



Biomass Cofiring in Coal-Fired Boilers

An Online Continuing Education Course for Engineers

Course Number: R-3013

Credit: 3 Hours / 3 PDH / 3 CPD

Abstract

Biomass energy technologies convert renewable biomass fuels to heat or electricity. Next to hydro-power, more electricity is generated from biomass than from any other renewable energy resource in the United States. Biomass cofiring is attracting interest because it is the most economical near-term option for introducing new biomass resources into today's energy mix.



Figure 1. The NIOSH boiler plant was modified to cofire biomass with coal.

Cofiring is the simultaneous combustion of different fuels in the same boiler. Cofiring inexpensive biomass with fossil fuels in existing boilers provides an opportunity for energy

managers to use a greenhouse-gas-neutral renewable fuel while reducing energy and waste disposal costs and enhancing national energy security. Specific requirements will depend on the site. But in general, cofiring biomass in an existing coal-fired boiler involves modifying or adding to the fuel handling, storage, and feed systems. Fuel sources and the type of boiler at the site will dictate fuel processing requirements.

Biomass cofiring can be economical at facilities where most or all of these criteria are met: current use of a coal-fired boiler, access to a steady supply of competitively priced biomass, high coal prices, and favorable regulatory and market conditions for renewable energy use and waste reduction.

This course describes biomass cofiring, cost-saving mechanisms, and factors that influence its performance. Worksheets allow the reader to perform preliminary calculations to determine whether a facility is suitable for biomass cofiring, and how much it would save annually. The worksheets also allow required biomass supplies to be estimated, so managers can work with biomass fuel brokers and evaluate their equipment needs. Also included is a case study describing the design, operation, and performance of a biomass cofiring project at the DOE Savannah River Site in Aiken, South Carolina.

About the Technology

Biomass is organic material from living things, including plant matter such as trees, grasses, and agricultural crops. These materials, grown using energy from sunlight, can be good sources of renewable energy and fuels.

Wood is the most commonly used biomass fuel for heat and power. The most economical sources of wood fuels are wood residues from manufacturers and mill residues, such as sawdust and shavings; discarded wood products, such as crates and pallets; woody yard trimmings; right-of-way trimmings diverted from landfills; and clean, nonhazardous wood debris resulting from construction and demolition work. Using these materials as sources of energy recovers their energy value and avoids the need to dispose of them in landfills, as well as other disposal methods.

Biomass energy technologies convert renewable biomass fuels to heat or electricity using equipment similar to that used for fossil fuels such as natural gas, oil, or coal. This includes fuel-handling equipment, boilers, steam turbines, and engine generator sets. Biomass can be used in solid form, or it can be converted into liquid or gaseous fuels. Next to hydropower, more electricity is generated from biomass than from any other renewable energy resource in the United States.

Cofiring is a fuel-diversification strategy that has been practiced for decades in the wood products industries and more recently in utility-scale boilers. Several facilities have also cofired biomass and coal. Cofiring involves

substituting biomass for a portion of the fossil fuel used in a boiler.

Cofiring inexpensive biomass with fossil fuels in existing boilers provides an opportunity for energy managers to reduce their energy and waste disposal costs while making use of a renewable fuel that is considered greenhouse-gas-neutral. Cofiring biomass counts toward goals for increasing the use of renewable energy or “green power” (environmentally benign electric power), and it results in a net cost savings. Cofiring biomass also increases our use of domestic fuels, thus enhancing the nation’s energy security.

This course focuses on the most promising, near-term, proven option for cofiring—using solid biomass to replace a portion of the coal combusted in existing coal-fired boilers. This type of cofiring has been successfully demonstrated in nearly all coal-fired boiler types and configurations, including stokers, fluidized beds, pulverized coal boilers, and cyclones. The most likely opportunities at facilities will be found at those that have stokers and pulverized coal boilers. This is because the optimum operating range of cyclone boilers is much larger than that required at most facilities.

One of the most important keys to a successful cofiring operation is to appropriately and consistently size the biomass according to the requirements of the type of boiler used. Biomass particles can usually be slightly larger than coal particles, because biomass is a more

volatile fuel. Biomass that does not meet these specifications is likely to cause flow problems in the fuel-handling equipment or incomplete burnout in the boiler. General biomass sizing requirements for each boiler type mentioned here are shown in Table 1.

Table 1. Biomass sizing requirements.

Existing Type of Boiler	Size Required (inches)
Pulverized coal	≤ 1/4
Stoker	≤ 3
Cyclone	≤ 1/2
Fluidized bed	≤ 3

More detailed information follows about the cofiring options for stoker and pulverized-coal boilers.

Stoker boilers. Most coal-fired boilers are stokers, similar to the one shown in the schematic in Figure 2. Because these boilers are designed to fire fairly large fuel particles on traveling or vibrating grates, they are the most suitable boiler type for cofiring at significant biomass input levels. In these boilers, fuel is either fed onto the grate from below, as in underfeed stokers, or it is spread evenly across the grate from fuel spreaders above the grate, as in spreader stokers. In the more common spreader-fired traveling grate stoker boiler, solid fuel is mechanically or pneumatically spread from the front of the boiler onto the rear of the traveling grate. Smaller particles burn in suspension above the grate, while the larger particles burn on the grate as it moves the fuel from the back to the front of the boiler. The ash is discharged from the grate into a hopper at the front of the boiler.

The retrofit requirements for cofiring in a stoker boiler will vary, depending on site-specific issues. If properly sized biomass fuel can be delivered to the facility premixed with coal supplies, on-site capital expenses could be negligible. Some facilities have multiple coal hoppers that discharge onto a common conveyor to feed fuel into the boiler. Using one of the existing coal hoppers and the associated conveying equipment for biomass could minimize new capital expenses for a cofiring project. Both methods have been successfully employed at stoker boilers for implementing a biomass cofiring project. If neither of these low-cost options is feasible, new handling and storage equipment will need to be added. The cost of these additions is discussed later.

Pulverized coal boilers. There are two primary methods for cofiring biomass in a pulverized coal boiler. The first method, illustrated in Figure 3, involves blending the biomass with the coal before the fuel mix enters the existing pulverizers. This is the least expensive method, but it is limited in the amount of biomass that can be fired. With this blended feed method, only about 3% or less of the boiler's heat input can be obtained from biomass at full boiler loads because of limitations in the capacity of the pulverizer.

The second method, illustrated in Figure 4 on page 5, requires installing a separate processing, handling, and storage system for biomass, and injecting the biomass into the boiler through dedicated biomass ports. Although this method is more expensive, it allows greater amounts of biomass to be used—up to 15% more on a

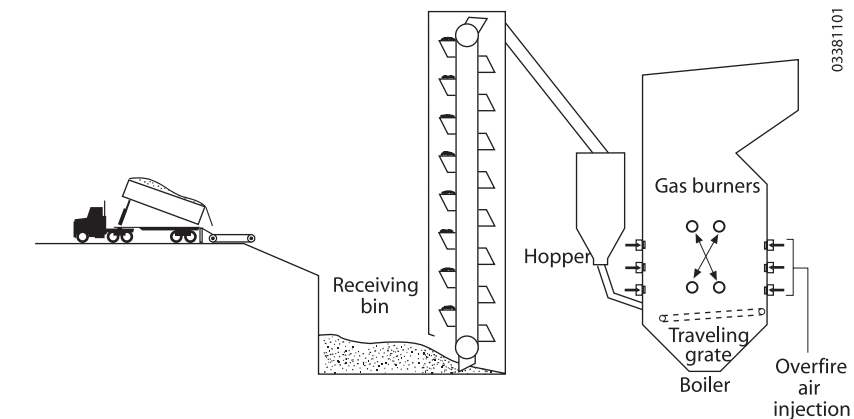


Figure 2. Schematic of a typical traveling-gate spreader-stoker.

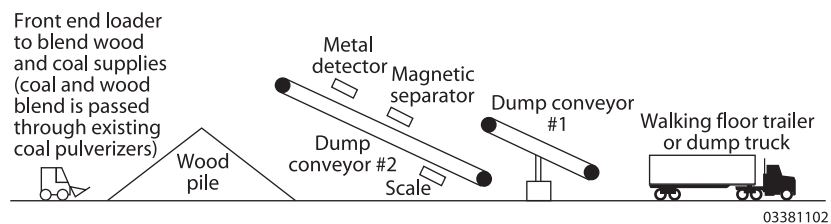


Figure 3. Schematic of a blended-feed cofiring arrangement for a pulverized coal boiler.

heat input basis. If the biomass is obtained at a significant discount to current coal supplies, the additional expense may be warranted to offset coal purchases to a greater degree.

Application Domain

The best opportunities for cofiring biomass with fossil fuels are at sites with regularly operating coal-fired boilers. Biomass cofiring has been successfully demonstrated in nearly all coal-fired boiler types and configurations, including stokers, fluidized beds, pulverized coal boilers, and cyclones. The least expensive opportunities are most likely to be for stoker boilers, but cofiring in pulverized coal boilers may also be economically attractive.

A few federal facilities have had experience with biomass cofiring. Two facilities—the NIOSH Bruceeton boiler plant in

Pennsylvania and DOE's Savannah River Site in South Carolina—have been considering implementing commercial cofiring applications. Other sites with cofiring experience include KI Sawyer Air Force Base in Michigan, Fort Stewart in Georgia, Puget Sound Naval Shipyard in Washington, Wright-Patterson Air Force Base in Ohio, Brunswick Naval Air Station in Maine, and the Red River Army Depot in Texas.

More than 100 U.S. companies or organizations have experience in cofiring biomass with fossil fuels, and many cofiring boilers are in operation today. Most are found in industrial applications, in which the owner generates a significant amount of biomass residue material (such as sawdust, scrap wood, bark, waste paper, or cardboard or agricultural residues

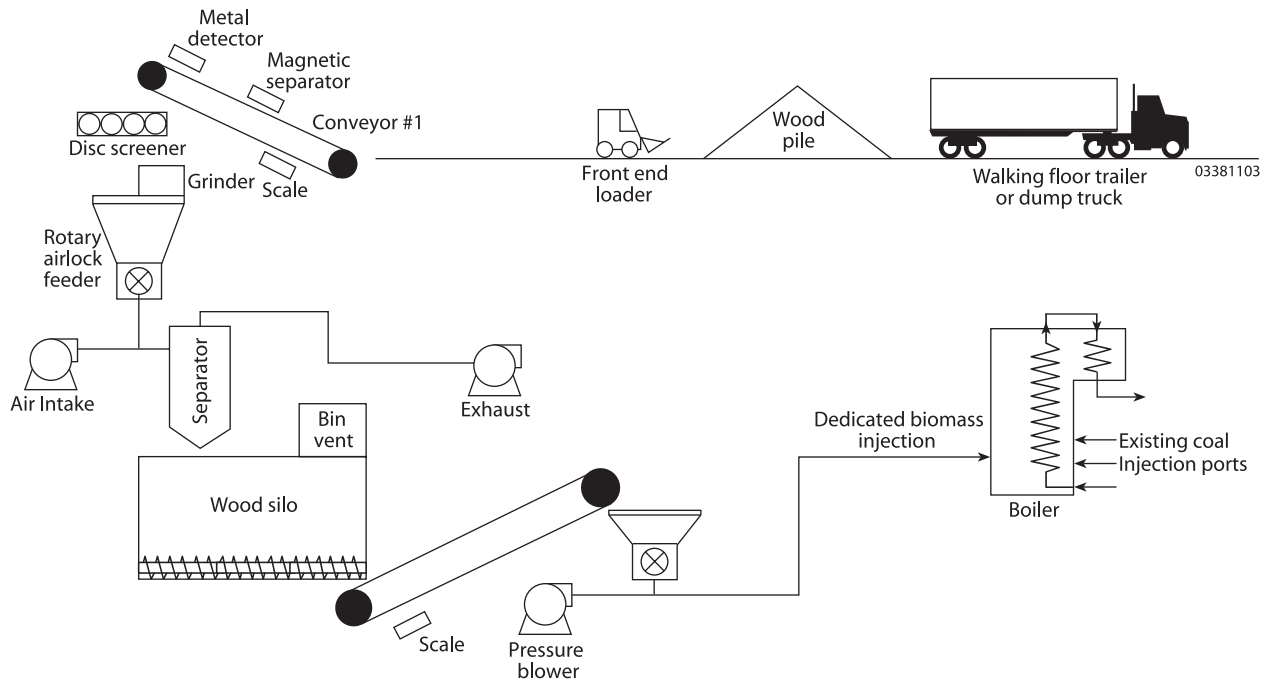


Figure 4. Schematic of a separate-feed cofiring arrangement for a pulverized coal boiler.

like orchard trimmings and coffee grounds) during manufacturing. Using these residues as fuel allows organizations to avoid landfill and other disposal costs and offsets some purchases of fossil fuel. Most ongoing cofiring operations are in stoker boilers in one of four industries: wood products, agriculture, textiles, and chemicals.

A screening analysis was done to determine which states have the most favorable conditions for a financially successful cofiring project. The primary factors considered were average delivered state coal prices, estimated low-cost biomass residue supply density (heat content in Btu of estimated available low-cost biomass residues per year per square mile of state land area), and average state landfill tipping fees.

The top 10 states in the analysis were classified as having high potential for a biomass cofiring

project, and the next 10 states were classified as having good potential. See Table 2 and Figures 5 and 6 on page 6.

Table 2. States with most attractive conditions for biomass cofiring.

Cofiring Potential	State
High Potential	Connecticut
	Delaware
	Florida
	Maryland
	Massachusetts
	New Hampshire
	New Jersey
	New York
	Pennsylvania
	Washington
Good Potential	Alabama
	Georgia
	Indiana
	Michigan
	Minnesota
	North Carolina
	Ohio
	South Carolina
	Tennessee
	Virginia

Within each group in Table 2, states are shown in alphabetical order, because slight variations in rankings result from selecting weighting-factor values. The analysis was intended simply to indicate which states have the most helpful conditions for economically successful cofiring projects. It found that the Northeast, Southeast, Great Lakes states, and Washington State are the most attractive locations for cofiring projects.

Utility-scale cofiring projects are shown on the map in Figure 5. These sites are in or near states identified by the screening model as having good or high potential for cofiring. This increases confidence that the states selected by the screening process were reasonable choices. Figure 6 shows the locations of existing coal-fired boilers. There is good correspondence between the locations of these facilities and the states identified as promising for cofiring.

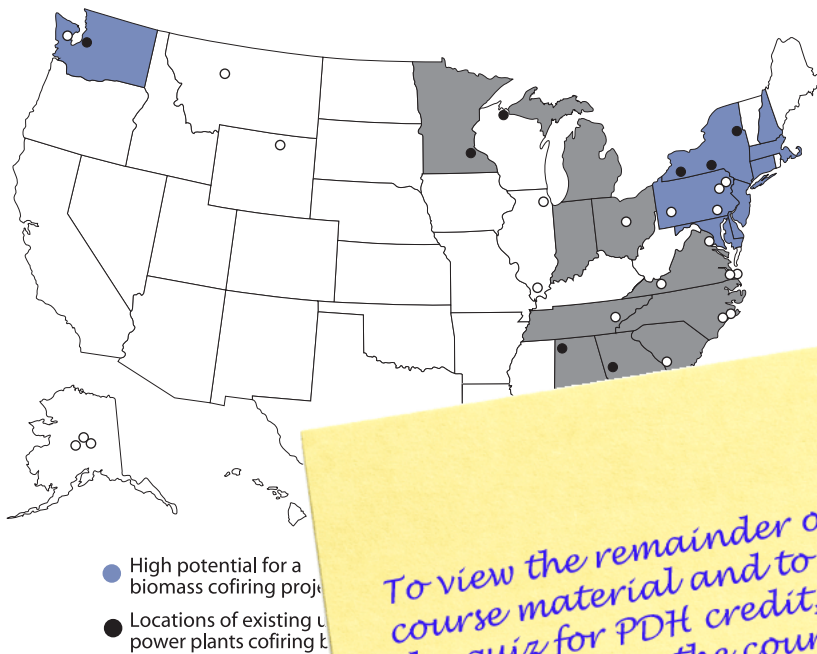


Figure 5. States with most favorable conditions for biomass cofiring, including high coal prices, availability of biomass, and high coal prices.

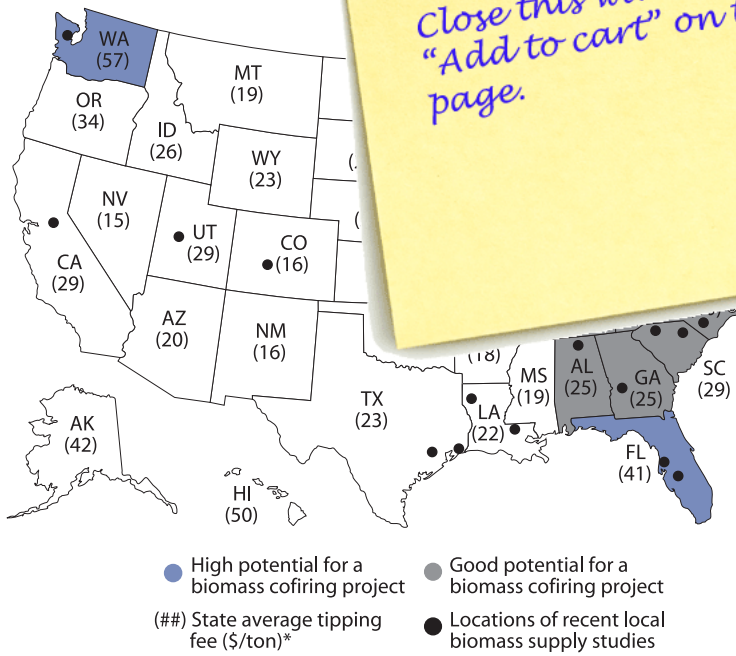


Figure 6. Average tipping fee and locations of local biomass supply studies (Chartwell 1997, Wiltsee 1998).

Coal-fired boilers in the 20 states indicated in the study would be promising for cofiring biomass

if annual coal use is high enough to obtain significant annual cost savings—enough to pay off the

initial investment—by switching part of the fuel supply to biomass. Facilities that operate coal-fired boilers but are not in states on the list in Table 2 could still be good candidates for cofiring if specific conditions at their sites are favorable.

“Wild card” factors, such as the impact of a motivated project manager or biomass resource supplier, the local availability of biomass, and the fact that a large university or campus could act as its own source of biomass fuel, along with realizing on fuel cost reductions by avoiding landfill fees. These factors could easily tip the scales in favor of a particular site. The coal-fired boilers in Alaska could be good candidates not only because of a long heating season, but also because of very high coal

Figure 6 indicates average tipping fees for wood waste. It also shows cities where fairly recent local biomass resource supply and cost studies have been performed, as reported in *Urban Wood Waste Resource Assessment* (Wiltsee 1998). To encourage new projects under the BAMF Super ESPC, the National Energy Technology Laboratory (NETL) has compiled a database that identifies facilities within 50 miles of 10 or more potential sources of wood waste.

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

Close this window and click “Add to cart” on the product page.

03381105