

1.0 Executive Summary

1.1 Phase II Air Quality Control Study

Following the submittal of the Phase I report on July 8, 2010, Black & Veatch (B&V) met with LG&E/KU on August 5-6, 2010 and conducted a technology workshop review to further define facility technology options based on the Phase I report. The purpose of this Phase II Air Quality Control (AQC) 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 AQC technologies (Phase II) for the Mill Creek Station.

This report summarizes the work performed by B&V. Descriptions of the documents prepared and included in this report are provided in Article 1.3 of this executive summary. The key documents included are the following:

- Air Quality Control Validation Report, which resulted in the validation of the AQC technology and selection of the preferred technology.
- Capital Cost Estimates
- O&M Cost Estimates
- Level 1 Schedules
- Cash Flows

In addition, completed conceptual design includes studies and technical descriptions, drawings, diagrams, and lists.

The estimated overnight capital cost for the Mill Creek Station is \$1.1 billion which includes \$48 million in common facilities, \$267 million for Unit 1, \$266 million for Unit 2, \$170 million for Unit 3, and \$312 million or \$321 million for Unit 4 Arrangement A or Arrangement B, respectively. The schedule is based on beginning preliminary engineering in September 2011 and completing all work in late 2017.

1.2 Primary Technologies Validated

The following primary technologies for control of the specified air emissions were evaluated and validated:

- Selective Catalytic Reduction (SCR) system for nitrogen oxides (NO_x) control (Units 1 and 2).
- Refurbishment of existing scrubbers or new wet flue gas desulfurization (WFGD) system (Units 1 and 2 refurbished scrubbers, Unit 4's

refurbished scrubber for Unit 3, and new WFGD for Unit 4) for sulfur dioxide (SO₂) and hydrogen chloride (HCl) control.

- Pulse jet fabric filter (PJFF) with powder activated carbon (PAC) and sorbent (trona/lime) collection for particulate (PM), mercury (Hg), Dioxin/Furan, and sulfuric acid (SO₃) control.
- Neural Networks for all four units for carbon monoxide (CO) control.

1.3 Documents Prepared and Included in Report

In performing this assignment, B&V prepared design criteria, studies and technical documents, drawings, diagrams, lists, technical descriptions, cost estimates, and schedules. With this draft report, each of these is being submitted to LG&E/KU for their review and comment. The final version of each of these documents will be included in the final report.

The following is a listing of the documents included in this report and a brief statement for each document.

1.3.1 Design Criteria

1.3.1.1 Project Design Memorandum (B&V File Number 166943.22.1000) The project design memorandum defines the technical and functional requirements to which the Mill Creek Phase II AQC Study is to be designed.

1.3.2 Studies and Technical Documents

1.3.2.1 Air Quality Control Validation Study (168908.41.0803) The following primary technologies for control of the specified air emissions were evaluated and validated in this study:

- SCR system for NO_x control on Units 1 and 2.
- Refurbishment of existing scrubbers on Units 1, 2, and 4, (with Unit 4's refurbished scrubber to be used for Unit 3), and a new WFGD for Unit 4 for SO₂ and HCl control.
- PJFF with PAC and sorbent (trona/lime) for control of PM, Hg, Dioxin/Furan, and SO₃.
- Neural Networks for all four units to improve CO control.

A validation presentation was held on November 9, 2010 at the Mill Creek Station to discuss the results of the validation study with LG&E/KU. The following arrangements were validated for conceptual engineering and cost estimating.

Unit 1 includes a new SCR, new sorbent injection system, new PAC injection system, new PJFF, new ID fans, refurbished scrubber and utilizes the existing common Unit 1/Unit 2 chimney. The project includes demolition of the existing CS-ESP as required for installation of the new SCR and does not include installation of a new CS-ESP. A neural network is also included. The new PJFF is located above the existing Unit 1 and Unit 2 SDRS pump/electrical building..

Unit 2 includes a new SCR, new sorbent injection system, new PAC injection system, new PJFF, new ID fans, refurbished scrubber and utilizes the existing common Unit 1/Unit 2 chimney. The project includes demolition of the existing CS-ESP as required for installation of the new SCR and does not include installation of a new CS-ESP. A neural network is also included. The new PJFF is located to the North of existing Unit 2.

Unit 3 includes the existing SCR, existing CS-ESP, existing ID fans, new sorbent injection system, new PAC injection system, new PJFF, new booster fans. Also includes the refurbishment of the existing Unit 4 scrubber for use on Unit 3 and utilizes the existing Unit 4 chimney. The project includes demolition of the existing Unit 3 scrubber as required for installation of the new PJFF. A neural network is also included. The new PJFF is located in the area currently occupied by the existing Unit 3 scrubber with ductwork extended to the existing Unit 4 scrubber.

Unit 4 includes the existing SCR, existing CS-ESP, existing ID fans, new sorbent injection system, new PAC injection system, new PJFF, new booster fans, new WFGD, and new chimney. A neural network shall also be included. Both arrangements, Unit 4 PJFF Arrangement A oriented north-south and Unit 4 PJFF Arrangement B oriented east-west, are included in the conceptual design and budgetary cost estimate steps.

1.3.2.2 Existing Scrubbers Upgrade Analysis (16690841.0803.4) The purpose of this analysis was to determine the cost associated with refurbishing the existing scrubbers for an increase in SO₂ control to a minimum of 96 percent, with an optional increase of 98 percent control. This included the existing scrubbers on Units 1, 2 and 4 (with Unit 4's scrubber reconfigured for use on Unit 3). The analyses were completed under separate agreements between LG&E/KU, Babcock Power, and Hitachi. The costs included in the Babcock Power analysis for the 98 percent collection efficiency were used in the project cost estimate.

1.3.2.3 Existing Scrubbers Structural Steel Assessment (16890841.0803.4) The purpose of this assessment was to determine the extent and costs associated with the refurbishment of the structural steel support system for each of the existing scrubbers. The analysis included the existing scrubbers on Unit 1, Unit 2 and Unit 4.

1.3.2.4 Auxiliary Electric System (168908.41.0809) This analysis determined the recommended modifications and additions to the existing auxiliary electric equipment.

1.3.2.5 Chimney Alternatives (168908.41.0810) This analysis described the alternatives for chimney flue materials that will be utilized for the new Unit 4 chimney. It was concluded that the new chimney liner would be FRP.

1.3.2.6 WFGD System Water Supply (168908.41.0812.1) This analysis reviewed the water supplies for the existing refurbished scrubbers and the new Unit 4 WFGD system. It was concluded that the current make-up water source from the Clearwell Pond will be used for the upgraded, existing scrubbers, which include Unit 1 scrubber, Unit 2 scrubber and Unit 4 scrubber (with Unit 4's refurbished scrubber functioning as the new Unit 3 scrubber). The new Unit 4 WFGD will also be supplied by the Clearwell Pond.

1.3.2.7 Constructability Review (168908.41.0813) A constructability review was developed for the suite of technologies proposed for each unit. A construction facilities drawing was included in the document.

1.3.2.8 Construction Materials (168908.0814.1) This analysis describes details of materials of construction for each of the new AQC equipment proposed for the Mill Creek Units. The equipment includes WFGD, PJFF, SCR, sorbent injection and PAC injection systems.

1.3.2.9 Sparing and Capacity (168908.0814.2) This analysis summarizes B&V Reliability, Availability, and Maintainability (RAM) analysis on the new components proposed for Units 1-4 AQC upgrades and modifications. This analysis was completed in order to evaluate system availability. The availability model reflects the expected configuration and redundancy of major equipment critical to plant operation on a per unit basis and used Monte Carlo simulation to provide the expected average availability.

1.3.2.10 Draft System (168908.41.0814.3) The flue gas draft system requires evaluation to determine if modifications or replacements of the existing fans and other draft system components will be required. This is due to the installation of additional draft system equipment to control, or enhance the control of, certain flue gas emissions.

1.3.2.11 WFGD and Landfill Waste Disposal (168908.41.0814.4) The purpose of this analysis is to evaluate the physical and chemical composition of the fly ash material removed by the new PJFF on Units 1-4, as well as the gypsum byproduct material that is produced by the new Unit 4 WFGD scrubber. This study does not discuss any potential impact of disposal of fly ash and scrubber byproducts on the existing landfill. The potential impact analysis on the existing landfill should be considered by LG&E/KU. Mass balances were developed for the Unit 4 WFGD. Mass balances indicate the estimated flows, pressures, temperatures, reagent usage, byproduct quantities, and water usage.

1.3.2.12 Fly Ash Handling (168908.41.0814.5) This analysis evaluated the existing fly ash handling and storage systems. The systems need to be capable of handling additional sorbents and powder activated carbon injected and collected in the PJFF and allow for the separation of sellable and non-sellable ash. Additional fly ash transfer systems are included on Units 2, 3 and 4, and a new storage silo will be added to facilitate separation of sellable and non-sellable ash and to increase on-site storage to 4 days.

1.3.2.13 Impact of PAC Injection (168908.41.0814.6) This analysis was completed to inform LG&E/KU of the current industry concerns considering the injection of PAC into the flue gas. The concerns include the increased risk of injecting a combustible material into the flue gas, collection of this material in the PJFF, and the need for fire suppression systems. In addition, options for bypassing current ESPs are discussed.

1.3.3 Drawings and Diagrams

1.3.3.1 Site Arrangements (168908.41.0402) Site arrangement drawings were developed for the overall site, for Units 1 and 2, and for Units 3 and 4. Unit 4 included two feasible arrangements. A construction facilities plot plan was also developed.

1.3.3.2 Plant Arrangements (168908.41.0402) Plant arrangement drawings were developed for Units 1 and 2 and for Units 3 and 4. The 3-D models developed during the validation study serve as the plant arrangements for this phase of the project. Various screen shots have been included.

1.3.3.3 Equipment and Load List (168908.41.0801) Equipment and electrical load lists were developed for each unit. The electrical load list was used to help develop the electrical one-line diagrams.

1.3.3.4 Electrical One-Lines (168908.41.0809.1) Electrical one-lines were developed for each unit and for the common reserve system.

1.3.3.5 Water Mass Balance (166943.41.0812) A water mass balance was developed for the new Unit 4 WFGD. The water usage required for the new WFGD was estimated as 986 gallons per minute at the base fuel case. A water quality summary was also developed.

1.3.3.6 Process Flow Diagrams (168908.41.0815) High-level process flow diagrams for major systems were developed for each unit.

1.3.4 Technical Descriptions

1.3.4.1 Modifications, Interfaces, and Tie-Ins to Existing Equipment and Systems with Terminal points (168908.41.0804.1) Descriptions were developed to state the modifications, interfaces and tie-ins that would be required to major existing equipment and systems. Each description contains a terminal point list for the associated tie-in.

1.3.4.2 Specifications and Systems Lists (168908.0804.2) Specifications and systems lists were developed for each unit. The specifications lists were used in the cost estimate and the system lists were used to develop the system descriptions.

1.3.4.3 System Descriptions (168908.41.0804.3) System descriptions were developed for each major system for each unit. The system descriptions included system identification, function, and process description.

1.3.4.4 Demolition and Relocation Requirements (168908.41.0804.5) The purpose of these descriptions is to describe the conceptual demolition and/or relocation requirements of the Mill Creek Station existing site structures. In general, the descriptions cover the work involving the major items to be demolished or relocated.

1.3.5 Cost Estimates

1.3.5.1 Capital Cost Estimate with Plan and Basis Memo (166943.41.0805) A capital cost estimate was developed for each unit and for common facility systems. A Plan and Basis memorandum was included with the capital cost estimate to describe assumptions and basis for the development of the cost estimate.

1.3.5.2 O&M Cost Estimate (166943.41.0805.1) An O&M (Operations and Maintenance) cost estimate was developed to show estimated differential O&M costs from current operations for each unit.

1.3.6 Schedules

1.3.6.1 Level 1 Schedule (166943.41.0807) Level 1 schedules were developed for each unit based on the proposed construction described in the Constructability Review document mentioned above in section 1.3.2.7. The schedules were based on the assumption that new regulations would require the environmental equipment to be in service prior by the end of 2017. However, to the extent that the schedules for the regulatory requirements change, the schedule for placing the environmental equipment in service will change accordingly. Per the Level 1 schedule, preliminary engineering and preparation of the EPC specification would need to begin in September 2011 with award of the EPC contract by the end of August 2012. It would also require starting preparation of the air permit application in November 2011.

1.3.6.2 Cash Flows (168908.0807.1) Cash flows were developed based on the capital cost estimates and the Level 1 schedules.