineers (ASCE)
- American Society of Mechanical Engineers (ASME).
- American Society for Testing and Materials (ASTM).
- American Water Works Association (AWWA).
- American Welding Society (AWS).
- Compressed Gas Association (CGA).
- Concrete Reinforcing Steel Institute (CRSI).

- Conveyor Equipment Manufacturers Association (CEMA)
- U.S. Department of Transportation (DOT).
- Factory Mutual (FM).
- Illuminating Engineering Society (IES).
- Institute of Electrical and Electronics Engineers (IEEE).
- Instrument Society of America (ISA).
- Insulated Cable Engineers Association (ICEA).
- International Building Code (IBC).
- Kentucky Building Code
- National Electrical Manufacturer's Association (NEMA).
- National Electrical Safety Code (NESC) and National Electric Code (NEC) as applicable.
- National Fire Protection Association (NFPA).
- Occupational Safety and Health Administration (OSHA).
- Underwriters Laboratory (UL) Standards.

2.3 Engineering Drawings and Data Content

B&V standards will be used to establish tagging schemes, drawing content, drawing borders, drawing software and formats, symbols, data report content and formats, virtual modeling format and protocols, and interfaces to contractor and subcontractor drawings and data. Interfaces with and references to non-B&V drawings will be provided in sufficient detail to describe the complete design, but generally will not be a duplication of non-B&V data on B&V drawings. Major equipment interfaces will be represented as needed to support construction.

In instances where the new design impacts existing LG&E/KU drawings, such drawings will be modified by B&V as required to reference new drawings or reflect the new design, depending on which results in the most practical, functional, and cost-effective set of deliverables.

Appendix A

LG&E/KU AQC Budgetary Cost Estimate Proposal

(Rev 1 - Pages 1-8)

PROPOSAL FOR
AIR QUALITY CONTROL BUDGETARY COST ESTIMATE

The purpose of this scope of work is to build upon the previous fleet-wide, high-level air quality technology review and cost assessment conducted for six LG&E/KU facilities (Phase I) in order to develop a facility-specific project definition consisting of a conceptual design and a budgetary cost estimate for selected air quality control technologies (Phase II). The Phase II scope of work is proposed for the Mill Creek, Ghent, and Brown facilities, and will be composed of the following tasks and deliverables to ensure that the study is properly defined, documented, and completed on time. It should be noted that there are some scope differences between the three facilities because of variations in the complexity of the future AQC equipment scenarios for each. These differences in study scope are noted below in the appropriate tasks and reflected in the cost estimate. For the purpose of this proposal, LG&E/KU's Mill Creek facility is assumed to be the first facility to begin the Phase II services, with the Ghent and Brown facilities to have a staggered kick-off delay of approximately 1 month each.

SCOPE OF WORK

Task 1 – Project Kick-off Meeting & Site Visit

The Black & Veatch project team members will attend project kickoff meetings at Mill Creek, Ghent, and Brown as depicted in the schedule. It is anticipated that Mill Creek's kick-off meeting will consist of an initial meeting with Project Engineering in Louisville, followed by a technical meeting and site walk down at the facility. The kick-off meetings for Ghent and Brown will be held on site. An agenda will be prepared prior to each kick-off meeting.

The following are the main objectives for the kick-off meeting and initial site visit:

- Discuss project objectives, expectations, and constraints.
- Discuss project communication procedures and identify project team contacts for both LG&E/KU and Black & Veatch for utilization in the *Project Instructions Memorandum*.
- Obtain or identify key site specific drawings, plant performance data, and existing equipment information not previously collected.
- Continue discussions of potential equipment locations with plant engineers.
- Develop understanding of draft system capabilities for supporting new emissions control equipment.
- Develop understanding of the general condition of the balance-of-plant and major equipment to estimate existing equipment upgrade costs for various plans.
- Assess potential arrangement interferences for support of cost estimate.
- Obtain copies of existing reports and studies that will be used during the preparation of the study.
- Establish and agree upon the study schedule and deliverables.

To expedite onsite communications and information collection, Black & Veatch understands that utilization of a single point of contact (SPOC) throughout the project is desirable to ensure proper communications and tracking of data exchanges.

Task 2 – Environmental Regulatory Considerations

During the technology evaluation part of the analysis (Task 6), Black & Veatch's experienced staff of regulatory specialists, air quality scientists, biologists, and other environmental professionals will participate in an advisory capacity to the Black & Veatch engineering staff assigned to the project. We will assign an Environmental Permitting Manager who will be responsible for coordinating with the environmental counterpart at LG&E/KU, providing guidance to LG&E/KU and Black & Veatch engineers relevant to regulatory scenario planning to ensure project conceptual design compliance with applicable federal, state, and local statutes and regulations.

Task 3 – Develop Project Instruction Memorandum

To ensure proper communications, interchange of data and information, and development of a sound project definition and cost estimate, the project itself must have a set of processes and procedures. Black & Veatch will develop a Project Instructions Memorandum (PIM) for the project that will include all Owner specific procedures and additional procedures established by Black & Veatch for use during the execution of the project. The memorandum will establish guidelines, methods, procedures, and lines of communication to administer, control, and coordinate the work between Black & Veatch, other project participants, and LG&E/KU as determined during the kick-off meeting. A full PIM will be completed for Mill Creek and amended for the Ghent and Brown facilities.

Task 4 – Project Management

The following Project Management tasks will be provided to ensure the success of the study.

Schedule & Planning

A project milestone schedule will be developed and issued to LG&E/KU for review within 30 days of Kick-off meeting. After discussion and receipt of comments, a base line schedule will be prepared and issued.

Communications & Coordination

To facilitate communications for the project, we would hold weekly teleconferences between the LG&E/KU team and the Black & Veatch project team. These meetings would include review of project status, schedule review, and review of the Action Item list. In addition to the weekly teleconferences, we would plan to attend periodic Progress Meetings at the plant site or LG&E/KU offices to discuss present project status and address any questions or concerns. A monthly Project Progress Report will be prepared and issued to LG&E/KU. In addition to normal email and telephone communication, Black & Veatch will establish a web based system for rapidly transmitting and exchanging information between LG&E/KU, Black & Veatch and Third parties. Information and instructions for utilizing this system will be included in the PIM.

Management Documentation

In addition to the project schedule and the Monthly Progress Reports, Black & Veatch will prepare minutes of the weekly teleconference and prepare an Action Item List which will address pending actions and note responsible parties and commitments dates. The Action Item list will be updated weekly and discussed during the weekly teleconference and the Progress Meetings.

Project Documentation

As defined in the PIM, Black & Veatch will prepare meeting minutes of all meeting attended with LG&E/KU and third parties for the project. The meeting minutes will be prepared and submitted for review and approval and subsequently issued as final. Project E-mail traffic will be captured and filed within the project filing system and key telephone conversations will be documented using confirming email to all parties. Black & Veatch will transmit, file, and track all reports, studies, drawings and other documentation in accordance with the PIM to ensure that the information is stored and retrievable.

Task 5 – Develop Project Design Memorandum.

Black & Veatch will build upon the initial design basis prepared for the fleet-wide, high-level cost assessment and develop a Project Design Memorandum (PDM) for each facility, which will incorporate the controlling requirements for the conceptual engineering design of the project. The purpose of this document will be to describe the design requirements of the project and to provide the basis for conceptual design and cost estimating. The PDM will include information already submitted by LG&E/KU, as well as addition information that may be necessary.

Information contained in the PDM includes the following

- Project description and purpose.
- Scope of Work.
- Governing Building Codes and Standards.
- The site information in the form of data summaries resulting from initial investigations or monitoring of ambient environment, hydrology, meteorology, geology, topography, background noise, and the load bearing capability and resistive characteristics of soils.
- Air emission rate targets as identified by LG&E/KU and reviewed by Black & Veatch.
- Unit capacity factors
- Capacities
- Flue gas temperature
- ID fan / FD fan capacities
- Other operating parameters
- Fuel data
- Water data
- Reagent/sorbent data
- Economic evaluation criteria
- Engineering design criteria, standards and codes for the engineering disciplines: mechanical, civil, structural, electrical, control, and chemical engineering, including site specific criteria.
- Flue gas flow rates and conditions.
- Ash production rates.

The project team will develop the PDM early in the project, but it will be a living document that will undergo updates during the course of the project to include new data and, results of decisions. The document will incorporate any modifications required by LG&E/KU so that the project going forward will be utilizing the most up to date data and information. The chief purpose of the PDM is to encapsulate the preferences of LG&E/KU under which the various control alternatives and conceptual design will be developed.

Task 6 – AQC Technology Validation and Selection

As LG&E/KU is aware, during the course of the high-level, fleet wide analysis conducted in the previous study, preliminary air quality control (AQC) technologies were initially recommended and approved for the purpose of generating order-of-magnitude cost estimates. However, the very nature of the previous work may have resulted in overly conservative AQC technology assumptions and selections in order to meet the project schedule and bracket the cost estimate. Accordingly, Black & Veatch understands that LG&E/KU may have plant-specific AQC preferences, configurations, and alternative control technology scenarios that may also be feasible and capable of meeting the stated environmental goals, particularly in light of fleet-wide averaging opportunities or other constraints.

To address the potential AQC technology scenarios, Black & Veatch will conduct a more refined available technology selection analysis to evaluate and validate the preliminary retrofit technologies, as well as improvement to existing site control equipment, that can achieve the required future emissions target levels. The evaluation includes estimating emissions reduction, addressing technical feasibility and capability, applying known site constraints, providing technical descriptions of each technology, addressing commercial availability and guarantees, and describing the pros and cons of each technology. The technology analysis will validate which retrofit technologies, or improvement to existing control technologies, are technically feasible and capable of meeting the established emission target levels. The analysis will also document and explain, based on physical, chemical, or engineering principles, why technical difficulties may preclude the successful use of a certain control or technology option. The analysis will consider various unit arrangements, including single unit as well as various combinations of multiple units. This task will ensure that the initial technology selection scenarios are feasible and suitable to the facility based on established selection criteria.

Based on the initial results of the Phase I work, as well as an AQC screening workshop conducted for Mill Creek, the following preliminary AQC technologies scenarios (and embedded options) have been identified for each facility.

- Mill Creek:
  - NIDs/DFGD or FF on Units 1-4
  - SCRs on Units 1 and/or 2
  - Refurbishing or replacing WFGDs on Units 1, 2 and 4, including using Unit 4's refurbished WFGD for Unit 3
  - New WFGD on Unit 4
  - PAC and/or trona/lime injection/SBS injection
  - Feasibility of neural network (NN) on Units 1-4
  - Feasibility of ESPs for pre-filtering
- Ghent
  - FFs on Units 1-4
  - PAC and trona/lime injection/SBS injection
  - SCR on Unit 2
  - Feasibility of neural network (NN) on Units 1-4
- Brown
  - FFs on Units 1-3
  - Separate or combined FF on Units 1 and 2
  - LNB/OFA or SCR on Unit 1
  - SCR on Unit 2
  - PAC and trona/lime injection/SBS injection
  - Feasibility of neural network (NN) on Units 1-3

In order to verify, properly vet, and ultimately select an AQC technology suite for each facility for final evaluation, Black & Veatch proposes to perform the following high level studies and comparative analyses.

- Overview analysis of existing water/wastewater systems (Mill Creek only)
- Water mass balance (Mill Creek only)
- Flue gas conditions
- Fan analysis
- Furnace design pressure analysis
- Simplified AQC mass balance
- Auxiliary electric system analysis/comparison
- Chimney analysis (Mill Creek only)
- High level differential cost analysis comparison for scenarios with multiple options (capital and O&M)
- Reagent cost analysis/comparison (Mill Creek only)
- WFGD mass balance and byproduct disposal analysis/comparison (Mill Creek only)
- Existing WFGD upgrade analysis with support from vendors for modeling (Mill Creek only)
- Truck and rail traffic analysis (Mill Creek only)
- Fly ash analysis/comparison
- High level site arrangement drawings for each AQC suite

Upon completion of the aforementioned studies and analyses, Black & Veatch will prepare a draft technology validation and selection report for LG&E/KU's review and comment. Following incorporation of comments, Black & Veatch will meet with LG&E/KU to discuss the results. During the meeting, the team will review the options suggested by the selection study to ensure they are consistent with the requirements and specific goals of the facility. Following the presentation of results, the LG&E/KU/Black & Veatch team will formally select the AQC technology suite for final evaluation.

Task 7 – Develop Preliminary Conceptual Design

The following list defines the predominant conceptual design engineering services to be performed by Black & Veatch to define the basis for the cost estimate, as well as specific deliverables for LG&E/KU. The conceptual design evaluation will address each item for the selected AQC technology scenario, as appropriate.

- Preliminary description of scope of work.
- Equipment performance and emissions review. Current emissions review of plant historical data provided by LG&E/KU.
- Assessment of potential modifications to existing equipment, including upgrading existing WFGDs at Mill Creek.
- Determine the associated balance-of-plant requirements and plant modifications necessary.
- Develop key process flow diagrams (conceptual)
- An overall site plan drawing (conceptual) of the project major equipment, including air quality control equipment, chimney, fuel handling systems, reagent (limestone or lime) handling system, ash handling system, chemical storage, sorbent or PAC injection systems, etc, as applicable. The location of other existing key buildings such as boiler, administration/services building(s) and other buildings and structures, electrical transmission lines/corridors, and access roads will also be identified.
- Building and Plant Arrangements
- Equipment Logistics/Transportation Requirements (see Task 10)
- Permitting/Environmental Impacts (see Task 2)
- Specification and System List
- Lighting Requirements
- Grounding Requirements
- Fire Protection Requirements
- Communication Requirements
- Layout of Critical System and Underground Piping
- Terminal Point List
- Water Mass Balance Diagram (Mill Creek only)
- Equipment Lists
- One-Line Drawing
- Construction Equipment Requirements
- System Descriptions
- Demolition/Relocation Requirements
- Civil/Structural Discipline Drawings
- Mechanical Discipline Drawings
- Electrical Discipline Drawings
- Instrumentation/Control System Discipline Drawings

In addition to the conceptual design services listed above, this task will address the following topics and issues in the manner described for each.

- **Construction Materials**. Black & Veatch will select the materials of construction based on engineering judgment, past experience, and general site technology specifics.
- **Sparing and Capacity**. Since the final selection of AQC technologies may allow a single system to influence the direct operations of more than one unit, impacts to outage scheduling, unit operations and unit reliability are important considerations. Black & Veatch will use LG&E/KU's planned usage pattern for the affected units to identify draft sparing and capacity guidelines and their implications for the units. Provision of these draft guidelines will allow LG&E/KU to evaluate potential tradeoffs and conflicts with the various goals of the project to allow adjustment of the guidelines to achieve the overall project goals in the best approach possible.
- **Draft System**. Depending on the existing ID fan capacity and the incremental draft load to be imposed by the new emissions control equipment, draft system modifications may be required. Additionally, draft

system modifications may require ductwork and/or boiler stiffening to withstand the new operating conditions or for compliance with NFPA-85. Black & Veatch will evaluate the existing draft system capacity and design, operating ranges, and anticipated additional draft losses and recommend modifications, including fan capacity (flow and head) and margins, motor speed(s), draft control alternatives, and structural reinforcing. This will be a high level evaluation based upon the conceptual design developed and is intended to provide sufficient information to allow LG&E/KU to evaluate the various options in the study. Additional future detailed study work would be required for any selected scenario implementation.

- **Chimney Alternatives.** As part of the overall study, Black & Veatch will evaluate the necessity for modifications or replacement of existing chimneys. This evaluation will only consider the physical characteristics of the stack(s) and its availability to operate under any new conditions imposed by the technology scenarios. This analysis is limited to the Mill Creek facility only.
- **Auxiliary Electric System**. Auxiliary electric power supply alternatives for multi-unit emissions control equipment retrofits typically involve a combination of unit-specific power supply and at a minimum, common load and/or startup power supply from the plant switchyards. Considerations in selecting the optimum site-specific configuration include unit startup, redundancy, bus capacity, load flow, generation metering, and capital cost issues. Black & Veatch will evaluate the emissions control equipment affects on the existing auxiliary electric system and a recommend solution for a reliable redundant power supply to the new AQC equipment. This will be a conceptual evaluation in order to provide sufficient information to evaluate the various AQC options of the study.
- **FGD and Landfill Waste Disposal**. As part of the study, Black & Veatch will define the physical and chemical characteristics of the by-products and determine the production rates. LG&E/KU may utilize this information in addressing the transport and final disposition of the byproducts. This analysis is limited to the Mill Creek facility only.
- **FGD System Water Supply.** The water supply to the FGD systems and auxiliaries will be determined by evaluating the potential water and wastewater streams that could be required or produced for the different scenarios. Preliminary water mass balances will be developed for the new or added systems. An overall plant water mass balance has not been included but can be added to the work at LG&E/KU's direction. This analysis is limited to the Mill Creek facility only.
- **Fly Ash Handling.** Black & Veatch will address modifications or replacement of the fly ash handling system only as necessary to accommodate the technology scenarios.

Task 8 – Project Cost Estimate

Black & Veatch will prepare a budgetary cost estimate for the AQC scenario selected by LG&E/KU for continuation. The cost estimate will include monthly cash flows based on the determined contracting strategy (see Contracting Strategy Analysis task). Black & Veatch will solicit major equipment letter quotations to support the cost estimate. As a provider for AQC solutions, Black & Veatch has developed estimating tools that will be utilized for this project, as well as leveraging the information available from the many large AQC projects and coal projects recently completed and ongoing. The capital costs estimates will be generated from proprietary in-house data for similar sized coal fueled units. The cost estimate will go through our internal review processes and procedures that we use when developing our own project pricing structure. When available, this data can also be supplemented with actual pricing and labor rates. Construction contracts will be adjusted for craft wage rates and productivity at the project site. Owner's costs (project development, permitting, financing, etc.) will be estimated as a percentage of the total capital cost unless identified as an amount from LG&E/KU.

In addition to the capital costs, annual O&M costs, both fixed and variable components, will be estimated. Black & Veatch will formulate the overall cost and cash flow estimate (month and year) for the agreed upon scenario. Black & Veatch will prepare capital and operating and maintenance (O&M) cost estimates using current (2010) dollars and include the estimated engineering cost for this project. The cost estimate will include analysis of the contingency use, analysis of any escalation used and a risk analysis for those elements of the cost estimate most at risk from market and pricing concerns.

Task 9 – Implementation Schedule

Black & Veatch will prepare a detailed Level 1 project implementation schedule from inception to commissioning using Primavera. The implementation schedule will begin with the conceptual design and specification development followed by the development period that will include licensing and permitting activities, bid negotiations, and finalization of procurement and construction contracts. Elements in the schedule will include engineering, procurement, construction, startup, and testing.

The implementation schedule will consider time required for each of the activities and their co-relationships, including contingency plans to offset permitting delays and the potential impact of licensing of patented technologies. The facility plant outage planning schedule will be included in the project scheduling process. The procurement and construction duration will also consider regional procurement strategies particularly related to major long lead items, and availability and productivity of local and regional labor.

In addition, as part of this task, Black & Veatch will develop project cash flows based on the implementation schedule and budget estimate.

Task 10 – Constructability Plan

Construction is a key consideration in the success of any major capital plan. The success or failure of a project is realized often only when construction begins. Black & Veatch strongly believes construction professionals must be involved early in the process to ensure the lessons learned from the past are not repeated and that adequate consideration is given to how the plant will be constructed. Simple changes early in the process can save millions only if fully considered at the appropriate time.

A constructability analysis will be developed and included as part of the project implementation schedule. Constructability will be a prime consideration as part of the selection process of virtually all the systems along with the considerations of overall costs, operability, and maintainability. As major systems are defined, the arrangement of the systems on the site will be reviewed with constructability and maintainability in mind. The ability to sequence construction, maintains crane and equipment access, levelize the construction labor force and provide for material deliveries, and lay-down space will be considered. The optimum approach for any one construction phase has to be balanced against available outages, interfacing work, cash flow considerations, fabrication and equipment delivery capabilities, engineering support, etc. In addition to the schedule input from the constructability plan, a construction facilities drawing will be developed as part of this task.

Task 11 – Evaluation Report

The end result of this study will be a document inclusive of the analyses conducted in the above tasks outlining the consideration undergone by LG&E/KU and Black & Veatch to arrive at the selected AQC conclusions. Black & Veatch will prepare and submit five (5) hardcopies and electronic copies of the draft project report of the work performed under this contract to LG&E/KU for review. Black & Veatch will forward some sections as drafts during earlier tasks and then amended to fit within the purpose of the final report. The draft report will include all conceptual engineering, drawings, costs and schedules developed for this project.

Following submittal of the draft report, Black & Veatch will meet with LG&E/KU to discuss the report and obtain any comments or modifications required. Within four (4) weeks of receiving LG&E/KU comments, Black & Veatch will incorporate these comments and issue five (5) hardcopies and electronic copies of the final report. If requested by LG&E/KU, Black & Veatch will prepare and deliver a formal presentation of the report to LG&E/KU noting conclusions, recommendations and decisions required by the project team and management.

Fabric Filter Letter Specification and Vendor Workshop

Black & Veatch will prepare letter specifications for new FFs at Mill Creek, Ghent, and Brown facilities. The letter specification will be approximately 2 to 3 pages in length, describing the design basis, scope of work, and technical requirements for budgetary purposes only. Following LG&E/KU's review and incorporation of final comments, Black & Veatch will assist LG&E/KU in contacting and scheduling vendor presentations to coincide with a FF workshop to be held at LG&E/KU's engineering offices. A two-day workshop is proposed, with the first half-day consisting of a FF primer and presentation by Black & Veatch personnel, in preparation for 2-3 back-to-back half-day vendor presentations to follow. The actual schedule date of the workshop will be determined once the vendors are contacted. Black & Veatch will prepare meeting minutes summarizing discussions from the workshop.

SCHEDULE

As previously discussed with LG&E/KU, this Phase II scope of work is proposed for the Mill Creek, Ghent, and Brown facilities. The Mill Creek facility is assumed to be the first facility to begin the Phase II services, with the Ghent and Brown facilities to have a staggered kick-off delay of approximately 1 month each. The following table identifies the major milestone schedule proposed herein.

Major Milestone Schedule			
Activity	**Mill Creek**	**Ghent**	**Brown**
Notice to Proceed	Aug 26, 2010	Aug 26, 2010	Aug 26, 2010
Project Kickoff and Site Visit Meeting (Task 1)	Sep 14, 2010	Oct 4, 2010	Nov 8, 2010
Begin AQC Validation (Task 6)	Sep 7, 2010	Oct 11, 2010	Nov 15, 2010
Select AQC Technologies - Meeting (Task 6)	Nov 8, 2010	Dec 6, 2010	Jan 10, 2011
Begin Conceptual Design (Task 7)	Nov 15, 2010	Dec 13, 2010	Jan 17, 2011
Begin Cost Estimate (Task 8)	Dec 13, 2010	Jan 10, 2011	Feb 7, 2011
Issue Draft Report (Task 11)	Feb 7, 2011	Mar 14, 2011	Apr 11, 2011
Final Report – Presentation Meeting (Task 11)	Mar 7, 2011	Apr 11, 2011	May 7, 2011

Appendix B

Design Basis

(Excerpt from Phase I Report Appendix C - Ghent Only - Revised 12/10/2010)

LG&E/KU Design Basis 12/10/2010					
Unit Designation	**Ghent**				**Reference**
	1	**2**	**3**	**4**	
Ultimate Coal analysis, wet basis					
Carbon, %	61.20	61.20	61.20	61.20	Data from LG&E/KU
Hydrogen, %	4.28	4.28	4.28	4.28	Data from LG&E/KU
Sulfur, %	3.36	3.36	3.36	3.36	Data from LG&E/KU
Nitrogen, %	1.27	1.27	1.27	1.27	Data from LG&E/KU
Chlorine, %	0.16	0.16	0.16	0.16	Data from LG&E/KU
Oxygen, %	6.89	6.89	6.89	6.89	Data from LG&E/KU
Ash, %	12.00	12.00	12.00	12.00	Data from LG&E/KU
Moisture, %	11.00	11.00	11.00	11.00	Data from LG&E/KU
Higher Heating Value, Btu/lb	11,200	11,200	11,200	11,200	Data from LG&E/KU
Trace Metal Analysis, ppm					
Antimony (Sb)	1.05	1.05	1.05	1.05	Data from LG&E/KU
Arsenic (As)	13.00	13.00	13.00	13.00	Data from LG&E/KU
Barium (Ba)	74.00	74.00	74.00	74.00	Data from LG&E/KU
Cadmium (Cd)	0.65	0.65	0.65	0.65	Data from LG&E/KU
Chlorine (Cl)	1600.00	1600.00	1600.00	1600.00	Data from LG&E/KU
Chromium (Cr)	23.00	23.00	23.00	23.00	Data from LG&E/KU
Fluorine (F)	98.00	98.00	98.00	98.00	Data from LG&E/KU
Lead (Pb)	11.00	11.00	11.00	11.00	Data from LG&E/KU
Magnesium (Mg)	684.00	684.00	684.00	684.00	Data from LG&E/KU
Mercury (Hg)	0.12	0.12	0.12	0.12	Data from LG&E/KU
Nickel (Ni)	20.00	20.00	20.00	20.00	Data from LG&E/KU
Selenium (Se)	2.94	2.94	2.94	2.94	Data from LG&E/KU
Strontium (Sr)	56.00	56.00	56.00	56.00	Data from LG&E/KU
Vanadium (V)	40.00	40.00	40.00	40.00	Data from LG&E/KU
Zinc (Zn)	48.00	48.00	48.00	48.00	Data from LG&E/KU
Ash Analysis, % by mass					
Alumina (Al2O3)	21.69	21.69	21.69	21.69	Data from LG&E/KU
Barium Oxide (BaO)	0.07	0.07	0.07	0.07	Data from LG&E/KU
Lime (CaO)	2.74	2.74	2.74	2.74	Data from LG&E/KU
Iron Oxide (Fe2O3)	21.80	21.80	21.80	21.80	Data from LG&E/KU
Magnesia (MgO)	0.91	0.91	0.91	0.91	Data from LG&E/KU
Manganese Oxide (MnO)	0.04	0.04	0.04	0.04	Data from LG&E/KU
Phosphorous Pentoxide (P2O5)	0.26	0.26	0.26	0.26	Data from LG&E/KU
Potassium Oxide (K2O)	2.33	2.33	2.33	2.33	Data from LG&E/KU
Silica (SiO2)	45.88	45.88	45.88	45.88	Data from LG&E/KU
Sodium Oxide (Na2O)	0.48	0.48	0.48	0.48	Data from LG&E/KU
Strontium Oxide (SrO)	0.05	0.05	0.05	0.05	Data from LG&E/KU
Sulfur Trioxide (SO3)	2.58	2.58	2.58	2.58	Data from LG&E/KU
Titania (TiO2)	1.04	1.04	1.04	1.04	Data from LG&E/KU
Undetermined	0.12	0.12	0.12	0.12	Data from LG&E/KU
Unit Characteristics					
Gross Turbine Generator Load, MW	541	517	523	526	Data from LG&E/KU
Boiler Efficiency, % (HHV)	85.74	86.83	86.31	86.77	Data from LG&E/KU
Boiler Heat Input, MBtu/hr (HHV)	5,300	5,300	5,300	5,300	Data from LG&E/KU
Coal Flow Rate, lb/hr	479,375	386,339	490,714	488,661	Data from LG&E/KU
Capacity Factor, %	81.00	71.00	78.00	77.00	Data from LG&E/KU
Fly Ash Portion of Total Ash, %	80.0	80.0	80.0	80.0	Data from LG&E/KU
Air Heater Leakage, %	10.0	10.0	10.0	10.0	Data from LG&E/KU
Excess Air, %	18.258	21.926	21.926	20.433	Data from LG&E/KU
Economizer Outlet Conditions					
Flue Gas Temperature, F	729	610	731	791	B&V Combustion Calculations
Flue Gas Pressure, in. w.g.	-3.2	-5.1	-5.1	-4.5	B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr	5,206,933	4,316,060	5,482,104	5,397,559	B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm	2,563,081	1,922,533	2,718,161	2,805,958	B&V Combustion Calculations
Uncontrolled Sulfur Dioxide Concentration, lb/MBtu	6.00	6.00	6.00	6.00	= % Sulfur in Coal x 20,000 / HHV
Uncontrolled Sulfur Dioxide Mass Flow Rate, lb/hr	32,181	25,936	32,942	32,805	B&V Combustion Calculations
Uncontrolled PM Concentration, lb/MBtu	8.746	8.746	8.746	8.746	B&V Combustion Calculations
Uncontrolled PM Mass Flow Rate, lb/hr	46,354	46,354	46,354	46,354	= Uncontrolled PM (lb/MBtu) x Heat Input (MBtu/hr)
Uncontrolled Mercury Concentration, lb/TBtu	10.85	8.75	11.11	11.06	= Hg in Coal (ppm) x Coal Flow Rate (lb/hr) / Heat Input (MBtu/hr)
Uncontrolled HCl Mass Flow Rate, lb/hr	789	636	807	804	= HCl in Coal (ppm) / 1,000,000 x Coal Flow Rate (lb/hr) x MW of HCl / MW of Cl
Uncontrolled HCl Concentration, lb/MBtu	0.15	0.12	0.15	0.15	= HCl Flowrate (lb/hr) / Heat Input (MBtu/hr)
Hot-Side ESP Outlet Conditions	**No Hot-side ESP. Unit has a Cold-side ESP**				
Flue Gas Temperature, F		605	708	770	B&V Combustion Calculations
Flue Gas Pressure, in. w.g.		-10.80	-10.90	-10.8	B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr		4,531,863	5,756,209	5,667,437	B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm		2,041,027	2,843,960	2,947,083	B&V Combustion Calculations
Controlled PM Concentration, lb/MBtu		0.0565	0.0451	0.0248	B&V Combustion Calculations
Controlled PM Mass Flow Rate, lb/hr		299	239	131.44	= Controlled PM (lb/MBtu) x Heat Input (MBtu/hr)
Particulate Removal Efficiency, %		99.35	99.48	99.72	= { 1- Controlled PM (lb/MBtu) / Uncontrolled PM (lb/MBtu) } x 100
SCR Outlet Conditions		**No SCR**			
Flue Gas Temperature, F	729		708	770	B&V Combustion Calculations
Flue Gas Pressure, in. w.g.	-13.2		-20.90	-20.8	B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr	5,311,071		5,871,333	5,780,786	B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm	2,682,371		2,977,658	3,085,629	B&V Combustion Calculations
Controlled NOx Concentration, lb/MBtu	0.0639		0.0479	0.0627	Data from LG&E/KU
Controlled NOx Mass Flow Rate, lb/hr	339		254	332	= Controlled NOx (lb/MBtu) x Heat Input (MBtu/hr)
Air Heater Outlet Conditions					
Flue Gas Temperature, F	361	309	322	309	B&V Combustion Calculations
Flue Gas Pressure, in. w.g.	-22.4	-18.60	-36.10	-29.4	B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr	5,842,179	4,985,049	6,458,467	6,358,865	B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm	2,091,568	1,657,754	2,288,309	2,175,592	B&V Combustion Calculations
Cold-Side ESP Outlet Conditions		**No Cold-side ESP. Unit has a Hot-side ESP**	**No Cold-side ESP. Unit has a Hot-side ESP**	**No Cold-side ESP. Unit has a Hot-side ESP**	
Flue Gas Temperature, F	358				B&V Combustion Calculations
Flue Gas Pressure, in. w.g.	-25.7				B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr	6,134,288				B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm	2,209,920				B&V Combustion Calculations
Controlled PM Concentration, lb/MBtu	0.023				Data from LG&E/KU
Controlled PM Mass Flow Rate, lb/hr	122				= Controlled PM (lb/MBtu) x Heat Input (MBtu/hr)
Particulate Removal Efficiency, %	99.74				= { 1- Controlled PM (lb/MBtu) / Uncontrolled PM (lb/MBtu) } x 100
Fabric Filter Outlet Conditions	**No Fabric Filter**	**No Fabric Filter**	**No Fabric Filter**	**No Fabric Filter**	
Flue Gas Temperature, F					B&V Combustion Calculations
Flue Gas Pressure, in. w.g.					B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr					B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm					B&V Combustion Calculations
Controlled PM Concentration, lb/MBtu					Data from LG&E/KU
Controlled PM Mass Flow Rate, lb/hr					= Controlled PM from fabric Filter (lb/MBtu) x Heat Input (MBtu/hr)
Particulate Removal Efficiency, %					= { 1- FF Controlled PM (lb/MBtu) / ESP Controlled PM (lb/MBtu) } x 100
ID Fan Outlet Conditions					
Flue Gas Temperature, F	376.94	325.52	346.34	333.60	B&V Combustion Calculations
Flue Gas Pressure, in. w.g.	6.10	11.40	5.90	14.60	B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr	6,134,288	4,985,049	6,458,467	6,358,865	B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm	2,086,965	1,571,913	2,119,437	2,010,799	B&V Combustion Calculations

LG&E/KU Design Basis 12/10/2010					
Unit Designation	**Ghent**				**Reference**
	1	**2**	**3**	**4**	
Scrubber Outlet Conditions					
Flue Gas Temperature, F	131.74	128.04	129.28	128.50	B&V Combustion Calculations
Flue Gas Pressure, in. w.g.	1.70	1.50	2.00	1.60	B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr	6,534,149	5,252,980	6,834,132	6,711,801	B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm	1,643,977	1,306,064	1,705,743	1,671,656	B&V Combustion Calculations
Controlled Sulfur Dioxide Mass Flow Rate, lb/hr	805	865	824	821	B&V Combustion Calculations
Controlled Sulfur Dioxide Concentration, lb/MBtu	0.152	0.163	0.155	0.155	= Controlled SO_2 (lb/hr) / Heat Input (MBtu/hr)
Sulfur Dioxide Removal Efficiency, %	97.47	97.28	97.41	97.42	= { 1- Controlled SO_2 (lb/MBtu) / Uncontrolled SO_2 (lb/MBtu) } x 100
Wet ESP Outlet Conditions					
Flue Gas Temperature, F	**No WESP**	**No WESP**	**No WESP**	**No WESP**	B&V Combustion Calculations
Flue Gas Pressure, in. w.g.					B&V Combustion Calculations
Flue Gas Mass Flow Rate, lb/hr					B&V Combustion Calculations
Volumetric Flue Gas Flow Rate, acfm					B&V Combustion Calculations
Stack Outlet Emissions[1]					
Sulfur Dioxide Emission Concentration, lb/MBtu	0.15	0.16	0.16	0.15	Data from LG&E/KU
Sulfur Dioxide Emission Rate, lb/hr	805	865	824	821	= SO_2 Emission (lb/MBtu) x Heat Input (MBtu/hr)
PM Emission Concentration, lb/MBtu	0.023	0.0565	0.0451	0.0248	Data from LG&E/KU
PM Emission Rate, lb/hr	122	299	239	131	= PM Emission (lb/MBtu) x Heat Input (MBtu/hr)
NOx Emission Concentration, lb/MBtu	0.0639	0.276	0.0479	0.0627	Data from LG&E/KU
NOx Emission Rate, lb/hr	339	1,463	254	332	= NOx Emission (lb/MBtu) x Heat Input (MBtu/hr)
Hg Emission Concentration, lb/TBtu	2.0	3.5	2.0	2.0	Data from LG&E/KU
Hg Emission Rate, lb/hr	1.06E-02	1.86E-02	1.06E-02	1.06E-02	= Hg Emission (lb/TBtu) x Heat Input (MBtu/hr) / 1,000,000
HCl Emission Concentration, lb/MBtu	0.0015	0.0017	0.0015	0.0015	Data from LG&E/KU
HCl Emission Rate, lb/hr	8	9	8	8	= HCl Emission (lb/MBtu) x Heat Input (MBtu/hr)
CO Emission Concentration, lb/MBtu	--	--	--	--	CO Emissions are not known
CO Emission Rate, lb/hr	--	--	--	--	CO Emissions are not known
Dioxin/Furan Emission Concentration, lb/MBtu	--	--	--	--	Dioxin/Furan Emissions are not known
Dioxin/Furan Emission Rate, lb/hr	--	--	--	--	Dioxin/Furan Emissions are not known

Notes:

1. Current Outlet Emissions as noted in E-ON Matrix

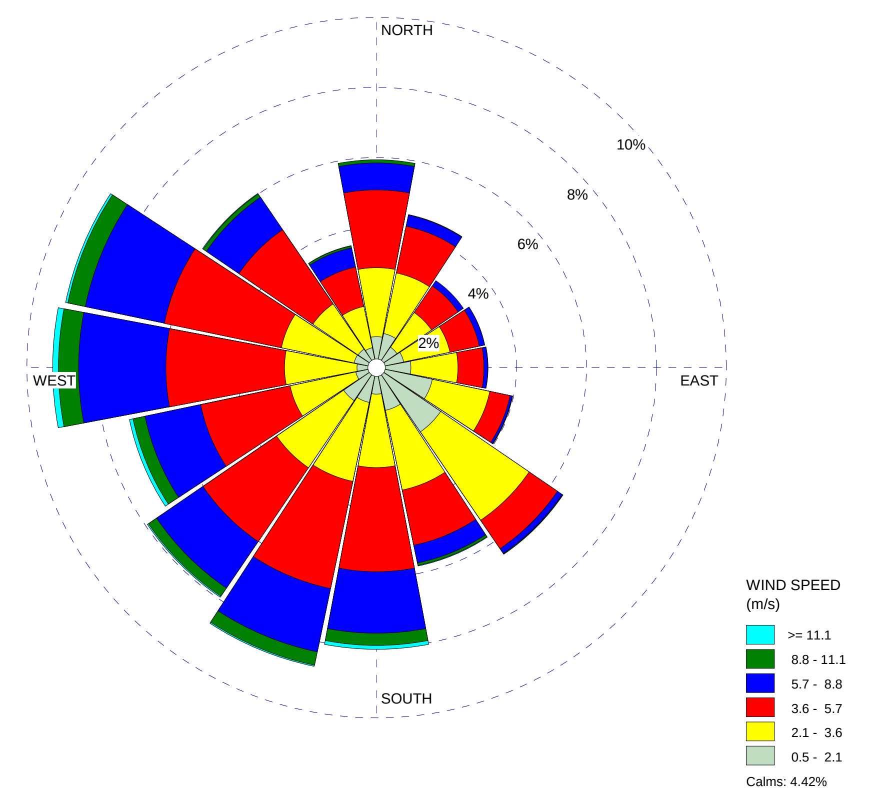
Revision History:

Rev	Date	Description
0	5/21/2010	Initial Issue
1	6/1/2010	Final Issue
2	10/19/2010	Corrected Chlorine Percentage for Phase II
3	12/10/2010	Revised Boiler Heat Input for all 4 units.

Appendix C

Wind Roses

WIND ROSE PLOT:	DISPLAY:
Louisville, KY	**Wind Speed** **Direction (blowing from)**



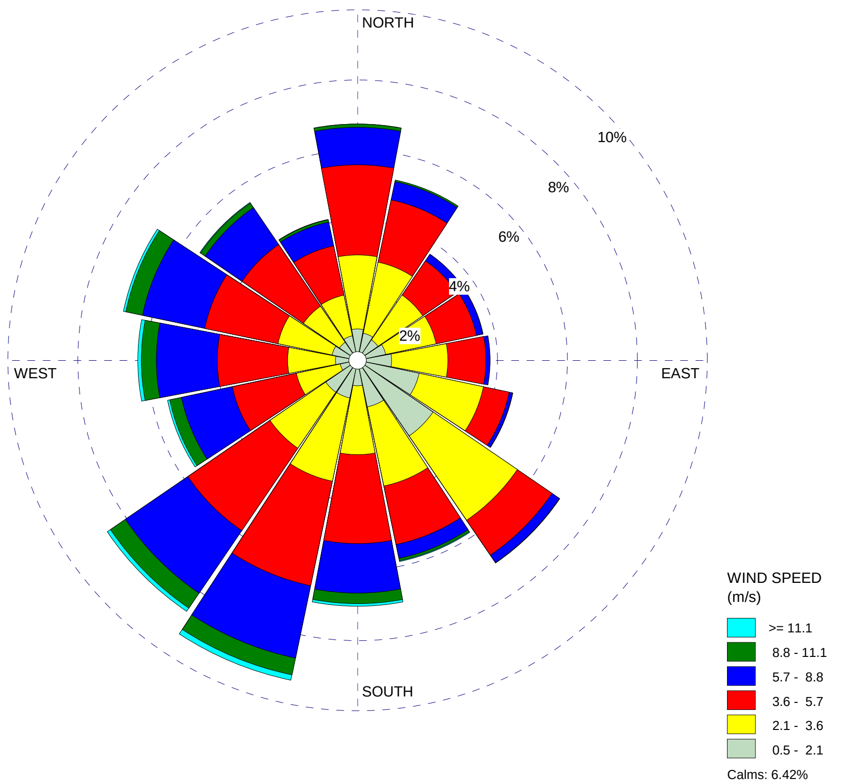
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Winter Wind Rose Louisville, KY	**1995-1999 2000 2001 2002 2003 2004 2005 2006 2007 2008** **Check Date Range Report** **00:00 - 23:00**	MODELER:	
	CALM WINDS: **4.42%**	TOTAL COUNT: **28648 hrs.**	
	AVG. WIND SPEED: **4.14 m/s**	DATE: **9/21/2010**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Winter Wind Rose 1995-2008
Louisville, KY

WIND ROSE PLOT:
Louisville, KY

DISPLAY:
Wind Speed
Direction (blowing from)

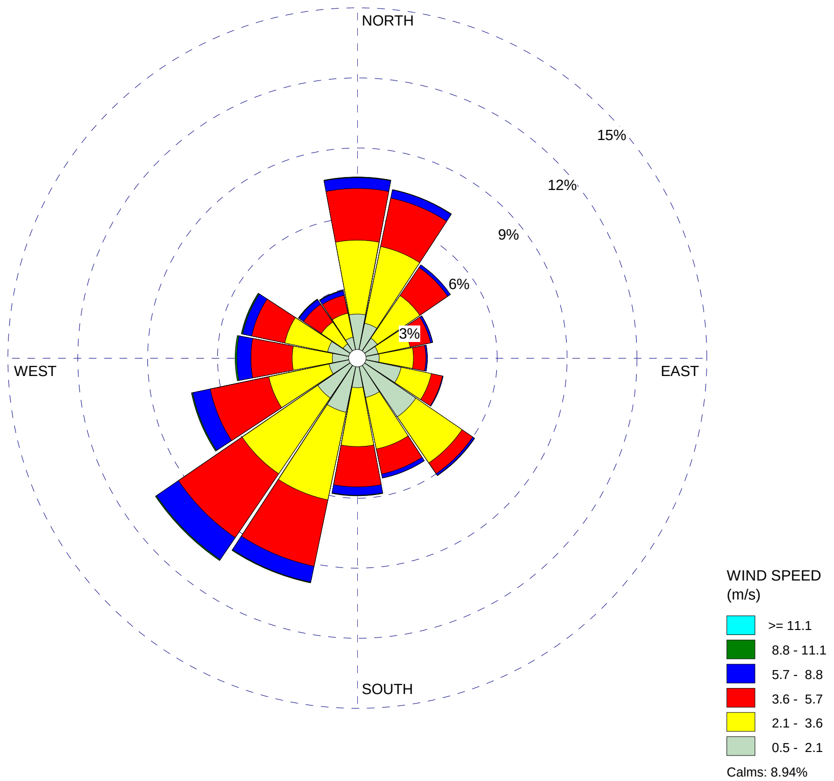


COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Spring Wind Rose Louisville, KY	**1995-1999 2000 2001 2002 2003 2004 2005 2006 2007 2008** **Mar 1 - May 31** **00:00 - 23:00**	MODELER:	
	CALM WINDS: **6.42%**	TOTAL COUNT: **29133 hrs.**	
	AVG. WIND SPEED: **4.05 m/s**	DATE: **9/21/2010**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Spring Wind Rose 1995-2008
Louisville, KY

WIND ROSE PLOT:	DISPLAY:
Louisville, KY	**Wind Speed** **Direction (blowing from)**



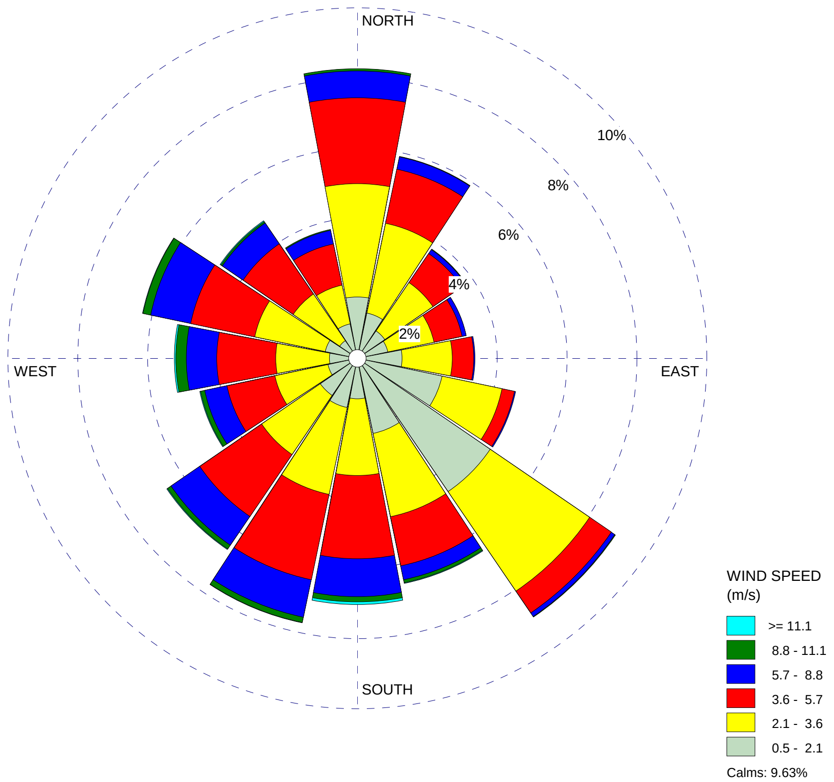
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Summer Wind Rose Louisville, KY	**1995-1999 2000 2001 2002 2003 2004 2005 2006 2007 2008** **Jun 1 - Aug 31** **00:00 - 23:00**	MODELER:	
	CALM WINDS: **8.94%**	TOTAL COUNT: **28224 hrs.**	
	AVG. WIND SPEED: **3.15 m/s**	DATE: **9/21/2010**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Summer Wind Rose 1995-2008
Louisville, KY

WIND ROSE PLOT:
Louisville, KY

DISPLAY:
Wind Speed
Direction (blowing from)



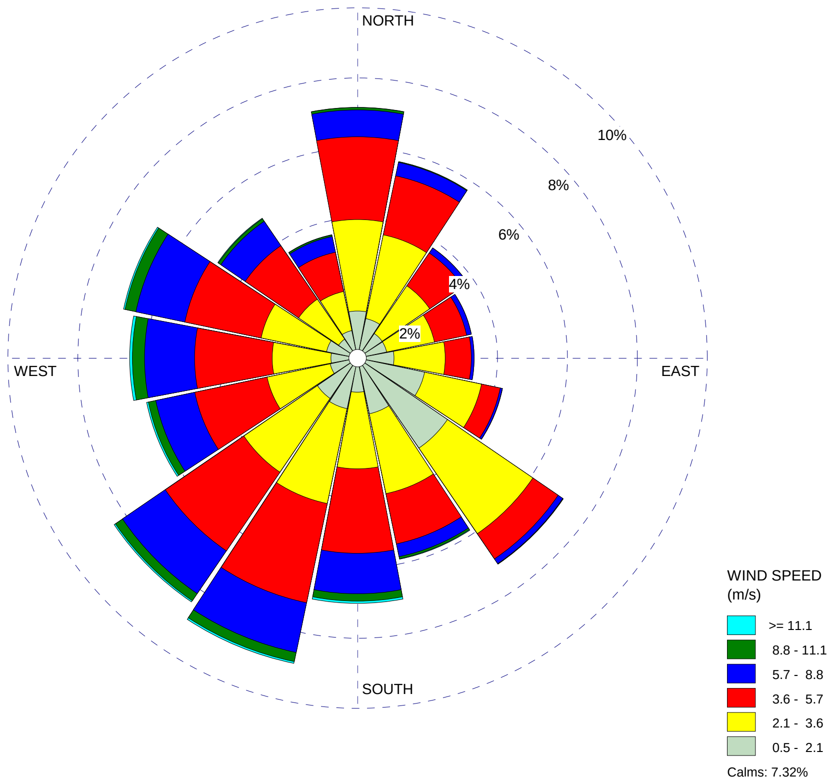
COMMENTS: Fall Wind Rose Louisville, KY	DATA PERIOD: **1995-1999 2000 2001 2002 2003 2004 2005 2006 2007 2008** **Sep 1 - Nov 30** **00:00 - 23:00**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **9.63%**	TOTAL COUNT: **27869 hrs.**	
	AVG. WIND SPEED: **3.33 m/s**	DATE: **9/21/2010**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Fall Wind Rose 1995-2008
Louisville, KY

WIND ROSE PLOT:
Louisville, KY

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS: Annual Wind Rose Louisville, KY	DATA PERIOD: **1995-1999 2000 2001 2002 2003 2004 2005 2006 2007 2008** **Jan 1 - Dec 31** **00:00 - 23:00**	COMPANY NAME: MODELER:
	CALM WINDS: **7.32%**	TOTAL COUNT: **113967 hrs.**
	AVG. WIND SPEED: **3.67 m/s**	DATE: **9/21/2010**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Annual Wind Rose 1995-2008
Louisville, KY