Large Scale Heating with Biomass

BTEC
Biomass Thermal Energy Council

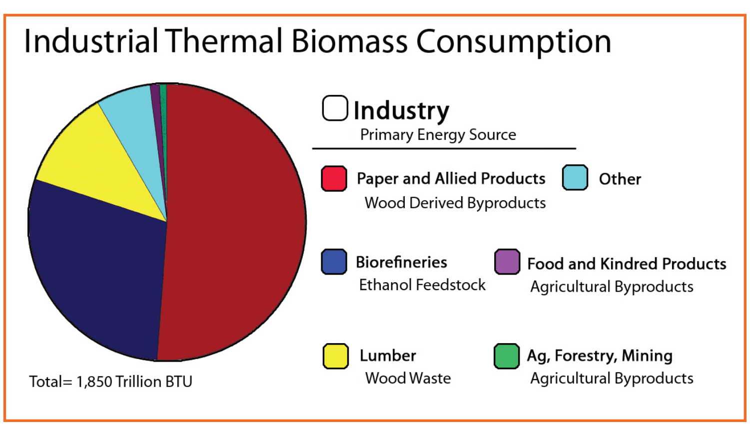
There are numerous benefits to using biomass instead of fossil fuels such as oil, coal, and gas for providing heat for homes, commercial users, and industrial processes.

The Commercial and Industrial Sector

The primary factor that differentiates commercial and industrial biomass thermal applications from residential heating is the heat requirement that they serve. Industrial and commercial applications have a larger area to heat and must often maintain a constant temperature. In order to deliver this much energy, these systems naturally require a much higher volume of feedstock. They are also much more sophisticated, incorporating automatic fuel delivery, advanced combustion techniques, and additional emission control technology.

The distinguishing feature between commercial and industrial systems is the end use of the heat that they generate. Commercial systems provide space and water heating to a building, or a network of buildings. In many cases, a single large boiler can provide heat for an entire community. Accordingly, these systems must be sized in order to accommodate variable seasonal heating needs.

As for the industrial sector, biomass systems supply large amounts of process heat for year round use in manufacturing, agriculture, and other industries. Both types of systems require low cost, locally sourced biomass in order to be economical. Many industries use the biomass byproducts that are generated onsite for use in their boilers. This strategy can realize deep cost savings by reducing the need for purchased energy as well as avoiding fees associated with disposing of these byproducts. Manufacturing plants within the forest products sector, for example, can generate more that half of their required energy just from onsite woody waste materials.[1]



Components

Regardless of the end user being served, large scale biomass systems generally require a similar integrated network of components, the complexity of which will vary according to the heat output and the type of fuel. The overall function is similar to conventional heating units, but with some adaptations in order to support the unique properties of biomass fuel. The following is a brief description of these components [2,4].

Storage Bin

The storage bin needs to be sized in order to ensure an adequate supply of fuel during peak demand and designed to function in sync with delivery vehicles. Most larger facilities will opt for an underground concrete bin which allows for easier, gravity assisted fuel unloading. This also avoids the requirement for mechanical conveyance into an above ground bin or silo.

Delivery System

Typically the fuel is fed from the bottom of the storage bin to the combustion unit with the assistance of conveyors, augurs, and other mechanical devices. Prior to entering the combustion chamber, the fuel usually passes through a metering bin which is responsible for feeding the fuel into the chamber at a particular rate dictated by the control systems and the required heat output.

Combustion

As the fuel enters the combustion zone, it is met with a series of controlled injections of air that are designed to optimize the amount of oxygen available for the fuel to thoroughly ignite. There are a number of configurations by which the fuel is moved through the combustion chamber and the ash deposited--each with its own specific attributes. Some of the more common configurations involve a sloped or moving grate transporting the fuel through the combustion chamber while exposing it to injections of air. In this way the volatile compounds in the biomass release and ignite while the remaining solid material burns through as the ash deposits into a collection bin.

In a more complex configuration known as fluidized-bed, the injection air constantly stirs a bed of sand until it is suspended in a fluid-like state. As the fuel is fed into combustor under these conditions it becomes well mixed, which results in more complete combustion and a high rate of heat transfer. Although these systems can accommodate a range of fuels, they are generally more costly to purchase and operate.

Gasification is another emerging technology in which the biomass is combusted in two stages. The biomass is first heated in a low oxygen environment which causes volatile gasses to be released. In a different section of the boiler these gasses are mixed with oxygen and combusted. Although this operation is more complex, the result is a cleaner and more efficient, combustion process.

Heat Exchange and Delivery

The heat exchanger provides the means by which the hot flue gas transfers its heat to another medium responsible for delivering the heat to the end user. This medium is typically hot water or steam, which can be uses for space and water heating as well as to process heat.

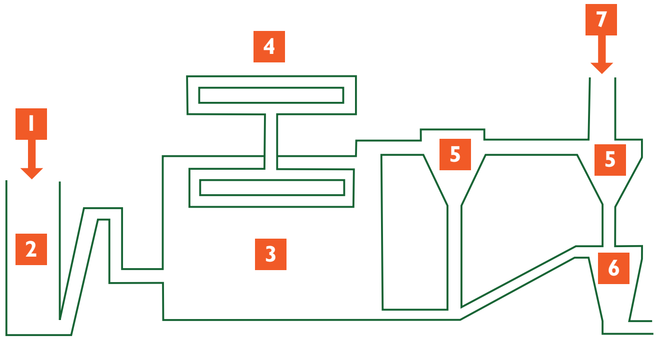
Pollution Control

Although potential pollutants can be mitigated by good combustion practices , most larger operations will require the use of some type of pollution control device in order to remove pollutants from the exhaust gas before it exits the stack. Of primary concern is the removal of particulate matter, which can be achieved with a variety of commercial technologies such as cyclonic separators, electrostatic precipitators, or baghouses. These technologies can be used in conjunction in order to achieve the desired removal rate, and scrubbers can also be employed to remove sulfur emission, if necessary.

Other Technologies

Beyond the combustion system--which is responsible for converting biomass into heat--there are a number of strategies which can be utilized in order to take full advantage of the energy being produced.

[1] Energy and Environmental Analysis Inc. and Eastern Research Power Group, (2007). Biomass Combined Heat and Power Catalog of Technologies. Report prepared for the EPA Combined Heat and Power Partnership.
[2] Sjaak, VL., and J. Koppejan, (2008).The Handbook of Biomass Combustion and Co-firing. Earthscan
[3] Khan, A. et al., (2009). Biomass Combustion in Fluidized Bed Boilers: Potential Problems and Remedies. Fuel Processing Technology. 90:1.
[4] Demirbas A., (2007).Combustion Systems for Biomass Fuel. Energy Sources. 29: 303-312.



Layout of a biomass combustion system

1. Fuel delivery
2. Fuel storage
3. Combustor
4. Heat exchanger
5. Pollution control device(s)
6. Ash removal
7. Stack

District Heating

District heating is the practice of heating a series of buildings by delivering thermal energy from a central plant through a network of insulated pipes via hot water or steam. District heating can confer a number of benefits by replacing multiple heating systems within a campus, community, or business park. Among these are better emissions control and dispersal since a single point source is easier and more cost effective to manage than numerous dispersed sources. This also allows for a large group of users to share the unit cost savings from bulk fuel purchasing agreements that a larger plant can secure.

The city of St. Paul, Minnesota offers a compelling example of how a district heating system can benefit its residents. Although the city is situated in one of the coldest regions of the United States, a centrally located boiler is able to heat 80% of the buildings downtown--including the capitol building, office buildings, and residences--primarily with urban recycled wood. As a result, 150 smokestacks and 300 chimneys have been eliminated from individual buildings and customers enjoy district energy rates below the cost of natural gas.[5]

Combined Heat and Power

Biomass combustion systems can be used to drive steam turbines in order to produce electricity, but the conversion efficiency is often quite low due do the excess heat created. In the case of electricity only systems, this excess heat is simply disposed of by being exhausted into the environment. However, a combined heat and power (CHP) systems capture this waste heat for its use in commercial and industrial purposes. Not only does this greatly increase the overall efficiency of the operation, but it also allows for both renewable heat and electricity to be generated and used onsite.

Cost Effectiveness and Other Benefits

Although large scale biomass projects are usually more capital intensive to install, they can realize significant cost savings through reduced fuel cost. Economic assessments suggest that the most important factors that enable the economic feasibility of a biomass project are the cost of fuel as well as the efficiency of the boiler[6]. This means that an efficient biomass boiler that replaces a high volume fossil fuel boiler is the most desirable. Switching to a biomass boiler and securing a local supply of fuel can also hedge against the inevitable increase and uncertain fluctuations of fossil fuel prices.

Beyond fuel cost savings, there many other benefits associated with replacing fossil fuels with biomass. Probably the most significant of these is the reduction of greenhouse gas emissions due to the low carbon profile of biomass. Directly combusting biomass for heating or CHP is a far more efficient energy pathway than standalone electricity or ethanol production, meaning that more units of energy are extracted from each unit of fuel. Accordingly, utilizing biomass in this manner affords a high degree of fossil fuel reduction. A recent study exploring this issue in the Northeast confirmed that Combined Heat and Power has the greatest potential for replacing fossil fuels and avoiding emissions when compared to other uses of biomass such as ethanol production.[7]

Middlebury College

The biomass boiler recently installed at the Middlebury College Campus in Vermont serves as a useful example of how these technologies can be integrated and the number of benefits that can be achieved. Below is a list of some of the highlights from the project.

- **Large belowground woodchip bunker**
- **Gasification boiler**
- **Heat delivery throughout campus via district heating network**
- **20% electricity demand met with CHP**
- **Annual fuel oil reduction of 1,000,000 gallons**
- **$2 million annual cost savings at 2008 fuel oil price**
- **12,500 tons annual greenhouse gas reduction**

Typical Commercial Heating Applications

- **Government Buildings**
- **Hospitals**
- **Office Buildings**
- **Communities**
- **Shopping Centers**
- **Greenhouses**
- **Sports Complexes**
- **Universities**
- **Housing Complexes**

Conclusion

Biomass thermal energy is renewable, carbon neutral, domestic and technologically mature. It can be applied on a variety of scales, including district heating plants, combined heat and power plants and localized heating combustion facilities. Improvements in technology have reduced the amount of emitted particulate matter dramatically. Additionally, the lower price per BTU of wood pellets and chips vs. fossil fuels make biomass an attractive option to consumers seeking large scale heating facilities. With so many benefits and range of implementation options, biomass thermal is poised to heat our future.

WERC
Wood Education and Resource Center

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This fact sheet is available online at www.biomassthermal.org.

[5] Schill, S. Cool, (2008). Hot and Green. *Biomass Power and Thermal.*
[6] McKenney, D. et. al. (2011). An Economic Assessment of the Use of Short-Rotation Coppice Woody Biomass to Heat Greenhouses in Southern Canada. *Biomass and Bioenergy*, 35.
[7] Buchholz, T., (2011). Forest Biomass and Bioenergy: Opportunities and Constraints in the Northeastern United States. Cary Institute of Ecosystem Studies.