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SPECIFICATION COVER SHEET

TITLE: Circulating Dry Scrubber Request for Information – Budgetary Cost Estimate Specification
SPECIFICATION NUMBER: BS2-FGDSCE-111210

PROJECT:	Big Sandy 2 – Circulating Dry Scrubber Cost Estimate
REVISION:	0
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INTERNAL APPROVAL SIGNATURES

	Original Issue	Date
AUTHOR: L. A. Hicks	Larry G. Hicks	11/12/2010
REVIEW: G. M. Gibbs	G. M. Gibbs	11/12/2010
APPROVAL: T. L. Hart	T. L. Hart	11/12/2010

REVISION HISTORY

REV.	SCOPE OF REVISION	APPROVAL
0	Initial Release	

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[redacted]

[redacted]

[redacted]

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1.0 PURPOSE

The purpose of this specification is to provide a Budgetary Cost Estimate for a circulating dry scrubber (CDS) system (or similar technology) and fabric filter (FF) as part of the Big Sandy Unit 2 Flue Gas Desulfurization (FGD) technology evaluation.

As consideration for the cost estimate, it is the Owner's intent to install a FGD system that will meet the required performance specifications, operate with a high degree of availability and reliability, provide ease of access for maintenance, and require low maintenance during all modes of operation throughout the life of the facility.

2.0 SELLER SCOPE OF WORK

This section of the specification summarizes the general scope of work for the Seller.

2.1 GENERAL INFORMATION

The Seller shall engineer, design, supply, deliver, and support erection and start up activities for the FGD circulating dry scrubber (CDS) system (or similar technology, herein referred to as circulating dry scrubber) and fabric filter. The FGD system shall be designed and fabricated to meet the fit, form and function intended.

2.2 DIVISION OF RESPONSIBILITY

The Seller scope of work shall begin at the inlet flange of the circulating dry scrubber and terminate at the outlet flange of the fabric filter.

[redacted]

2.5 ENGINEERING INFORMATION

The Seller shall provide all drawings and documentation necessary for installation, checkout, start-up and acceptance testing of the FGD CDS and FF system.

The Seller shall provide the information necessary for the Owner to design all other systems, equipment, structural steel, foundations, buildings & structures, etc. outside of the Seller's scope of supply, but necessary to interface with the Seller's scope of supply. Seller shall also provide wiring diagrams for Seller's wired components.

The Seller shall provide all technical services necessary to satisfy the various documentation and drawing requirements identified in this specification.

3.0 OWNER SCOPE OF WORK

This section of the specification summarizes the general scope of work for the Owner.

3.1 ELECTRICAL

The Owner will provide the auxiliary electrical power system. The electrical service shall be based on the Seller's identification of the design requirements for such service including load requirements, voltage requirements, power feed redundancy requirements, control, protection and monitoring requirements. This also includes building lighting and receptacles. The Owner shall be responsible for all necessary cable, conduit, cable trays, connectors and terminations with Seller supplied equipment and motors.

3.2 AUXILIARY PLANT SERVICES

The Owner will provide all required auxiliary plant services such as service water, seal water, compressed air, instrument air, etc. The Owner will also provide all potable water, fire water and plumbing systems. These services shall be based upon the Seller's identification of all requirements necessary for the design of such services. The Owner shall be responsible for all necessary piping, tubing, fittings, and valves to terminal points near the CDS and FF footprint identified by the Seller. The Owner shall supply a stub up through the foundation or flange connection near the interface of the CDS and FF footprint with an isolation valve.

3.3 INSTRUMENTS AND CONTROL

The Owner will provide a Distributed Control System (DCS) and the remote I/O cabinet(s). The Owner shall be responsible for all necessary cable, conduit, cable trays, connectors and termination cabinets for interface with the DCS.

3.4 EMISSION MONITORING SYSTEMS

The Owner will provide all required flue gas emission monitoring systems.

3.5 INDUCED DRAFT FAN

The Seller shall specify the additional draft requirements needed to adequately operate the FGD System. The Owner will provide any necessary upgrades to the existing FD Fans and provide any new ID or Booster Fans required for the FGD System including ductwork from the fabric filter outlet flange to the fan.

3.6 LIME HANDLING

The Owner will provide the equipment necessary for the receiving, unloading and bulk storage of the lime delivered to the plant site. In addition, the Owner will provide the equipment necessary for transporting the lime to a terminal location, identified by the Seller, for day silos integral to the circulating dry scrubber footprint.

3.7 FGD BY-PRODUCT DISPOSAL

The Owner will be responsible for equipment necessary for FGD byproduct removal from the discharge of the fabric filter to the final disposal or storage location.

3.8 STATION DRAINAGE, ROADWAY, AND YARD LIGHTING

The Owner will be responsible for all station drainage, roadways and yard area lighting.

3.9 FOUNDATIONS

The Owner will provide foundations for equipment, buildings and structures. The Seller shall provide the information necessary, including certified vendor information, for the Owner to design the foundations

3.10 COMPRESSED AIR SYSTEM

The Owner will provide a compressed air system with two (2) 100% air compressors in the FGD System area.

3.11 COMMUNICATION SYSTEM

The Owner will be responsible for all public address systems, telephones, and computer connections.

3.12 ERECTION

The Owner is responsible for the erection of the Seller supplied equipment and materials in accordance with the Seller's erection instructions. The Owner is responsible for the identification and relocation of buried piping and electrical equipment.

3.13 ENGINEERING SERVICES

The Owner is responsible for review and acceptance of Seller and equipment supplier's drawings, flow model protocols and results, erection manuals, operation and maintenance manuals, vendor literature, control procedures and set points, system descriptions, start up procedures, training program and other documentation. However, Owner's review and acceptance of Seller's

documents shall not relieve the Seller, as the Engineer of Record, of its obligations to comply with contract requirements. Owner is responsible for any necessary geotechnical surveys.

3.14 RECEIVING, HANDLING, AND STORAGE

The Owner is responsible for the receiving, handling and storage of all Seller supplied equipment and materials in accordance with the Seller's instructions.

4.0 TECHNICAL REQUIREMENTS

This section of the specification covers the high level technical requirements for the FGD system and required unit operating conditions.

4.1 DESIGN BASIS & PERFORMANCE REQUIREMENTS

The following items establish the high level design basis requirements and performance requirements for the FGD system.

[redacted]

4.1.3 OTHER FLUE GAS EMISSIONS

The fabric filter shall be designed to remove particulate down to an emission limit of 0.015 lb/MMBtu in the flue gas produced by the steam generator during all periods of operation from full load to minimum load when firing fuel specified in Section 4.1.8.

The FGD system must be able to remove flue gas emissions other than sulfur dioxide, such as sulfur trioxide, mercury with the addition of activated carbon injection, hydrochloric acid and hydrofluoric acid.

4.1.4 SYSTEM PRESSURE DROP

The FGD System across the entire vendor supplied equipment shall be designed in such a way to minimize the flue gas pressure drop. Component design such as flow straightening devices, turning vanes, and rounded ductwork corners shall be utilized.

4.1.5 EQUIPMENT MODULARIZATION

In order to minimize field construction costs and on-site storage requirements, the FGD System shall be engineered to maximize the extent of off-site equipment fabrication and component modularization. Owner desires overall least-cost project that includes material/equipment, erection labor and professional services.

4.1.6 STANDARIZED EQUIPMENT

The Seller shall consider to the greatest extent possible, standard sized equipment and arrangements (pumps, fans, motors, instruments, agitators, etc.) that gives the Owner the capability for interchangeable equipment and spare parts.

4.1.7 ACCEPTABLE PROCESS CHEMISTRY

The FGD System shall be designed based on lime reagent process chemistry.

4.1.8 FUEL DATA

The Unit 2 fuel is defined as 4.5 lb/MMBtu SO2 and is considered the installed equipment basis fuel. The FGD system shall be designed to operate and perform as specified with the steam generator firing any coal whose properties are defined by the typical coal quality and mineral ash properties listed below in Table 4.1.8.

Table 4.1.8. Big Sandy Unit 2 Fuel Analysis – 4.5 lb/MMBtu SO2.

4.5 lb SO2/mmBTU

45% Central Appalachian Coal / 55% Northern Appalachian Blend

Mine Name: 45% Harris #1 / 55% McElroy

Proximate Data:	As Received:	Dry Basis: (Calc)
% Moisture:	6.63%	
% Ash :	9.89%	10.59%
% Volatile Matter:	36.15%	38.72%
% Fixed Carbon:	47.33%	50.69%
Total Proximate:	100.00%	100.00%
% Sulfur:	2.69%	2.88%
BTU/#:	12,490	13,376
Moist.-Ash-Free BTU/#:	14,962	
Grindability:	49	

Ultimate:	Dry Basis:	As Rcvd: (Calc)
% Carbon:	74.25%	69.33%
% Hydrogen:	5.00%	4.67%
% Nitrogen:	1.43%	1.34%
% Chlorine:	0.05%	0.05%
% Moisture:		6.63%
% Ash:	10.59%	9.89%
% Sulfur:	2.88%	2.69%
Ultimate subtotal:		94.59%
% Oxygen by Diff.:	5.80%	5.41%
% Total:	100.00%	100.00%

 # SO2/mmBTU: 4.31 #

Mineral Ash Data:	Dry Basis		SO3 Free Basis
% SiO_2:	40.59%		41.55%
% Al_2O_3:	20.76%		21.25%
% TiO_2:	0.93%	62.28%	0.95%
% Fe_2O_3:	28.56%		29.24%
% CaO:	2.72%		2.78%
% MgO:	0.72%		0.74%
% K_2O:	1.67%		1.71%
% Na_2O:	0.46%	34.13%	0.47%
% SO_3:	2.32%		
% P_2O_5:	0.46%		0.47%
% SrO:	0.00%		0.00%
% BaO:	0.00%		0.00%
% MnO_2:	0.00%		0.00%
% Undetermined:	0.81%		

Ash Fusion Temperature Data: Reducing Temperatures:	
Initial Deformation (ID):	2265
Softening (H=W):	2310
Hemispherical (H=1/2W):	2395
Fluid (Fl):	2484
Other Data:	
T250 Temperature:	2285

4.1.9 GENERATING UNIT / STEAM GENERATOR INFORMATION

Big Sandy Plant is located in Louisa, Kentucky along the Big Sandy River. The physical address is 23000 Highway 23, Louisa, KY 41230.

Road Access: Entrance to the plant is from U.S. Route 23.
Rail Access: CSX Transportation
Barge Access: No; however barge access is available less than 10 miles away from the plant for construction purposes.

Big Sandy Unit 2

Full Load Firing Rate	8,180 million BTU/hr
Nominal Unit Rating (Gross / Net)	865 / 800 MW
Full Load Net Unit Heat Rate	10,225 BTU/kW-hr
Boiler Type	Pressurized Dry Bottom
Firing Method	Wall fired
[redacted]	
Annual Starts (Hot / Cold)	6 / 4
[redacted]	
Minimum Load Firing Rate	3,089 million BTU/hr
Minimum Load Net Unit Heat Rate	10,472 BTU/kW-hr
Unit Ramp Rate (SCR in/out of service)	5 / 10 MW/min
Air Heater Type	Ljungstrom Rotary Tri-Sector
Ignition Fuel	#2 Fuel Oil
Particulate Control Device	ESP (cold)
Combustion Control Devices	Low NO_x Burner
Other Emission Control Devices	SCR (High Dust, 2003)
Nominal Flue Gas O_2 @ Economizer Outlet	3.5 % (by volume – wet)
Max (upset) Flue Gas O_2 @ Economizer Outlet	4.5 % (by volume – wet)

The Big Sandy Unit 2 circulating water system is a closed loop system. Therefore, the circulating water is recycled and reused in the steam turbine condensers. The heat transferred to the circulating water in the condenser is rejected to the atmosphere by the evaporation process in the cooling tower.

The river water makeup intake structure at Big Sandy consists of two river intake systems: normal and backup.

The normal system has three vertical double suction type river water makeup pumps that are each rated for 10,000 gpm at 130' TDH and are driven by 400 HP, 1800 rpm, 550V motors. Normally two pumps operate to provide all the water needed for the plant and make-up for both cooling tower.

The backup system has two vertical turbine type river water makeup pumps that are each rated for 6,750 gpm at 135' TDH and are driven by 200 HP, 1180 rpm, 550V motors. These backup pumps are used when dirty river conditions cause pluggage to the normal system intake strainers and prevent normal flow of water.

4.1.10 FLUE GAS CONDITIONS

The FGD System shall be designed to treat the expected nominal inlet flue gas conditions downstream of the existing air heater at full load.

Big Sandy Unit 2

Volumetric Flow Rate	3,600,000 acfm (at 350°F & -19" H_2O static pressure)
Mass Flow Rate	9,950,000 lb/hr
Average Flue Gas Temperature	350 ° F
SO_2 Flow Rate	35,300 lb/hr
Flue Gas Particulate Loading	6.33 lb/MMBtu at air heater outlet
SO_3 concentration	23 ppmv
Percent of Flue Gas Treated	100 %

* Note: Calculated gas flow rates are based upon fuel analysis in Table 4.1.8 and operating the steam generator at 21% excess air and an assumed air in-leakage rate of 20 % to account for air heater leakage and any additional leakage due to conversion to balanced draft operation.

[redacted]

Lime Reagent Properties

Proximate Analysis, Dry Basis	Units	Range
Total Calcium Oxide, CaO	% by wt	[redacted]
Total Magnesium Oxide, MgO	% by wt	
Inerts	% by wt	
CO_2	% by wt	

Lime Reactivity Analysis

Lime Analysis, Reactivity Average	Average	Min	Max
3 Min Temp. Rise (°C)	[redacted]		
Slaking Rate (°C/minute)			
Slaking Residue (% remaining on 20 mesh)			

4.1.12 WATER BALANCE AND SUPPLY

The FGD system shall be designed to operate with the only water losses permitted being by evaporation and that leaving with the FGD byproduct. The water balance shall be designed in such a manner that the requirements for fresh makeup water are minimized.

The normal water supply for process water to the FGD system shall be strained Big Sandy River water as defined by the ranges stated in the following tabulated data.

Table 4.1.12. Big Sandy River Water Analysis.

	Average	Range
Iron, Fe (mg/L)	1.00	0.5-5.39
Copper, Cu (ug/L)	5.43	2-10
Sulfate, SO4 (mg/L)	53.33	32-183
Total Hardness, as CaCO3 (mg/L)	153.14	96-260
Chloride, Cl (mg/L)	18.69	7.7-24
Conductivity @ 25 °C (umho)	450.53	210-697
TSS (mg/L)	178.81	6-1300
PH @ 25 °C	7.66	6-8.1
Aluminum	1.7	0.69-4.97
Manganese (mg/L)	0.11	0.08-0.22
Magnesium (mg/L)	48.82	15-83

[redacted]

4.1.14 AMBIENT NOISE EMISSIONS

Near field noise level from operating equipment shall not exceed 85 dBA (when measured 3 ft in the horizontal plane, and 5 feet above grade or personnel platform) whether from the single or surrounding area operating equipment. Far field noise shall not exceed the current preexisting noise level at the property fence line.

4.1.15 EQUIPMENT REDUNDANCY

Redundant equipment shall require that a stand-by installed spare is always available for service with equipment in normal operation and maintenance requirements. A spare fabric filter compartment shall be provided to facilitate maintenance without the loss of generation due to load curtailments. For example on other mechanical equipment: 1) if two pumps are required to be in service at all times, a third installed pump is required to be a spare; 2) if two pumps are required to be in service at all times, but periodic/frequent removal of one pump for maintenance is required, then four pumps are required (2 operating, 1 in routine maintenance, 1 installed ready for service).

[redacted]

4.1.17 EQUIPMENT MAINTENANCE ACCESS

Major motors and equipment shall be accessible for maintenance purposes such as platforms. Overhead cranes or monorails will be provided to facilitate removing and installing components. Buildings shall have access hatches in the operating floors to transport equipment up through the floor to the appropriate elevation. All valves will be remotely operated or accessible from platforms.

4.2 OPERATING CONDITIONS

The FGD CDS and FF system shall be designed to maintain 98% SO2 removal while following Unit load without deposition of solids in ductwork or fabric filter. It shall have sufficient turndown to operate under each of the following conditions without impeding the normal operation of the steam generator while continuously achieving the specified sulfur dioxide (SO_2) removal efficiency.

- During all periods of steam generator operation from initial start-up to full load.
- Continuous service at the maximum scrubber inlet flue gas conditions.
- Continuous service at minimum load.
- During steam generator load swings from 33 to 100 percent of the maximum inlet flue gas flow rate.
- During extended periods of the steam generator start-up while burning No. 2 Fuel Oil, coal, or any combination thereof.
- Weekly start-up, following any weekend shutdown, which lasts approximately 48 hours.

The Owner anticipates that the following type of operating abnormalities may occur to varying degrees throughout the operating life of the plant. While specific design criteria for all possible conditions cannot be defined herein, the Seller shall be aware of the Owner's concern and consequently make necessary design provisions to insure that the following potential abnormalities do not cause catastrophic failure to the FGD System equipment or its auxiliary equipment.

[redacted]

4.3 SITE ENVIRONMENTAL CONDITIONS

The table below lists the general Big Sandy Plant site environmental conditions.

Table 4.3. Big Sandy Plant Site Environmental Conditions.

Condition	Value/Range
Plant Elevation at Grade	568 ft above sea level
Ambient Temperature Normal Range, °F	-20 to 97
Ambient Relative Humidity Range, %	25 to 100
Annual Average Temperature, °F	56.1
Annual Average Relative Humidity, %	70
Annual Average Summer Temperature, °F	74.3
Annual Average Winter Temperature, °F	37.5
Average Wind Velocity (mph)	6.7
Prevailing Wind Direction (Degrees)	186
Annual Average Precipitation (inches)	43.06

5.0 SELLER'S BUDGETARY ESTIMATE REQUIREMENTS

The Seller shall provide the following items for the Owner to properly evaluate the budgetary cost estimate for the FGD CDS and FF system. The budgetary cost estimate shall include, but is not limited to labor, materials, equipment, tools, services, and supervision for the engineering, design, fabrication, delivery, training, startup and commissioning of the FGD CDS and FF system.

5.1 SCOPE STATEMENT

The Seller shall provide a statement of scope for the FGD CDS and FF system. The statement of scope shall describe the scope supplied by the Seller and any exceptions or variations by the Seller to the Owner's scope.

5.2 TOTAL EQUIPMENT COST

The Seller shall provide a total equipment cost for the FGD CDS and FF system. An itemized list of major equipment, including the quantity, shall be included with the total equipment cost.

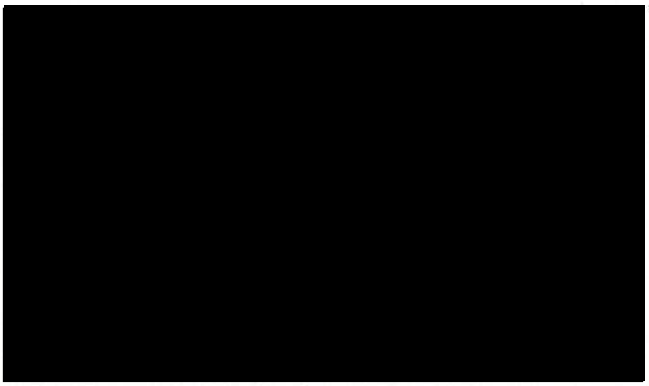
5.3 CONCEPTUAL DRAWINGS

The Seller shall provide a conceptual flow diagram and general arrangement drawings for the FGD CDS and FF system.

5.4 CONCEPTUAL SYSTEM DESCRIPTION

The Seller shall provide a conceptual system description for the FGD CDS and FF system. The system description shall include a description of the process, equipment, and operation. The means of isolation for in-service maintenance of the CDS and FF shall also be described in the conceptual system description.

[redacted]



5.6 LIST OF MATERIALS AND SERVICES

The Seller shall provide a detailed list of any special materials and services included within the scope of the budgetary cost estimate. The list shall itemize the equipment and components the Seller shall supply. The Seller shall also provide a detailed description of the support steel, platforms and stairways to be supplied by the Seller under this budgetary cost estimate.

5.7 KEY MILESTONE SCHEDULE

The Seller shall provide a milestone schedule detailing engineering, fabrication and delivery of all components and equipment for the FGD CDS and FF starting from day 0.

5.8 LIST OF INSTALLATIONS AND REFERENCES

The Seller shall provide a list of installations and references of CDS and FF. The reference should include general information about the site such as:

- Plant name
- Unit number
- Megawatt rating, MWnet
- Application; PC or CFB
- Unit opacity, lb/MMBtu
- Gas flow, acfm at scrubber inlet
- Type of fuel; bituminous, PRB, or other
- Sulfur content of the fuel, lb/MMBtu SO_2
- FGD outlet SO_2 emission, lb/MMBtu SO_2
- FGD commercial date
- Site location
- Plant contact name, email address, and phone number

Technical Specifications Checklist

Project Name: Big Sandy Unit 2 Circulating Dry Scrubber RFI - Budgetary Cost Estimate

Originated by: Larry A. Hicks

Checked by: Gregory M. Gibbs Date: 11/12/2010

Description: Develop a circulating dry scrubber specification for a budgetary cost estimate.

Unique Document ID: BS2-FGDSCE-111210 Rev 0

		Checking Engineer's Initials
1.	Purpose of technical specification is identified.	GMG
2.	Technical requirements are identified including: design basis criteria, performance requirements, applicable regulatory, statutory & industrial codes, and ambient environmental conditions.	GMG
3.	Auxiliary services such as power supply (voltage, current, source), air supply (pressure, volume, source), cooling water (pressure, temperature, volume, source), steam (pressure, temperature, volume, source), etc. are identified.	N/A
4.	Off-site fabrication and modular construction requirements are identified.	GMG
5.	Quality, inspection, and testing requirements are identified. This includes testing requirements to determine quality, reliability, or performance of the product are listed and acceptance criteria identified; requirements for bidders to submit documentation of their quality assurance program; requirements for nondestructive examination, including inspections or examinations prior to shipment are identified; and equipment or systems which involve special requirements such as fire protection or special features such as Professional Engineer seals on documents or Underwriter certifications are identified.	N/A
6.	Vendor documentation requirements are identified including: types of documentation required, document submittal requirements, submittal due dates, specific warranty requirements, identify drawings subject to liquidated damages, and document format requirements.	N/A
7.	Shipping and storage requirements are identified including: bill of material requirements, tagging requirements, special shipping & handling requirements, storage requirements such as the use of preservatives and inhibitors, weather protection, etc. are identified.	N/A
8.	Guarantee and guarantee basis are clearly identified.	N/A
9.	Requirements to provide operation and/or maintenance training are identified.	N/A
10.	Requirements for spare parts are identified.	N/A
11.	Requirements to provide field support services such as installation, start up and/or testing assistance are identified.	N/A

Technical Specification Checklist cont.

		Checking Engineer's Initials
12.	Attachments are included such as: data sheets which contain detail to provide a clear understanding and evaluation of the design parameters (pressure, temperatures, flows, etc.), design features and materials of construction; drawings, industry standards, addenda or other documents, and a list of other documents that form part of the technical specification.	GMG
13.	Verify technical specification cover sheet has a title, a technical specification number, date, and a technical specification revision number.	GMG
14.	Verify revision index includes revision number and description of revision.	GMG
15.	Verify that supporting calculations have been performed and checked.	N/A
16.	Appropriate interdisciplinary review complete.	GMG
17.	The specified materials, parts, equipment, and processes are suitable for the required application.	GMG
18.	The specified materials are compatible with each other and the design environmental conditions to which the material will be exposed.	GMG
19.	Plant specific operating data have been verified and if necessary, incorporated into design basis	GMG
List others below as applicable.		
20.		
21.		

Note: Use N/A to indicate check is not applicable.

G. M. Gibbs	G. M. Gibbs	11/12/2010
Checked by *(Print name legibly)*	*Checked by (Signature)*	Date

Engineering completed in accordance with SOP 730.04, Technical Specifications and reviewed by:

	FP-DCE	11/12/2010
Engineering Manager	Department	Date