

Combustion

FEEDSTOCK CLASSIFICATION

Lignocellulosic biomass

FEEDSTOCK EXAMPLES

- [alfalfa](#)
- [corn stover](#)
- [crop residues](#)
- [debarking waste](#)
- [field corn](#)
- [forage grasses](#)
- [forest residues](#)
- [manure \(dairy\)](#)
- [manure \(poultry\)](#)
- [manure \(swine\)](#)
- [municipal solid waste](#)
- [paper mill residue](#)
- [sawdust](#)
- [sweet corn](#)
- [switchgrass](#)
- [waste wood chips](#)
- [wood chips](#)

FEEDSTOCK RESTRICTIONS

Almost anything organic will burn, but low moisture biomass is preferred for combustion, as opposed to high-moisture biomass like manures or fats, grease and offal.

PROCESS DESCRIPTION

Combustion refers to rapid oxidation. The feedstock is placed into a combustion chamber, where it is exposed to high heat. This completes the drying of the feedstock. Once all of the water has been evaporated, the feedstock can become hot enough for pyrolysis to occur. (In plant matter, this is 440°F-620°F for hemicellulose and 480°F-930°F for lignin.) Pyrolysis refers to the chemical breakdown of the feedstock, and the primary reactions such as volatile compounds like carbon monoxide, carbon dioxide, methane and tar. The release of volatile gases inhibits further combustion because they prevent necessary oxygen from reaching the feedstock. When completely pyrolyzed, what remains of the feedstock is known as char. Given sufficient oxygen, oxidation of both the char and the volatile gases will occur. The oxidation of the gases is referred to as flaming combustion, and only carbon dioxide and water will remain if the process is given enough heat, turbulence and residence time. Otherwise, this incomplete conversion will yield intermediate chemical compounds like carbon monoxide, polycyclic aromatic hydrocarbons and chlorinated hydrocarbons, all of which are pollutants. Likewise, the oxidation of the char is referred to as glowing combustion, and its completeness is also a function of heat, mixing and time. So long as every surface of the char comes into contact with oxygen, it will react and become carbon monoxide and carbon dioxide. (Ideally, the carbon monoxide will be oxidized during flaming combustion and become carbon dioxide.)

In addition to those gases, combustion gives off heat. A common strategy in those industries whose processes require combustion equipment like boilers is to co-fire biomass with fuels like coal. There are marginal efficiency losses from co-firing biomass, and can provide a waste handling solution for industry. Similar to the substitution of gasoline with ethanol, the inclusion of biomass in coal-firing operations can reduce emissions by displacing coal.¹

Another approach to combustion is the pelletization of biomass. This involves combining multiple feedstocks and generating biomass pellets of uniform size and known, if not uniform, Btu value. With a workable distribution system in place, these could be used as a commodity heating fuel in furnaces for large and small heating applications.²

PRIMARY BIOBASED PRODUCTS

Volatile gases (energy)

PROCESS BYPRODUCTS

Carbon dioxide, water, carbon monoxide, soot, polycyclic aromatic hydrocarbons, chlorinated hydrocarbons (furans, dioxins) and char. Additionally, anything in the biomass that is not carbon, hydrogen or oxygen needs to be contended with, including nitrogen and alkali.

MAJOR EQUIPMENT

There are many approaches to the combustion of biomass. Grate-fired systems throw fuel onto a moving grate, typically achieving efficiencies of less than 90 percent. Suspension burners blow pulverized fuel up through the combustion chamber, and can be more than 99 percent efficient. Biomass can be burned in both systems, but is better suited for fluidized bed combustors, which move air through a bed of hot sand, creating a turbulent combustion environment that provides excellent heat transfer. All of these systems presume additional equipment that provide a high level of heat recovery and, in most applications, steam generation.

In small-scale applications, such as home heating with pelletized biomass, a furnace is sufficient, although to make such heating competitive with other commodity fuels, the most efficient furnace would be necessary.

ENERGY REQUIRED

High, but the process is exothermic

CAPITAL AND OPERATING COST

Varies depending on the technology implemented

COMMERCIALIZATION STATUS

Established. Fluidized bed combustors have been commercialized but are not yet common. Pelletized biomass as a commodity fuel is not yet commercialized.

COMMERCIAL SUPPLIERS

Bixby Energy Systems³ is investigating the use of pelletized biomass as a commodity fuel. Bixby intends to manufacture and distribute biomass pellets of known Btu value, and has designed a furnace especially for the pellets with a 99.7 percent fuel combustion ratio, which not only

maximizes value but limits emissions and ash residue to negligible amounts. Bixby is also interested in scaling up its combustion for a 2 MMBtu electrical generation facility.²

REFERENCES

¹ Brown, Robert C. 2003. Biorenewable Resources Engineering New Products from Agriculture, Iowa State Press, Ames IA.

² Walker, Bob. Co-founder, Bixby Energy Systems Inc. BioCycle Renewable Energy from Organics Recycling conference speaker, Minneapolis, MN. 17 November 2003.

³ Bixby Energy Systems Inc., 14295 James Rd., Roger, MN 55374, 877.500.2800
<http://www.bixbyenergy.com> (23 April 2004).

Biopower. 2000. Biomass Co-Firing: A Renewable Alternative for Utilities. US Department of Energy Energy Efficiency and Renewable Energy Network.
<http://www.nrel.gov/docs/fy00osti/28009.pdf> (23 April 2004).