Biomass Cofiring With Coal at Seward, Pennsylvania

Evan Hughes
Electric Power Research Institute

Joseph Battista
GPU Genco

David Tillman
Foster Wheeler Environmental

Abstract

The first test under the EPRI/FETC biomass cofiring process was at GPU Genco's 32-MW_e pulverized coal boiler at Seward, Pennsylvania. The unit used in the test (Boiler #12) is a wall-fired boiler built by Babcock & Wilcox, and has a nominal steaming capacity of 300,000 lb/hr of 675 psig/850 °F steam. The furnace of Boiler #12 has a volume of 20,000 ft^3, and has a volume in the primary combustion area of 12,700 ft^3. The boiler has two rows of burners, with three burners installed on each row. Typically it consumes coal at about 14 ton/hr when firing at 100 percent of capacity. This boiler, along with Boiler #14, supply steam to a 64 MW_e Westinghouse turbine. The net station heat rate (NSHR) for Boilers #12 and #14, and the associated turbine, is 14,200 Btu/kWh. Boiler #14 has been used to test coal water slurry (CWS), and that experience contributed to the design and execution of this cofiring test, where sawdust was the biomass fuel.

Under contract to EPRI, Foster Wheeler Environmental Corporation (Foster Wheeler) designed and procured a cofiring system used for the testing. This system included a trommel to screen the wood to < 1/4 inch particle size, a large tent for fuel storage, a metering bin with the capacity to feed three lock hoppers. Those lock hoppers, in turn, fed three pneumatic transport systems. Each transport system had the capacity to deliver up to 4,000 lb/hr of sawdust to the face of the boiler. Each transport was injected down the center pipe of each burner on the top row, and diffused into the coal flame.

Foster Wheeler also procured two types of sawdust: a coarse sawdust produced by a sawmill with a circular saw headrig, and a finer sawdust produced by a sawmill with a bandsaw headrig. Both types of sawdust contained significant percentages of moisture. Both types were fine, with the majority of the material being < 1/8 inch particle size and a significant fraction being < 1/16 inch particle size.

Ten tests were conducted during the period of December 11 through 16, 1996. These tests were established to determine the influence of cofiring on the following parameters:

- boiler steaming capacity

- boiler efficiency
- boiler stability
- combustion temperatures
- heat release rates and residence times in the furnace and primary combustion area
- combustion completeness
- formation of airborne emissions, particularly NO_x

Cofiring tests were conducted with up to 20.7 percent sawdust (mass basis), or up to 9 percent sawdust (heat input basis). The results of the test program were significant, and generally favorable although certain problems were uncovered.

Because of the fuel delivery system, cofiring increased the capacity of the boiler, particularly when firing wet coal. Because wet coal limits the steaming rate of the boiler to < 300,000 lb/hr, and because the cofiring system had the potential to increase the delivery of fuel to the furnace, cofiring increased the potential capacity of the unit.

Cofiring decreased boiler efficiency, but not severely. Three tests conducted without sawdust in the unit had calculated boiler efficiencies of 85.4 percent, 83.9 percent, and 84.3 percent. Efficiencies when cofiring wood waste ranged from 83.7 percent to 85.1 percent depending upon the percentage wood cofiring, the type of wood, and the excess O_2 of the boiler. This modest decrease was within the range of acceptability. Boiler stability was not at issue.

Combustion temperatures decreased, but only slightly, when cofiring was practiced. Heat release rates increased as a function of the firing rate of the boiler. Residence times in the furnace, and in the primary combustion zone did not decrease significantly when cofiring was practiced.

Potential problems with combustion completeness may have occurred when cofiring was practiced. Visual evidence also exists of some embers being in the flyash at the mechanical collectors, although the extent of this problem is not documented. Carbon monoxide formation increased when cofiring was practiced, however this increase was within acceptable limits.

SO_2 emissions are a function of fuel sulfur content. Cofiring reduces fuel sulfur content and, consequently, SO_2 emissions. NO_x emissions also decreased as a function of cofiring and the ability to reduce NO_x emissions proved substantial. Although there were few tests with acceptable NO_x data, and some uncertainties existed with the data due to the sampling location, these data led to the creation of the following NO_x management equations:

$$NO_x,\ lb/10^6\ Btu = 0.59 + 0.001\ (HI) - 0.924\ (W) \qquad (r^2 = 0.97)$$

$$NO_x,\ lb/10^6\ Btu = 1.245 - 2.75\ (V/FC) + 0.25\ (FN) \qquad (r^2 = 0.87)$$

Where:

HI is heat input to the boiler in 10^6 Btu/hr
W is the percent wood cofired, expressed on a mass basis
V/FC is the volatile/fixed carbon ratio
FN is the fuel nitrogen content in lb/10^6 Btu

Essentially, the wood reduces the fuel nitrogen content and, because of the combustion technique, reduces the stoichiometric ratio at the center of the flame, leading to increased combustion staging in that location. The volatility of wood accentuated the ability to reduce the stoichiometric ratio at the center of the flame.

The cofiring test then demonstrated that sawdust could be fired with coal in a wall-fired boiler. Economic advantages occurred in terms of increasing the boiler capacity when cofiring with wet coal, and reducing SO_2 and NO_x emissions. Economic penalties associated with boiler efficiency were modest. The primary concern, unburned carbon in the bottom ash and flyash, merits additional investigation because this issue must be resolved if moderate percentage cofiring is to be practiced commercially in older wall-fired pulverized coal boilers.