Wood Boiler Systems

OVERVIEW

BERC

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Biomass Energy
Resource Center

Highly efficient biomass energy technology is rapidly becoming available in the domestic US marketplace.

This proven technology is reliably performing in homes, hospitals, schools, municipal buildings, campuses, and other institutional, commercial, and industrial settings around the world.

Wood boiler systems use technology that converts woody biomass fuels to thermal energy through the processes of:

- **COMBUSTION – burning fuels in the presence of oxygen,**
- **PYROLYSIS – rapid thermal degradation in absence of oxygen, or**
- **GASIFICATION – converting biomass fuels into combustible syngas.**

This thermal energy is then used for space and domestic hot water heating, process heating, cooling, and the thermal portion of combined heat and power (CHP).

Although any of the above processes can be used for energy conversion, the systems described in this publication focus on the most common and cost-effective combustion technologies: wood-chip, pellet, and cordwood.

Woodchip Systems

Overview

Woodchip boiler systems vary in terms of capacity and automation features. The most common type is a conventional grate and stoker boiler consisting of one or more refractory-lined cells.

COMBUSTION PROCESS

The fuel is augured into the furnace cell and forms a small bed of woodchips on the grate and heated combustion air is introduced into the cell.

In the first zone—the gasification/primary air zone—preheated air is introduced and flows up through the grates, which drives off the moisture in the fuel and releases the volatile gases.

In the ignition/secondary air zone, the heated volatile gases rise up into the ignition region of the cell and additional preheated air is added to achieve combustion.

In the combustion/tertiary air zone, air is added to achieve complete combustion.

These processes may be carried out in a single stage in a single unit, or in some systems, may take place in separate compartments. Most boilers operate with a fixed grate, but other manufacturers use a moving-grate system where the grate moves like a conveyer belt.

FLUIDIZED BED TECHNOLOGY

Some larger woodchip boilers utilize fluidized bed technology, which uses a heated bed of sand-like material suspended (fluidized) within a rising column of air to burn many types and classes of fuels. The height of the fluidized bed boiler is designed to maintain a long-enough retention time for the complete combustion of fuel particles in a fluidized state and separation of ash from gases.

The thermal "flywheel" effect of the bed material allows swings in the moisture and heating content of the fuel to be absorbed by the system without negative impact.

The low-fuel inventory present in the unit makes it very responsive to varying loads, and the lack of moving parts reduces maintenance costs and down time.

EQUIPMENT

Equipment provided and installed by the vendor typically includes:

- fuel storage
- fuel-handling systems
- combustion chamber and boiler
- combustion air-supply fans
- boiler connection to the stack
- controls
- safety devices
- required emissions-control equipment

FUEL HANDLING

One component of woodchip boiler systems that can vary greatly from installation to installation is the fuel-handling system. Some facilities opt for fully automated fuel handling that requires no operator intervention from truck to boiler while others choose varying degrees of mechanized fuel handling and use operator labor at other points in the system. Fully automated fuel handling involves higher capital and electrical costs but lower labor costs.

Woodchip Systems

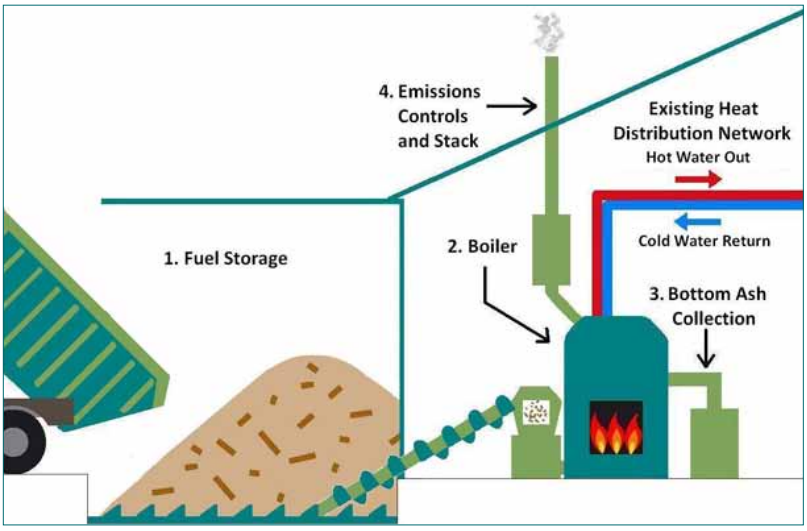
Fully Automated Fuel Handling

Fully automated fuel-handling systems employ a woodchip storage bin—typically located below grade—that can hold at least 1-1/2-to-2 tractor loads of woodchips (35-50 tons). The bin is filled by a self-unloading truck with little to no need for onsite staff assistance.

Little to no operator intervention is required for fuel handling.

From the chip storage bunker, the fuel is fed automatically to the boiler by augers and conveyors.

The fully automated system is a good match for facilities where the maintenance staff has a large work load and cannot spend very much time working with the heating plant.



PRIMARY FUEL

Green woodchips (mill or forest residue, 25-50% moisture content)

SIZE (Boiler Output)

2-10+ MMBtu*/hour

FUEL STORAGE

Below-grade concrete bin (min. capacity 2,500 ft^3)

FUEL HANDLING

Automated from bin to combustion (no operator labor)

OPERATOR WORKLOAD

Approx. 30-60 minutes daily

APPROPRIATE SCALE

Medium-size facilities: 50,000-500,000 ft^2

Larger facilities and district heating systems: 500,000+ ft^2

ASH REMOVAL

Manual or automated

**MMBtu/hour is million British Thermal Units per hour. A British Thermal Unit is the amount of energy needed to raise one pound of water by one degree Fahrenheit.*

Fully automated woodchip systems require little to no operator intervention for fuel handling.

Woodchip Systems

Semi-Automated Fuel Handling

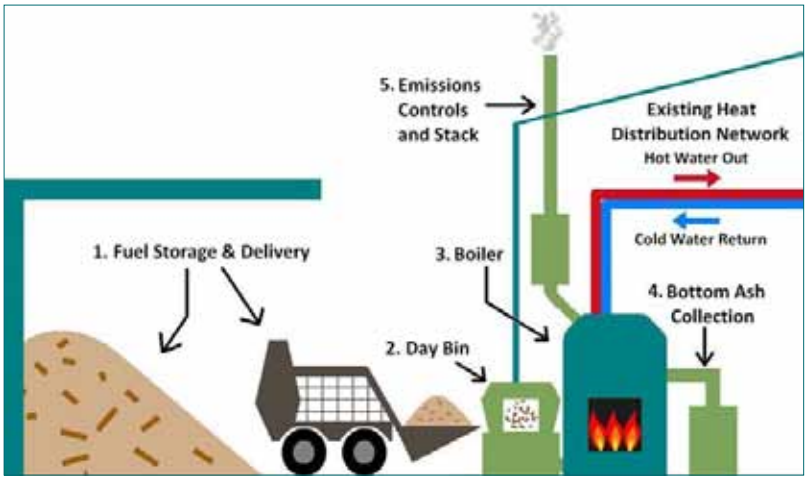
Semi-automatic fuel-handling systems are cost-effective alternatives for smaller facilities with lower heating loads. Both the building it is housed in and the vendor equipment are less expensive than a fully automated fuel-handling system.

A semi-automated system is typically installed in an on-grade slab building that includes a boiler room, chip storage (a chip pile on the slab floor), and a day bin fuel hopper of sufficient capacity to supply the boiler automatically for one-to-two days without reloading. Fuel is delivered to the boiler with augers and conveyors from the day bin hopper.

The day bin is loaded by an operator using a small tractor with a front-end bucket or skid steer. Automated controls manage fuel supply and combustion air, although the controls are simpler than those in a fully automated system.

It takes the operator an estimated additional 30 minutes per day over the typical operation and maintenance time required for a fully automated system; this additional time is for loading the day bin.

The system is a good match for a smaller rural school or office building where the additional time in fuel handling is not a significant burden to maintenance staff.



PRIMARY FUEL
Green woodchips (mill or forest residue, 25-50% moisture content)

SIZE (Boiler Output)
0.5-2.0 MMBtu/hour (or larger)

FUEL STORAGE
Slab-on-grade building (overhead door for delivery)

FUEL HANDLING
Tractor with front-end bucket, from pile to day bin (performed by operator, once or twice daily). Automated from day bin to combustion chamber (no operator labor)

OPERATOR WORKLOAD
Approx. 60-90 minutes daily

APPROPRIATE SCALE
Small facilities:
10,000-50,000 ft^2

ASH REMOVAL
Manual or automated

In semi-automated chip systems, the day bin is loaded by an operator using a small tractor with a front-end bucket or skid steer.

Pellet Systems

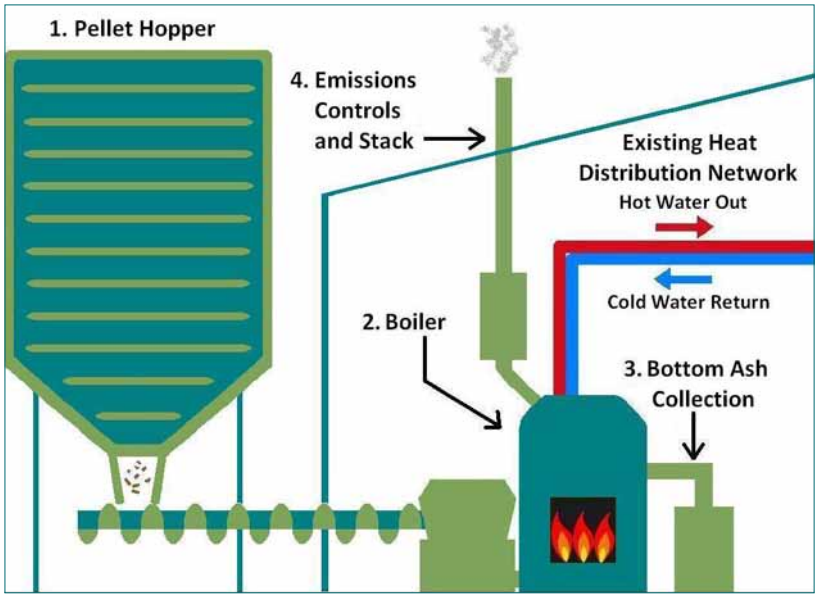
Pellet systems are fully automatic in fuel feed and offer low costs for both installation and operation. In a complete pellet boiler system, fuel is stored in a relatively low-cost grain silo and automatically fed, with no operator intervention, to the boiler or boilers with auger systems similar to those used for conveying feed grain on farms.

The fuel-handling system uses electric motors and is run by automated controls that provide the right amount of fuel to the combustion chamber based on facility demand.

No operator involvement is needed for moving pellets from storage to boiler, and pellets, unlike woodchips, will not jam the auger system. Operation is limited to ash removal and the maintenance of motors and augers, estimated to be about 20-30 minutes per day, and often less. No emission controls are anticipated for these small-scale systems.

Vendor-supplied equipment includes:

- metal fuel silo
- fuel-handling augers
- pellet boiler
- stack connections
- automated controls



PRIMARY FUEL
Pelletized fuel (such as wood or grass, 4-6% moisture content)

SIZE (Boiler Output)
0.1 to 2.0 MMBtu/hour (or larger*)

FUEL STORAGE
Storage silo, sheet metal storage tank, fabric storage tank, storage room, etc.

FUEL HANDLING
Automated from silo to combustion chamber (no operator labor)

OPERATOR WORK LOAD
20-30 minutes daily

APPROPRIATE SCALE
Small facilities: 2,000-10,000 ft^2

ASH REMOVAL
Manual or automated

**Multiple pellet systems can be installed for larger output requirements (i.e., 1.0 MMBtu x 4 = 4.0 MMBtu)*

Pellet systems are easier to use, require less space, and are often less expensive to install, operate, and maintain.

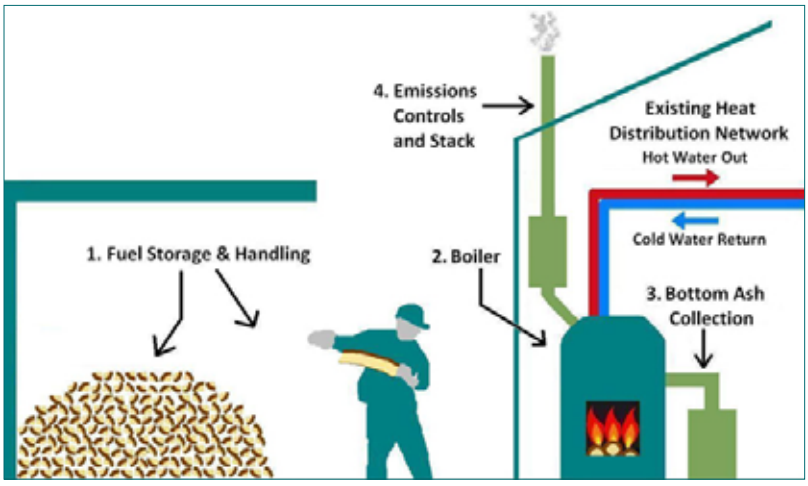

Cordwood Systems

Modern cordwood boiler systems use wood-fired combustion and gasification technology to achieve high efficiencies and burn temperatures between 1800-2000 F°. They differ from ordinary cordwood boilers in their use of modern controls and automation features.

Typically thermal storage is built into the system in the form of a large-volume hot water tank. The fire is stoked periodically (once or twice a day in cold weather) to charge the water storage with heat. This keeps the fire continually hot, fast, and clean, unlike ordinary wood stoves or cordwood boilers that smolder and smoke when little heat is called for. A heat exchanger and circulating pump remove heat from the tank as needed to serve the heat or domestic hot water requirements.

Each system includes a hand-fired cordwood boiler, an induced draft fan, controls, and stack connection. They can differ among companies in configuration of the water storage: one has integral water storage with the combustion chamber surrounded by the water jacket tank, the other has an external hot water storage tank.

An advantage of cordwood systems is that cordwood is widely available and can be stored without a costly bin or expensive building construction. They are only attractive in cases where the operator wants to hand fire the system. Although they can be used for fairly large loads (up to 1MMBtu/hour), the amount of wood that must be manually handled becomes a constraint for the operator.



PRIMARY FUEL
Cordwood (green or seasoned, 0-50% moisture content)

SIZE (Boiler Output)
0.1-1 MMBtu/hour

FUEL STORAGE
Covered outdoor storage

FUEL HANDLING
Hand-fired fuel feed

OPERATOR WORK LOAD
Dependent on system size and load

APPROPRIATE SCALE
Small facilities: 1,000-25,000 ft^2

ASH REMOVAL
Manual

An advantage of cordwood systems is that cordwood is widely available and can be stored without a costly bin or expensive building construction.

Which system is right for my facility?

You need to consider several factors in determining which type of biomass boiler system is right for any given facility, including:

ENERGY DEMAND – Woodchip boilers are more suitable for facilities with a high energy demand, while cordwood systems are better choices for facilities with a lower energy demand. Pellet systems can be suitable for facilities with both high or low energy demands.

OPERATOR TIME – Both semi-automated woodchip systems and cordwood systems are a good fit for facilities with underutilized maintence staff or can hire additional staff to operate the biomass energy system. Fully automated woodchip systems or pellet systems are a better fit for facilities that do not want to spend additional time on their heating system.

LOCALLY AVAILABLE BIOMASS FUELS – The choice between boilers may be as simple as a survey of locally available biomass fuels. The types, quantities, and pricing (on a cost per MMBtu basis) of locally available biomass fuels should be gathered and reviewed as part of the decision-making process.

SPACE REQUIREMENTS – Woodchip and cordwood boiler systems take up more space for both fuel storage and boiler equipment than pellet systems with the same energy output. If space constraints are a barrier to a cordwood or woodchip boiler, a pellet boiler may be a solution.

APPROACH ROAD TO THE FACILITY – Woodchips are typically delivered by a 44-48 foot live-bottom trailer for a fully automated system. Wood pellets are delivered in bulk by either a 10- or 25-ton delivery truck similar to that used for delivering grain, and its ability to reach the facility is an important consideration, particularly for those located in urban areas.

For more information on community-scale biomass energy—including case studies, a biomass facilities database, fact sheets, a glossary of wood-heating terms, frequently asked questions, an image library, and links to additional resources—visit the BERC website at:

www.biomasscenter.org

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The Biomass Energy Resource Center (BERC) is an independent, national nonprofit located in Montpelier, Vermont with a Midwest office in Madison, Wisconsin, that assists communities, colleges and universities, state and local governments, businesses, utilities, schools, and others in making the most of their local biomass energy resources. BERC's particular focus is on the use of woody biomass and other pelletizable biomass fuels. Its work is funded in part by the US Department of Energy through the generous support of Senator Patrick Leahy.

Biomass Energy Resource Center • PO Box 1611, Montpelier, Vermont 05601-1611
Phone: 802-223-7770 • info@biomasscenter.org • www.biomasscenter.org

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