Small muni co-op achieves big NO_x reductions

The Texas Municipal Power Agency is two years ahead of schedule to comply with a state mandate to reduce NO_x emissions from its Gibbons Creek power plant to 0.165 lbs/mmBtu or less. Two things are remarkable about TMPA's achievement: NO_x was reduced by modifying only the plant's combustion and fuel-delivery systems, and the initiative wasn't structured as a typical EPC project—because the Texas regulator wouldn't allow it.

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The cities of Bryan, Denton, Garland, and Greenville created the Texas Municipal Power Agency (TMPA) in 1977 to pool their resources in order to better cope with a perceived rise in natural gas prices. TMPA was the first entity of its kind in Texas to take advantage of a then-new state law allowing municipalities to own power plants.

Today, TMPA owns and operates the Gibbons Creek Electric Generating Station, which has one 480-MW, tangentially fired, pulverized coal unit. The unit became operational in 1983 and originally fired a locally mined, low-grade Texas lignite (Figure 1). Gibbons Creek is about 18 miles east of Bryan/College Station and roughly 90 miles north of Houston.

In 1996, TMPA management switched exclusively to PRB coal to improve the economics of Gibbons Creek and to lower SO_2 emissions. The switch required relatively minor changes to the physical plant and its control systems. Only one of the original eight mills was removed from service, although only five mills are needed for full-load operation using PRB coal as fuel.

Gibbons Creek is located in an ozone attainment area of east Texas between the Dallas–Fort Worth and Houston-Galveston nonattainment regions. A few years ago, the Texas Natural Resource Conservation Commission (now the Texas Commission on Environmental Quality, TCEQ) decided that emissions from facilities located in nearby attainment regions can affect the environmental compliance of plants in nonattainment areas. As a result of Texas Legislature Senate Bill 7, TCEQ established a NO_x emission limit of 0.165 lb/mmBtu for plants in such areas. Staying within that limit will become mandatory in 2005 for TMPA and the Gibbons Creek plant.

1. Gibbons Creek Station. TMPA's 480-MW Gibbons Creek Station must emit no more than 0.165 lb/mmBtu of NO_x beginning in 2005. The plant began burning PRB coal in 1996. *Courtesy: Burns & McDonnell*

At the time of the fuel switch to PRB coal, NO_x emissions from Gibbons Creek were limited to 0.60 lb/mmBtu. TMPA initially had trouble developing a response to the new NO_x regulations due to staffing and budget limitations. Adding to this difficulty was a complicating factor: The state would not allow management of TMPA (or any other Texas muni) to structure the necessary emissions-reduction initiative as an engineer, procure, and construct (EPC) project. This requirement, which typically forces vendors to bid only on portions of a project rather than as a turnkey job, serves to limit project flexibility and the potential for cost savings.

Hatching a plan

TMPA management assigned two people to work on the project with air quality scientists from Burns & McDonnell Engineering (Kansas City, Mo.). The team's primary goal was to reduce NO_x emissions without resorting to selective catalytic reduction (SCR) and at the same time correct long-term shortcomings resulting from the 1996 fuel switch. The team estimated that the project would take a minimum of three years to complete, with major installation and modification activities scheduled to take advantage of the unit's annual spring outages.

Burns & McDonnell acted as TMPA's engineer in a support/auditing role by creating specifications for major portions of the work and by assisting TMPA personnel in quality control and drawing support. Using a "first-principles" technique, the team devel-

oped a phased approach to maximize guaranteed NO_x reductions, minimize adverse operational changes, and complete the project within a relatively tight budget. Initial expectation of a 42% reduction in NO_x to a level of 0.20 lb/mmBtu seemed optimistic but nonetheless was made the initial goal.

The team envisioned a three-phase plan covering seven areas of plant operation. Its initial assumption was that no vendor would provide meaningful NO_x emissions guarantees unless the vendor could be assured that coal with certain specifications, including required particle fineness, would be delivered to the boiler. Phase I therefore focused on optimizing fuel preparation and transport to the boiler. Phase II focused on modifications that integrated combustion improvements with NO_x reduction. Phase III, which is ongoing, addresses additional NO_x reduction possibilities and fine-tuning of controls.

Tackling fuel supply first

The project kicked off with the examination of a variety of fuel-delivery problems. One was that the coal piping at Gibbons Creek was too large to handle PRB coal properly. Another was that the plant's existing system for controlling primary air to individual mills was adequate for safe combustion and temperature control but too variable for precise control and measurement. The project team corrected the fuel line-sizing problem by replacing the original, 26-inch-diameter piping with 4,000 feet of 24-inch piping designed and supplied by BendTec Inc. (Duluth, Minn.). TEI Constructors (Mobile, Ala.) had no problem installing the new pipe in 21 days (Figures 2 and 3).

The project team solved the primary-air problem by replacing the existing control system's venturi flow meters with modern airflow instrumentation in the form of Raleigh, N.C.–based Air Monitors' combustion air monitoring system (CAMS). As part of this effort, all of the plant's original damper drives were replaced with more rugged Beck drives. Several original dampers were replaced as well.

The final step TMPA took to improve fuel delivery was removing the plant's top pulverizer, a 1003-RP model from Combustion Engineering, from service. Each of the original eight pulverizers was designed to run with 60% particle passage through a 200-mesh screen, but 70% through 200-mesh has proven better for low-NO_x combustion. The pulverizer discharge ring surrounding the multiport outlet was extended and optimized on all pulverizers.

These fundamental changes to the fuel supply system not only improved combustion efficiency but also reduced NO_x generation by 20%, as confirmed in tests performed by Pittsburgh-based independent testing lab Energy Systems Associates Inc. These first steps focused on increased fuel velocity, which enhanced fireball locations and fuel/air mixing characteristics.

Major air mods

The aggressive project schedule required boiler burner modifications to be done quickly. Several vendors were invited to participate in baseline combustion testing following completion of the Phase I outage. The bids called for compliance with emission guarantees with five or six of the seven available mills. Several innovative and competitive proposals were submitted, and Foster Wheeler Energy Corp.'s (FWEC) Tangential Low NO_x (TLN3) system was ultimately selected as having the most flexible design, the strongest guarantee, and the best track record of reducing NO_x on similar units (Figure 4).

Foster Wheeler typically takes a conventional approach to NO_x control: the use of separated overfire air ducts (SOFA) and the retrofitting of low-NO_x burners to existing T-fired windboxes. The integrated solution FWEC came up with uses a combustion air distribution monitor (CADM) system to measure the flow of secondary combustion air moving through the windbox and an electron-charged transfer (ECT) system to measure the flow of fuel through each coal conduit. The combined system measures coal flow to the boiler corners and optimizes airflow to each combustion cell.

2. Downsizing. More than 4,000 feet of 26-inch-diameter fuel piping was replaced with 24-inch pipe in only 21 days. *Courtesy: Burns & McDonnell*

4. TLN3 system. Foster Wheeler Energy Corp.'s tangential, low-NO_x (TLN3) combustion system was chosen for its flexible design and successful track record on similar projects. *Courtesy: Burns & McDonnell*

3. Modernizing. In addition to replacing Gibbons Creek's fuel piping, the emissions-reduction project team improved primary air control by installing modern airflow instrumentation and replacing the original damper drives and several dampers. *Courtesy: Burns & McDonnell*

5. New ductwork. The TLN3 system installation required the addition of ductwork, which was routed through existing structural members without restricting access to any wall blowers. Four new windboxes were placed about 30 feet above the primary windbox. *Courtesy: Burns & McDonnell*

The two systems work hand-in-glove. The calculated optimum air-fuel balance at each elevation and corner is transmitted as a bias signal to the windbox damper controllers. The resultant closed-loop control minimizes NO_x production while ensuring that enough air flows with the fuel to minimize the formation of CO.

The TLN3 system was engineered, fabricated, and delivered to the plant in 16 weeks by Foster Wheeler. Modifications included installation of the SOFA take-off duct on the east and west sides of the unit. The duct was routed through existing structural members without restricting access to any wall blowers. Four SOFA windboxes were placed about 30 feet above the primary windbox (Figure 5).

The work also included changes to the plant's original windbox damper actuation system. New bearings were installed, damper compartments were modified to maintain control even if secondary air is lost, and damper actuator controls were upgraded to provide independent actuation and feedback to the plant control system. Watkins Engineers and Constructors Inc. (Tallahassee, Fla.) installed the equipment and made it operational in four weeks. In conjunction with this work, Watkins also installed new stationary coal nozzles that had been resized by Foster Wheeler to replace the lignite nozzles, which were worn out. Four new Beck nozzle-tilt drives with independent control and feedback replaced the original pneumatic drives that were actuated by a single demand signal.

The ECT-CADM fuel injection system already has been commissioned. With the complete system in service, the plant now enjoys a significant reduction in NO_x as well as improved O_2 distribution and temperature balance.

The final phase

Following the successful completion of rough combustion tuning during the 2002 spring unit outage, Emerson Process Management (Houston, Texas) began work tuning Gibbons Creek's WDPF 2 plant control system from Westinghouse Electric Co. This work was performed prior to precommissioning work on the Foster Wheeler fuel injection system to take advantage of the availability of the project team to troubleshoot the firing systems as they were being tuned.

Because of new demands imposed by the Electric Reliability Council of Texas as part of its deregulation of the state's electricity market, the controls upgrade will allow Gibbons Creek to operate in true load-following mode rather than as a classic baseload plant. In this mode, the plant can respond more quickly to dispatchers' call for more supply to meet demand.

In addition to making the changes to Gibbons Creek's fuel-delivery and combustion systems, TMPA contracted with Pavilion Technologies Inc. (Austin, Texas) to install its Pegasus Power Perfecter artificial intelligence software to predict and manage NO_x-related parameters. The application has been effectively used at other utilities to lower heat rate, reduce emissions, and allow quicker, more efficient operation of boilers.

The bottom line

To date, the results of the NO_x-reduction project have been very encouraging. The emission rate for the pollutant has been documented at 0.11 lb/mmBtu, with CO emissions at 0.5 lb/hr. With some mill combinations, NO_x output at full load has averaged less than 0.11 lb/mmBtu. The unit's heat rate is less than 10,100 Btu/kWh, and temperature distribution is more even across the boiler. The saving in fuel costs resulting from the decrease in the plant's net heat rate is expected to be $250,000 per year. TMPA personnel anticipate that, once system tuning is complete, Gibbons Creek's NO_x emissions will be less than 0.1211 lb/mmBtu with less than 10 ppm of CO. As a result, the plant may find itself in compliance with the 2005 TCEQ NO_x limit of 0.165 lb/mmBtu two years early. ■