RENEWABLE AND ALTERNATIVE ENERGY FACT SHEET

Commercial-Scale Biomass Combustion Equipment

Overview

A biomass combustion system burns renewable biomass fuel (e.g., wood, field crops) to produce heat. Commercial-scale systems are different from smaller residential systems in that they typically (1) incorporate automated feed and control systems and (2) require emissions control equipment to ensure that strict emissions regulations are met. If the combustor generates steam or hot water, it is often called a "boiler." If it generates hot air, it is called a "furnace." Biomass combustion systems are a great option for heating commercial buildings in Pennsylvania because they provide significant operating cost savings, use renewable fuel, and have low emissions when compared with many other heating systems.

This fact sheet gives an overview of the equipment common to most commercial-scale biomass combustors and discusses some of the considerations in selecting a biomass combustor. If you are considering installing a biomass combustor in your building, you should familiarize yourself with the basic operation of these systems and use the services of an experienced engineer for the design and installation process.

Major Components of a Combustion System

Commercial biomass combustion systems have several distinct components, each of which is needed for the entire system to operate properly (see diagram below).

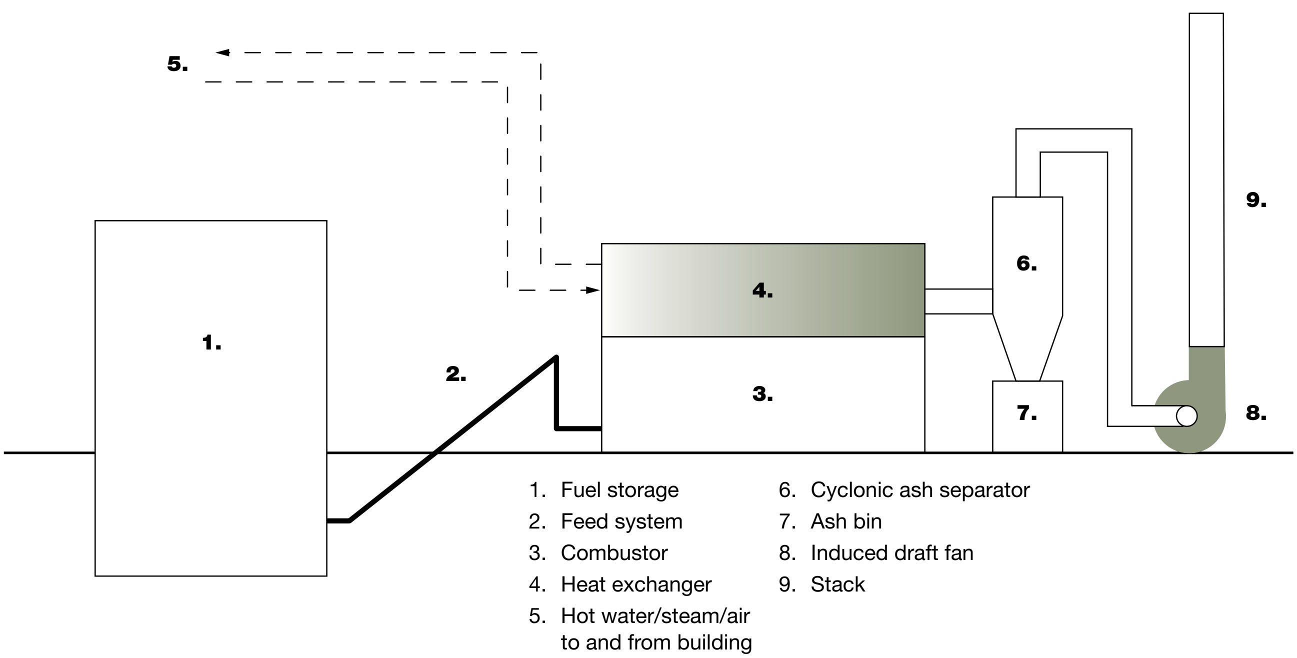
Fuel Storage

The fuel storage bin should be sized to provide sufficient fuel for the maximum possible interval between deliveries. At minimum, the storage should accommodate enough fuel for a long holiday weekend during midwinter. However, a larger storage capacity may be worthwhile if practical. The bin should be designed for easy loading of the fuel; "walking floor" trailers are the most common delivery method. Often, the storage bin is dug into the ground to allow for easier unloading of the fuel. The storage bin should be structurally sound and should be kept at a temperature above freezing. Otherwise, fuel can freeze into large chunks that may damage the delivery system's machinery. If the storage bin is not kept warm, the facility may need to specify dried fuel (which is more costly and often dusty).

Fuel Delivery

The fuel delivery system is one of the more problem-prone elements of the facility and should be designed and operated carefully. Typically, fuel is drawn from the bottom of the bin using a moving floor or screw conveyor. The fuel is then moved to a metering device, where it is fed into the combustor in a controlled manner. Burnback protection devices should be incorporated into the system to prevent a fire from ever escaping the combustor and traveling back to the storage bin.

Major components of a commercial-scale biomass combustor system.



Combustor

The combustor is the enclosed chamber where the fuel is burned by heating it and adding oxygen (air) in the right amount and proportion. Many different combustor designs are available, but they all serve to combine the fuel with air in a hot environment so that the fuel combusts completely. Combustors are generally grouped according to two major categories: direct combustors and gasifier combustors.

Direct Combustors

Direct combustors are devices in which the fuel is heated, dried, and combusted all in one compartment. This is the most common type of combustor available on the market today, and there are several varieties, related to the manner in which fuel is fed into and through the combustor. Some of the more common varieties include:

- Fixed-grate: Fixed-grate combustors place the fuel on a static grate (often sloped), with combustion air provided both below and above the grate. Ash falls through the grate as the fuel burns, where it is collected below and removed. Fixed-grate combustors are one of the older configurations in use today. These systems are well suited for variable-size fuel but are not able to control the application of combustion air as precisely as some other configurations.
- Moving-grate: In a moving-grate combustor, fuel moves into and through the combustor on a metal grate that either slides or shakes the fuel along, sometimes tumbling from one grate to another with the grates arranged much like a staircase. This configuration is more successful at fine tuning the delivery of combustion air, but it requires fuel of regular size and composition.
- Auger floor: Auger floor combustors slide fuel along the floor of the combustor using screw augers that rotate slowly as the fuel is fed into the machine.
- Suspension/entrained combustion: Suspended fuel systems use very small particles of fuel, such as sawdust. They blow the fuel into the combustor, where it combusts in an impressive ball of fire.
- Fluidized-bed: A fluidized-bed combustor burns fuel by adding it to a continually stirred bin of heated, sandlike material. This arrangement allows for extremely even heating of the fuel and high efficiency of combustion. It also gives the combustor a great deal of flexibility as to which fuels to use. However, the system is expensive to purchase and operate.

Other configurations, such as the spreader stoker and the under feed stoker, are variations of the above. Each feed configuration has advantages and disadvantages, although the efficient implementation of a given design is probably more important than the configuration type.

Gasifier Combustors

Gasifier combustors are a less common type that operates using a distinct two-step process. First, the biomass fuel is heated in an oxygen-free compartment. At the right combination of temperature and pressure, the biomass chemically breaks down into a combustible gas called "syngas" or "producer gas." The composition of syngas can vary depending on the fuel and the equipment, but it is typically composed of methane, carbon monoxide, carbon dioxide, water vapor, and other minor components. In the second step, the combustible gas is mixed with air and burnt under controlled conditions to produce heat, much in the same way that natural gas or propane is used as a combustion fuel.

Gasifier combustors are more expensive and complex than direct combustion units, but they offer the potential for precise control of the combustion process, reduced slagging and fouling problems, and shorter response time to varying loads.

Heat Exchanger

The heat exchanger removes the heat from the combustion gases and places it in the air or water that is used for space heating or other needs. Heat exchangers can be a common location for deposits and buildup of ash (fouling), which must be controlled if thermal efficiency is to remain high.

Ash Handling System

Combustion ash is removed at several locations within the combustor. Bottom ash is the heavier ash material that falls through the grate to the bottom of the combustor. It is removed manually or with the aid of a screw auger. Top ash is lighter ash that settles in other parts of the combustor. Top ash is also often removed from the combustor using a screw auger. Fly ash is the lightest; it is carried out of the combustor along with the exhaust gases. Fly ash must be separated from the exhaust gases by the pollution control system, and it is then deposited into a bin. Ash from a biomass combustor can be landfilled or used as a fertilizer or soil amendment.

Pollution Control Devices

Large combusters require some sort of additional treatment to reduce the amount of pollution in the stack gas. Devices for treatment include cyclonic separators, bag houses, electrostatic precipitators, and scrubbers. Cyclonic separators are standard on almost all biomass combustors and are the only pollution control needed on many devices (see photo at right). These separators use centrifugal force in rotating airflow to separate ash particles from the combustor's flue gas. They are simple to operate and are very reliable. Ash is deposited in a container at the base of the separator, where it can be collected and discarded.

If the concentration of particles in the flue gas is still too high, it may be necessary to use a "bag house." This is a large enclosure containing filters shaped like bags. The flue gas is

Cyclonic separator

forced through the filters, which trap particles and prevent them from being released into the air. A "backflow" cleaning cycle is used to clean the filters and collect the ash. Electrostatic precipitators may also be used to collect particles. These consist of large, electrically charged plates that apply an electric field to the flue gas and draw out charged particles.

Lastly, scrubbers may be used, in which a liquid spray (often water) is used to "wash" chemicals (e.g., SO_2) and particles out of the flue gas. These devices are often costly and are usually only necessary in extremely sensitive environments.

Stack

The stack is the final pathway for flue gases to the outside. An electric fan, called an "induced draft fan," is usually used to maintain a steady flow rate of flue gas. If the temperature of the flue gas is low enough, moisture will condense out of the gas and deposit on the flue walls. This "condensate" liquid is acidic and can cause accelerated corrosion of the flue components. Care should be taken to either keep the flue gas temperature high enough to prevent condensation or ensure that all flue components are sufficiently resistant to corrosion.

Auxiliary Heating System

Biomass combustors work best when they are operating at or near full capacity. When the heat requirement is very low, the combustor is not able to maintain the proper thermal environment for combustion, leading to smoky stack gas and low thermal efficiency. This problem can occur during spring or autumn, when heat requirements for a building are relatively small. The combustor's "turndown ratio" is the minimum heat output (relative to full load) that can be maintained while still providing good performance.

The most common approach to dealing with this problem is to use a small "auxiliary boiler" that provides heat only when the requirement for heat drops below the biomass system's turndown ratio (often about 20 percent of full load). Facilities that switch over from natural gas, electricity, or fuel oil systems often keep their old equipment to use for auxiliary heat.

Combustor Building

The combustor building holds the fuel and the major equipment. It must have sufficient space for maintenance and operations, as well as room for fuel storage. Access for trucks must be accounted for, since they typically provide fuel in "walking floor" trailers.

Control System

The control system measures the operating parameters of the device; it adjusts the device to ensure smooth, high-efficiency, safe operation. Digital controllers and monitoring systems are standard components for these systems, and they allow operators to assess the combustor's performance in detail.

Maintenance

Modern biomass combustors require relatively little maintenance, but they are more complex than natural gas or oil-fed boilers. Typical routine maintenance includes a daily system check and regular disposal of accumulated ash. Many combustors require manual startup of the fire, but this typically needs to be done only once or twice per heating season.

Depending on the facility and fuel, it may be necessary to clean the grates regularly as well. Seasonal cleaning of the internal components of the combustor and heat exchanger is also required for most systems.

Factors To Consider When Selecting

Compatibility With Existing Facility

Make sure that the heat your system provides, whether in the form of steam, hot water, or hot air, is at a temperature and flow rate that matches the needs of your facility. Avoid the temptation to oversize the system unless there are plans to expand the building in the near future. Oversized equipment is more expensive to install, less efficient to operate, and less able to handle "low load" conditions such as those commonly found in spring and fall. Often, it is more economical and effective to size your biomass combustor to meet about 80 percent of the peak heat requirement and to use the auxiliary heating system (discussed above) to "top off" the heating system during the most extreme cold periods.

Efficiency

The combustor's thermal efficiency is an important parameter to consider when choosing among systems. The thermal efficiency for large biomass combustors is often in the 70-80 percent range. Higher efficiency models must be designed to accommodate corrosive condensation water in the flue.

Parasitic Loads

Parasitic energy loads are the electrical loads used to operate the equipment. Fans, motors, and control systems all require energy, and the cost of their operation can be significant. A well-designed combustor minimizes parasitic loads without compromising performance.

Maintenance Needs

While biomass boilers are relatively low maintenance, they do require some regular care, including servicing of ash bins and monitoring of system performance. Buyers of a biomass combustor should ensure that their staff are able and willing to carry out the regular maintenance needed for the equipment, or that suitable outsourcing is available to meet that need.

Availability of Support and Assistance

A well-designed and operated combustor should be relatively trouble free throughout its lifetime. However, if problems do occur, it is very comforting if the manufacturer or other knowledgeable individuals are available to assist with troubleshooting in a quick and cost effective manner.

Durability

Most biomass boilers are constructed in a durable manner, and manufacturers back their equipment with a full warranty. The best way to determine the actual longevity of a combustor, however, is to speak to people who have operated that company's equipment for a long time. Often, manufacturers will provide you with a list of previous installations that you can use to track down and speak with users.

Safety

As with all combustors, safety is a vital component of the system. The combustor should be constructed in a manner that makes it intrinsically safe to operate (burnback protection, no exposed sharp or moving parts, protection from burns as well as slip-and-fall injuries) and well equipped to handle problems should they occur (sensors, alarms, etc.).

Fuel Compatibility

It is important to know in advance what sorts of fuels are compatible with the combustor. Some combustors will burn only one type of fuel (e.g., wood chips), while others offer flexibility in terms of fuel type, size, and moisture content. Occasionally, coal combustors are used for biomass fuel, although this is not ideal since the combustion characteristics of coal are somewhat different from those of biomass.

Pollution Measurement and Monitoring

In Pennsylvania, all combustors with a peak-rated fuel input greater than 732 kW (2.5 million BTUh) must be licensed for operation by the Department of Environmental Protection. Allegheny and Philadelphia counties have special requirements in addition to the statewide regulations. Most manufacturers are familiar with these requirements and may be able to provide permitting services as part of the purchase and installation price.

Conclusion

Biomass combustors are an excellent option for providing renewable, locally produced heat for commercial buildings in Pennsylvania. Modern combustors are efficient and relatively trouble free, but they do require some regular maintenance to ensure safe and optimal performance. Selecting a combustor is not a simple task, and prospective buyers should consider the merits of different systems before making their selection.

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Penn State's Biomass Energy Center: **www.bioenergy.psu.edu**
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