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Case Histories: Asheville Power Station's Retrofit First to Meet North Carolina's Clean Smokestacks Act

Asheville Power Station's Unit 1 in Arden, North Carolina, was the first coal-fired unit to be modified with a flue gas desulphurization (FGD) system and placed in service to meet the clean air requirements of the state's Clean Smokestacks Act. As of November 16, 2005, at least 97% of the sulfur dioxide that had been emitted from the plant's boiler is now being removed. The FGD system for Unit 2, the second FGD to be placed in service in the state, went into operation May 17, 2006.

Asheville is part of an $82 million Clean Smokestacks Program contract awarded by Progress Energy Carolinas in 2002. The goal of the program is to provide air quality control systems for a number of the company's coal-fired units throughout the state.

Asheville's Units 1 and 2 are drum-type units rated at net generating capacities of 200 MW and 194 MW respectively. They include a single wall-fired boiler and reheat steam turbine with auxiliary facilities common to both units. Unit 1 went into commercial operation in 1964; Unit 2 joined it in 1971.

The retrofit project encompassed the installation of a wet FGD system for each unit with new individual flues enclosed in one common concrete stack. In addition to the FGD work, selective catalytic reduction (SCR) systems were added to both units with a common two-unit ammonia supply system.

The SCR systems were designed to remove a minimum of 90% of nitrogen oxides from the boiler flue gas. Unit 2 was converted to balanced-draft operation. Asheville's Unit 1 SCR is on schedule to be operational by April 2007.

In addition to the FGD and SCR systems retrofit, a generator step-up transformer was installed on Unit 1, and SO_3 mitigation systems were installed on both units. Larger steam coil air heaters to raise the flue gas temperature above the acid dew point were also installed on the units. Prior to this addition, the low flue gas temperature led to corrosion of Unit 1's precipitator and ductwork. This retrofit required installation of a new high-efficiency electrostatic precipitator (ESP) to replace the existing ESP.

Meeting the aggressive in-service dates, which were tied to Progress Energy Carolinas' planned maintenance schedules, required close coordination and cooperation of the project team. That team consisted of WorleyParsons, The Babcock & Wilcox Co., and Fluor.

Challenging schedule dates and the need to reduce overall cost while maintaining plant operations throughout the erection, required the team to follow tight sequencing of an accelerated schedule of 26 months (27 to 30 months is the norm). Efficiency was enhanced by the use of an integrated 3-D model of the plant with continual real-time input from the entire team. As a result, it allowed for a smooth transition from engineering and design to construction execution.

Communication

Communication among project team members and the client was critical in order to minimize rework and to address concerns in a timely manner. Weekly teleconferences were rigorously held to review the critical path schedule and disposition of open action items. Additional weekly teleconferences with the client's lead engineers discussed drawing/document review status, comments, and technical issues.

Biweekly 3-D model reviews were conducted via the Internet to address engineering and design issues and constructability reviews. Constructability reviews were also held during monthly site meetings with all interested plant personnel attending. A site-initiated request for information (RFI) system, requiring responses within 24 hours of receiving an RFI, and a project execution plan to formalize and standardize common processes and procedures helped the team meet critical workflow milestone targets.

Schedule Milestones

In order to accomplish the Unit 1 FGD system tie-in within a two-week outage starting in November 2005, modifications to the existing balance-of plant-systems, such as the air and water systems, were made during a six-week turbine outage that started September 18, 2004. Replacement of the unit auxiliary and start-up transformers were completed during this outage.

The Unit 2 FGD and SCR systems were tied into the existing plant during a six-week turbine outage starting April 29, 2006. Due to the balanced draft conversion of the boiler, the critical path activity included stiffening of the existing electrostatic precipitator. All Unit

2 commissioning activities were completed 36 hours ahead of schedule.

The chimney and the FGD absorber towers had to be constructed within the same time period. This was accomplished by starting the chimney work a few weeks earlier than the first absorber tower. To safely allow for parallel construction, a certified safety bar was placed over the scaffolding of the absorber tower. With the chimney crew finishing their work earlier than the absorber tower crew, the absorber tower safety barrier was raised in time to support the next day's chimney and absorber tower construction activities.

The FGD building was offset to the west of the coal pile and required long flue gas duct runs to the inlet of the absorber towers. To facilitate the construction schedule and minimize construction costs, the ductwork was designed to maximize shop fabrication while meeting truck shipping limits.

Special permitting and escorts were required by the trucking companies to transport several sections of the oversized ductwork sections from Alabama to the plant in North Carolina. The shop fabrication and extra shipping costs were more than offset by savings in field installation costs.

Due to the increased draft needs for the FGD and SCR systems, the induced draft fans for Unit 1 had to be replaced. Because Unit 2 was converted to balanced draft, new induced draft fans were installed. To minimize outage time, the fan foundations, fans and motors, and interconnecting ductwork were procured, engineered, installed, and commissioned as pre-outage activities.

Engineering and Design Considerations

A process selection study comparing wet with dry FGD systems was completed in 2003. Results of the study showed marginal but positive benefits to using a wet limestone forced-oxidation process.

Two key factors that contributed to Progress Energy Carolinas' decision to select the wet FGD system were cost savings and efficiencies in construction that will carry over to the other coal-fired plants targeted to have wet FGD systems installed. In addition, the gypsum by-product of a wet FGD process can be sold for commercial use, thus lowering disposal costs. In contrast, a dry FGD system's by-product is unusable and must be disposed of in a landfill.

Other benefits to selecting a common, wet FGD system — from engineering, operation, and maintenance standpoints — included:

- The opportunity to apply lessons learned during engineering and construction of the early units to subsequent units.
- Better fuel flexibility, equipment and spare part cost savings, and enhancements in the operation and maintenance of the FGD systems because they'll be the same for all Progress Energy Carolinas' plants.

To facilitate FGD system operation and maintenance, a facility arrangement was developed that co-located all 1 and 2 units and common systems into a single FGD system area.

Engineering and design of the foundation for the new chimney and its specification required the vendors to furnish not-to-exceed loads in their proposals. The design was based on the successful chimney vendor's loading. For the major FGD system equipment, including the absorber tower, the not-to-exceed loads were supplied by the tower vendor and Babcock & Wilcox.

To maintain the entering flue gas temperature to the SCR reactor within the limits required by the SCR catalyst supplier, a portion of the Unit 1 economizer tubes was removed. The remaining tubes were jumpered to raise the boiler exit gas temperature. Due to the boiler configuration and available space, it was not possible to use economizer bypass dampers. Because Unit 2 had a different boiler design than Unit 1, it was possible to regulate the flue gas temperature going to the reactor economizer by installing bypass dampers.

Project Details

Phase 1 of the project began in early 2003 and consisted of securing the location of the FGD and SCR systems and the limestone- and gypsum-handling systems. At the same time, preparation of preliminary general arrangements, piping and instrument drawings and electrical one-line diagrams, major equipment sizing, conceptual engineering and construction scheduling, estimated bulk material quantities, and estimated project cost were completed. Phase 2 began in September 2003 with detailed engineering and design, procurement, construction, and commissioning of the FGD, SCR, and balance-of-plant systems.

Given the location of the plant in the far western portion of North Carolina and its contribution to the local electrical grid, maintaining at least one of the units in service at all times was critical. Minimizing single-source failures was a primary consideration in systems engineering and equipment redundancy. Even though one absorber tower could have been used for both units, each unit has its own absorber tower and associated support systems.

The original chimneys for Units 1 and 2 were abandoned and will be demolished in the future. Because of the high moisture droplet content of the flue gas exiting the absorber towers, the chimneys cannot be used with a wet FGD system.

Because the plant is located near a residential area, the FGD system equipment was enclosed in a building to mitigate noise. The enclosure allowed for construction during the winter months and eliminated the need for electrical heat tracing of piping. It also minimized low-temperature concerns associated with FGD system rubber-lined equipment and piping during construction and operation.

Water and Compressed Air Systems

Redundant pumps were provided for all balance-of-plant water systems. Fire water and potable water are supplied from existing fire water and potable water systems; make-up water is pumped from on-site Lake Julian. The lake is also the source of the plant's cooling water. Service and instrument air is provided by two new 100% capacity air compressors, and the FGD compressed air system is cross-tied to the existing plant service air system.

Limestone and Gypsum Handling

Limestone is delivered by truck to the limestone storage pile. The limestone-handling system is a single-train system moving limestone from the storage pile to a crusher and then to the limestone day bins. A single-train system was specified because the limestone day bins were sized to provide 48 hours of inventory, thereby maintaining limestone feed to the process while conveying system maintenance is performed.

A backup procedure uses crushed limestone delivered by a pressure differential truck and discharged directly into the limestone day bins. Motor and belt repair can be done within the storage time of the redundant limestone day bins. Due to long delivery times for the limestone, spare gear boxes were purchased.

Gypsum handling is accomplished via a single-train system, which moves gypsum from the four dewatering centrifuges to the storage dome. As with the limestone-handling system, to ensure availability of the gypsum-handling system, spare gear boxes were purchased. Motor and belt repair can be done within the storage time of the process tanks.

If the gypsum conveyor is out of service the gypsum can be moved directly to the gypsum storage dome. The dome was installed over the gypsum pile to avoid excessive moisture from rainfall. It has a concrete floor to facilitate removal of the gypsum by a front end loader into trucks.

A truck scale was installed to weigh incoming trucks delivering coal and limestone, and outgoing trucks removing gypsum. A truck wash station was installed to wash the truck bed after a coal delivery to minimize carbon contamination of the gypsum. Because the trucks travel through a neighboring residential area, a truck's tires are washed before the truck leaves the plant.

Auxiliary Power Distribution Systems

The existing unit auxiliary transformers and the common start-up transformer were replaced with larger-capacity three-winding transformers. This was necessary due to the increase in plant electrical load from the FGD, SCR, and balance-of-plant system's equipment and new induced draft fans for each unit. New 6.9-kV and 480-volt distribution systems were provided for the FGD, SCR, and balance-of-plant systems' equipment. The existing plant's 4.16-kV system is now fed from the new transformers.

An existing Honeywell distributed control system was upgraded and expanded to accommodate the I/O for the FGD, SCR, and balance-of-plant systems. In addition, the control room was expanded for the additional HMI (human-machine interface) screens and new control console.

Wastewater Treatment

The primary wastewater treatment system consists of a clarifier for solids removal, redundant filter presses, and pH control using acid and caustic metering systems. All of the absorber tower blowdown is mixed with the dilution water. This lowers the chlorides concentration and temperature to a level acceptable to the secondary treatment system. The primary wastewater treatment system is enclosed in a building for the same reasons that the FGD system equipment is: mitigating noise and minimizing heat tracing.

A unique aspect of the wastewater treatment system is the use of a constructed wetlands treatment system (CWTS) based on a pilot plant implemented at Clemson University in March 2003. Funding for the pilot plant was shared by Progress Energy Carolinas and Duke Energy. The CWTS is a secondary wastewater treatment system configured to remove selenium and mercury from the FGD system blowdown. It is essential for ensuring that the plant achieves effluent limitations established under the National Pollutant Discharge Elimination System, the Clean Water Act, and in accordance with North Carolina State wastewater discharge limits.

In order to have the waste treatment facilities on-line by November 2005, the waste treatment building was ordered prefabricated, and the equipment support steel was designed as free-standing structures internal to the building. The elimination of interfaces with the prefabricated building supplier minimized the prefabricated building supplier's fabrication time and maximized site equipment installation time.

The primary wastewater treatment system, previously described, has a clarifier to remove suspended solids, a chemical feed systems to adjust pH, and mixing facilities to dilute the treated flow with service water. Dilution is required to cool the treated flow to 104F – 105F and to lower the chloride concentration to 6,000 ppm levels acceptable to the CWTS plants.

The CWTS was designed to treat approximately 0.54 million gallons/day at the average projected FGD wastewater flow of 375 gallons/minute (75 gallons/minute FGD blowdown and 300 gallons/minute dilution water). Effluent from the primary treatment system initially enters two equalization basins for cooling, mixing, concentration equalization, and secondary settling of solids.

Water from the equalization basins is split into two equal flows, each entering a treatment train. The treatment trains consist of two 0.83-acre bulrush wetland cells, a 0.14-acre rock filter, and a 1.11-acre cattail wetland cell. Total treatment area is 6.5 acres with a hydraulic retention time of eight days based on the average projected flow. Design of the CWTS will achieve the treatment discharge objectives for mercury (0.00063 mg/L) and selenium (0.263 mg/L). The oxidation-reduction (redox) potential of the cells is monitored to ensure that the needed biological, chemical, and physical processes are taking place.

Progress Energy Carolinas and WorleyParsons, together with their project team members, successfully met the required in-servic dates for the FGD and SCR systems. Effective communication, aggressive scheduling, and lessons learned from engineering and construction have allowed the plant to achieve its sulfur dioxide and nitrogen oxide reduction targets. Safety was a priority, and because of this the project was finished with zero lost time accidents and a recordable incident rate of 0.46.

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