BIOMASS ENERGY

TECHNIQUES INC

Feedstock Fuel

The BET Technology by BioMass Energy Techniques Inc is currently being used in over 100 applications across North America. This technology has proven versatile and effective on a wide range of feedstocks with high moisture content. Traditionally used to consume wood waste as a fuel feedstock, the basis of the BET system has been proven over many decades in both off-grid and newer, leading edge technology applications.

The basic operating premise is based on heating the feedstock to the point that flammable gases are driven off of the solid materials. These gases are ignited when heated to the correct ignition temperature and combined with the proper amount of combustion oxygen. Under proper operating parameters, complete combustion of the gases occurs, resulting in a clean burn.

The BET System accomplishes this process in a simple and effective manner. First, the shredded feedstock is gravity fed into the primary combustion chamber through a hopper. The feedstock flows onto a series of inclined step grates and horizontal toe grates. A solid fuel bed of hot embers builds up on the grates. Additional fuel is added, which forms a layer over the hot fuel bed. Primary combustion air enters through the draft doors and passes through the fuel bed. The gases from the fresh layer of fuel are distilled by the primary air stream passing through the fuel bed, creating volatile gases in the combustion chamber. Preheated secondary air entering from the top of the system provides the oxygen and turbulence needed to ignite such gases, providing complete combustion.

While the BET System can be adjusted to handle many different types of fuel, it should be noted that non-combustible matter, such as minerals will reduce the quality of combustion and may cause other operational issues; for this reason, efforts should be made to reduce the mineral content in the feedstock. Optimum performance is maintained when the woody biomass component of the feedstock is not below 65% by weight.

Each feedstock will require initial monitoring to ensure optimum performance. Correct adjustment of the system settings will insure proper operation with a wide variety of fuel types. The grates must be adjusted in such a way to ensure they are uniformly covered, and to control the thickness of the feedstock fuel bed. The baffle controls how far forward the feedstock goes on the toe grate. Coarse feedstock, like chips, which allow air to move relatively easily through the feedstock burn well with a thick bed and the grates tipped down. In order for air to penetrate through feedstock such as bark and thick sawdust, a thinner fuel bed is needed.

Operating under negative pressure conditions, BET Systems eliminate potential for gas or vapor to escape. To accomplish this, operators need to ensure the grates are adequately adjusted, based on the characteristics of the feedstock, to allow air to pass through the fuel bed. BET Systems automatically adjust to small amounts of ambient air infiltration without diminishing performance.

Woody BioMass Feedstock

Woody biomass, including hogged fuel, sawdust, shavings, and chips, is the optimum feedstock for the BET System. These materials flow evenly and uniformly over the grates inside the BET System, and can easily be gravity fed into the System. This fuel type, with moisture content between 25% and 65%, is ideal fuel for the BET System and will deliver superb performance.

While we have noted slight variations in performance with differing wood species, Woody BioMass has long proven to exceed expected performance, reduce long term maintenance needs, and require the least amount of operator expertise.

Waste Wood

Waste wood streams, such as bark, railroad ties & power poles, freight pallets, peeler waste, chip residues, waste lumber, and cutting waste, all can make for ideal feedstock provided the fuel is hogged or shredded down in such a manner as to allow free and uniform movement into the BET System and across the grates.

Contaminates soaked into or coated on these feedstocks do not notably impact the performance of the system or the energy production. The wood fiber is heated to the point that flammable gases are produced and driven off from the solid materials. These gases can be ignited when heated to the correct temperature and combined with the appropriate amount of combustion oxygen. When the proper conditions exist, complete combustion of the gases occurs. In extreme cases, commercially available emissions control technologies can be added to destroy all known hazardous, toxic, and pathogenic organic materials.

Pellet Fuels

Pellet Fuels are biofuels made from compressed organic matter or biomass. Pellets can be made from any one of five general categories of biomass: industrial waste and co-products, food waste, agricultural residues, energy crops, and virgin lumber. Wood pellets are the most common type of pellet fuel and are generally made from compacted sawdust and related industrial wastes from the milling of lumber, manufacture of wood products and furniture, and construction.

Pellets commonly have less than 10% water content, are uniform in density, have good structural strength, and have low dust and ash content. Because the wood fibers are broken down by a hammer mill, there is virtually no difference in the finished pellets between different wood types.

Due to the extreme low moisture content, pellet fuel may be presoaked with water up to a ratio of 1:1 to improve efficiency and overall performance. The mixture of pellets and water should be allowed to stand until the pellets swell enough to create a uniform consistency prior to feeding into the BET System. Depending on the volume of pellets and water, agitation may be necessary to achieve the goal of uniform consistency prior to being fed into the BET System as feedstock.

Agricultural / Green & Brown Waste

Green waste, also known as "biological waste," is any organic waste that can be composted. It is most usually composed of refuse from gardens such as fresh grass clippings or leaves, and domestic or industrial kitchen wastes. Brown waste is any biodegradable waste that is predominantly carbon based. The term includes such items as dry grass cuttings, dry leaves, twigs, hay, paper, sawdust, corn cobs, cardboard, pine needles or cones, etc. Brown wastes are known to be rich in carbon, while green wastes contain high concentrations of nitrogen. These agricultural wastes produce gases in the primary combustion chamber that result in a very highly efficient source of thermal energy in the BET System.

Agricultural waste mixtures should be monitored for moisture content by weight, to maintain levels of moisture below 70%.

To effectively use this feedstock, it must maintain a loose enough consistency to allow air to flow through the fuel bed on the grates in the primary combustion chamber and for uniform gravity feeding into the BET System.

Paper & Cardboard Recycling

Paper and Cardboard Recycling waste, with its high woody biomass composition, can make a great feedstock fuel provided that it is shredded to allow for uniform gravity flow into the BET System and across the primary grates. In some cases, the high ash content may create concerns with particulate matter (PM) in the emissions, necessitating the addition of commercially available PM filters.

Additional attention may be needed to the in-feed conveyance system to ensure this feedstock can flow easily from the feedstock storage and containment into the BET System.

Household Waste / MSW

MSW or Household Waste should be introduced into the BET System gradually after the System has achieved optimum temperature and performance with a clean woody biomass feedstock.

This feedstock generally has a natural dry combustible factor of approximately 35%, including newsprint, cardboard, mixed papers, and a small amount of wood. This dry combustible factor is usually the second largest category behind putrescible waste, such as food and yard waste, which is normally around 40%. Both of these categories represent largely organic feedstock which can result in near ideal characteristics for fuel in the BET System. Care should be taken to watch for batches or sections of fuel with extreme moisture (exceeding 65% by weight) which will reduce the airflow through the fuel bed.

The remaining 25% factor of MSW or Household Waste is generally made up of plastics, which will not adversely impact performance in these quantities, and inert materials, such as minerals, metals, and glass. As non-combustible feedstocks will reduce the performance of the BET System, reasonable efforts should be made to decrease the quantity of these factors in the feedstock. Additional woody biomass feedstocks should be added to the MSW feedstock mixture to improve performance if necessary.

Construction & Demolition Waste / C&D

Construction and Demolition Waste should be introduced into the BET System gradually after the System has achieved optimum temperature and performance with a clean, woody, biomass feedstock.

C&D Waste consists of unwanted material produced directly or incidentally by the construction and demolition industries. This includes building materials such as insulation, nails, electrical wiring, shingles, and roofing, as well as waste originating from site preparation such as dredging materials, tree stumps, and rubble. Generally speaking, C&D Waste represents a feedstock with a high concentration of damaged or unused wood which is highly combustible. Feedstock materials containing metal or mineral, fiber, wire, or meshes will require project specific pre-processing or a custom configured system arrangement. System operators should be trained to watch for and remove obvious metal components from feedstock. Metal or mineral components inadvertently remaining in feedstock (appropriately sized) will pass through the process and exit in the ash. Metal cans, etc. deform while larger glass pieces tend to break up. All pass through the system.

Much building waste, however, is made up of materials such as bricks and concrete damaged or unused for various reasons during construction. While it would appear that this non-combustible material represents only 10%-15% of the overall mixture, it should be noted that when calculated by weight, this largely mineral based component of the feedstock can have a negative impact on the combustion process.

Given that the characteristics of this feedstock may vary significantly from batch to batch, the BET System operators should monitor this feedstock and ensure adequate woody biomass is added to the mixture as required.

Industrial Waste / ICI

ICI or Industrial Waste should be introduced into the BET System gradually after the System has achieved optimum temperature and performance with a clean, woody, biomass feedstock.

Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations. Industrial waste may be solid, liquid, or gaseous. It may be hazardous or non-hazardous waste. Hazardous waste may be toxic, ignitable, corrosive, reactive, or radioactive.

Because many types of industrial waste include dirt and gravel, masonry and concrete, scrap metal, and other non-combustible materials, ICI / Industrial Waste can create a number of challenges when being used for feedstock. While oil, solvents, chemicals, scrap lumber, and even vegetable matter do not pose a major concern, the unstable nature of this feedstock creates the need for heightened operator awareness and management.

Specific care needs to be taken with this feedstock to ensure minerals and non-combustible fuels are minimized, while ensuring the consistency is maintained to accommodate uniform gravity feeding into the BET System and across the grates in the primary chamber. A readily available supply of woody biomass should be used to adjust the feedstock mixture as needed.

Liquids, Slurries, & Vapors

Liquids, slurries, and vapors can be mixed into woody feedstock at rates not exceeding 65% average feedstock moisture content. Care should be taken to reduce sudden and severe fluctuations in moisture content to ensure a consistent and clean combustion process.

While contaminated streams may be added into the feedstock at any stage prior to entering the BET System, a uniform and consistent flow of the feedstock into the System and onto the primary grates must be maintained.

Plastics

Plastic waste of all types that has been reduced to meet the feedstock sizing requirements of the BET System can be mixed at a rate of up to 25% of the overall feedstock composition. Today's plastic made from hydrocarbons is highly combustible, and is more energy dense than coal or any other refuse when burned. With high enough heat and retention time, the harmful chemicals such as hydrochloric acid, sulfur dioxide, dioxins, furans, heavy metals, and other particulates can be eliminated.

Glass

Glass does not burn or oxidize because it already is an oxide. As glass is heated up and reaches temperatures of around 700°C, it can begin to melt and flow. While excessive amounts of glass in the feedstock will create operating issues with the BET System, a small amount of glass (<5%) will simply pass through the system and be discharged.

Dirt, Gravel, & Other Minerals

Minerals do not combust; therefore, they reduce energy output and have a detrimental impact on the BET System's ability to effectively consume other feedstock. While small amounts (<5%) of minerals will simply pass through the system and be discharged, every effort should be made to reduce the amount of minerals contained in any feedstock.

Understanding Feedstock

Feedstock, or the fuel used in the BET System, is gravity fed into the unit. It is important that the characteristics of the feedstock allow it to flow uniformly into the system and across the grates. The screen size, or maximum size, of the feedstock is determined by the throat opening of the hopper going into the BET System. Feedstock should not be so large as to bridge across the throat opening of the BET System which would block the flow of other feedstock fuel.

While the BET System can be adjusted to handle many different types of fuel, it should be noted that non-combustible matter, such as minerals will reduce the quality of combustion and may cause other operational issues; for this reason, efforts should be made to reduce the mineral content in the feedstock. Optimum performance is maintained when the woody biomass component of the feedstock is not below 65% by weight.

Each feedstock will require initial monitoring to ensure optimum performance. Correct adjustment of the system settings will insure proper operation with a wide variety of fuel types. For a complete review of feedstock considerations, please review the Feedstock Fuel section.

Understanding BioMass Combustion

Woody biomass consists mainly of organic substances such as cellulose, hemicellulose, and lignin. Each of those substances consist of the elements carbon, oxygen and hydrogen. The medium composition is as follows:

Carbon (C) approximately 51% by weight
Oxygen (O) approximately 43% by weight
Hydrogen (H) approximately 6% by weight

When biomass is heated, a gradual decomposition of the organic material occurs. The decomposition results in the release of the organic materials in a gaseous state. Left behind is the residue, in the form of ash.

To make biomass burn, it is necessary to heat it until the gases are liberated. The liberated gases, when mixed with atmospheric air, will burn after the ignition point has been reached (the ignition point is approximately 575° F). Upon combustion of the gases, the temperature increases to the point at which the carbon in the biomass gases is ignited. The ignition of the carbon results in new gases, carbon monoxide and carbon dioxide.

In order to maintain continuous combustion, combustion air, in suitable volume must be added to the combustion chamber. If the volume of combustion air is insufficient, combustion will decrease and eventually stop. If, on the other hand, the volume of combustion air is too great, the combustion will be incomplete, with relatively large loss of latent heat following the flue gases out of the combustion chamber and up the stack.

The combustion air which is added in order to generate the gases is referred to as primary air. Such air is added through the grates. A sufficient fuel feedstock pile should be maintained so that the grates are covered with feedstock, thus requiring primary air to pass through the fuel bed (the fuel feedstock also has the effect of protecting the grates from excessive heat).

The gases generated by the primary air are ignited through the introduction of secondary air. The secondary air must be added at a point where the flame temperature is the highest in order to insure that the gas-air mixture can be ignited and burned completely.

A relatively small proportion of air is necessary in order to turn the carbon in the fuel into combustible gases. On the other hand, it requires a relatively large volume of air to ignite and completely burn the gases. As a result, the ratio between primary and secondary air should be about 1:5.

In the event the volume of primary air is too great compared to the volume of secondary air, the carbon gases are created but not burned. This incomplete combustion will result in black smoke being emitted from the stack. In order to attain complete combustion, either additional secondary air must be introduced, the primary air reduced, or a combination of the two.

The flue gases exiting the stack, when the system is attaining complete combustion, will contain the following substances:

Nitrogen (from the combustion air)
Oxygen (from excess combustion air)
Carbon dioxide (from the combustion of the carbon)
Water vapor (from the moisture in the fuel)
Fly ash (minimal - from the residues)

In the event of incomplete combustion, the fuel gases will also contain carbon monoxide, and increased amounts of fly ash.

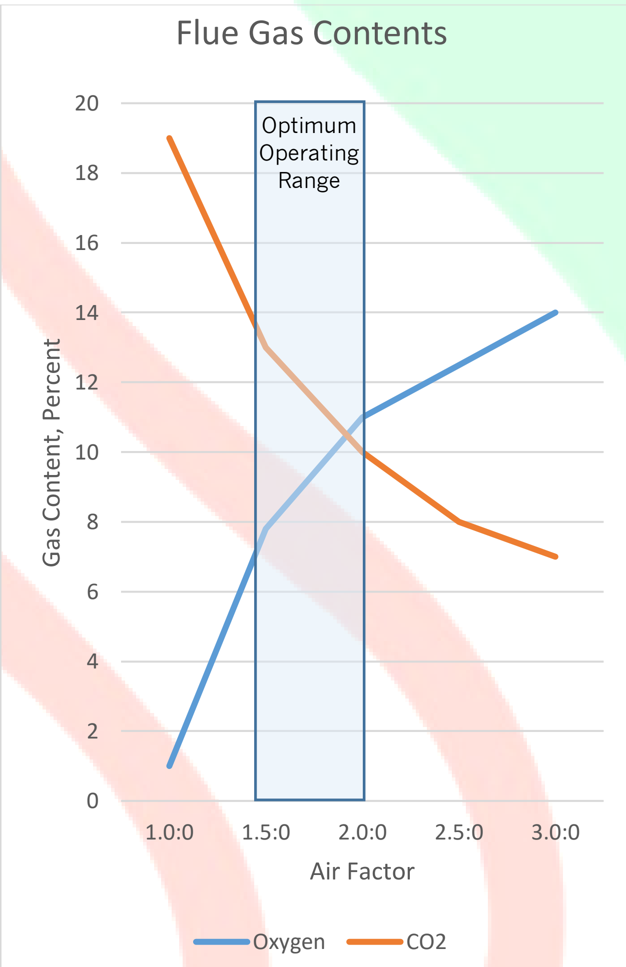
If combustion is complete, the smoke exiting the stack will be virtually invisible (an exception is if the stack temperature is not high enough, in which case the water in the flue gases will condense upon contact with the atmosphere and the smoke will be white).

If combustion is incomplete, the smoke will have a color ranging from light grey to black. Light grey indicates slight incomplete combustion, while black signifies rather poor combustion. Generally, combustion can be improved through an increase in secondary air.

On a theoretical basis, complete combustion is attained through the introduction of the exact volume of air required for converting the combustible substances into carbon dioxide and water vapor. In short, there would be no excess air and minimum flue gases from the stack. In the event more combustion air is added than required, that additional air is referred to as “excess air”. If twice the volume of air than is theoretically necessary is added, the system is said to have air factor of 2:0.

In practice, it is impractical to measure the air factor itself in order to determine the volume of flue gases from the stack. However, by measuring the content of oxygen and/or the carbon dioxide in the flue gases, it is possible to estimate the air factor. The diagram attached hereto shows the oxygen and carbon dioxide contents of the flue gases at various amounts of excess air. It is recommended that the air factor be kept in the 1.5:0 to 2:0 range.

The air factor can be determined by testing the carbon dioxide level in the flue gases, using a Bacharach tester (heating contractors generally use some model of this type of tester to determine the efficiency of gas and oil fired residential furnaces).



Oxygen (O) and Carbon Dioxide (CO^2) content in the dry flue gas at various excess of air on the combustion of biomass.

Air Factor of 1.0:0 is the theoretically required air volume for combustion without excess air.

Optimum operation of the BET System is with an Air Factor in the range of 1.5:0 to 2.0:0.