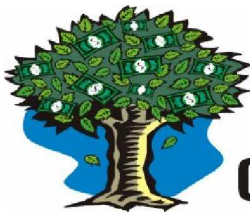


Chip Energy's BIOMASS FURNACE



A 20' shipping container with a look inside to the Biomass Furnace's air compressor, water tank, gasifier and hopper



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Scenario:

- The winter months in your area of the country send your furnace into overdrive and the bills skyrocket as more and more heat is necessary to keep the area comfortable.
- The community is looking for new innovative ways to lower heating costs and is even prepared to be a “test site” for a product that is not yet in full commercial production.
- By investing in a quality product in its final test stages, your organization qualifies for Federal Grants that will fully finance the purchase.
The question is, which product do you choose?

Solution:

Chip Energy has been developing a fully automated Outdoor Biomass Gasifier Hydronic Heater (OBGHH) for three years. It is now at the stage where communities, townships, institutions, and individuals can incorporate the unit into a practical project to heat their buildings. This one-of-a-kind method functions like a wood burning furnace, only more efficiently, and with a fraction of the human intervention. It is not for sale as a commercialized product yet, but only available as part of appropriate energy-saving trial projects for a \$40,000 investment. There are numerous government grants to be given to organizations willing to invest in products that lower the cost of gas and contribute to community development.



Furnace parts and the PLC touch screen inside the container

Part 1: What is biomass fuel?

Biomass fuel is any non-fossil fuel source that is derived from a once living organism, most commonly plants. The most obvious example is wood; however, there is a seemingly endless list of biomass sources, most of which come from agricultural waste. Corn stalks, rice husks, coconut shells, switch grass, miscanthus, peanut shells, fruit pits, and dung are a few other common examples.

When properly processed (i.e. sufficiently dried and, in some cases, pelletized), biomass can be used as a very potent fuel. A particular form of biomass’s “potency” is dependent on its natural energy content (represented in BTUs per pound). Energy content typically varies between 7,000 BTU/lb and 9,000 BTU/lb. For instance, most wood measures at approximately 8,400 BTU/lb. At the extremes there is corn with a value of 6,800 BTU/lb, and some fruit pits contain up to 10,000 BTU/lb.

Biomass related to your Biomass Furnace

The furnace’s ability to run on a particular type of biomass depends on several things: moisture content, energy content, density and size. Chip/pellet size is important because any fuel type put into the hopper must be able to flow through the system. For instance, the standard Biomass Furnace unit has a hopper with a fuel feed tube of five inches in diameter, perfect for wood chips. The end user who wants to use two inch briquettes would need a larger fuel feed diameter, and possibly a larger gasifier.

Despite variances in energy content, gasifier performance is affected more from the fuel's density and moisture content. For example, the energy content of a wood chip is the same as an equal weight wood pellet made from the same material. The pellet performs better because the material is dried to a standard moisture content level and then pelletized to a density of 40 lb/ft³. This can be beneficial for the end user looking to minimize hopper maintenance. The furnace will run unattended far longer on a hopper filled with wood pellets compared to wood chips (10 lb/ft³).

The best thing about biomass is that massive quantities of different types are found locally and can be used to support decentralized systems across the country. The productive-efficiencies of costly large-scale corporate centralized systems can be quickly lost to the costs of transportation, both to and from the location. Every region of the country (and the world) has access to its own waste-stream biomass. Annually, the agricultural industry produces millions of tons of biomass waste that could be utilized for energy. An estimated 350 million tons of it ends up in landfills. Landfill space is scarce and valuable. With Chip Energy's products being used in different regions of the country, recycling centers can be established all over to process biomass into usable fuel. This creates jobs, lessens the amount of biomass in landfills by 30%, and promotes community development.



A Chip Energy facility recycles pallets into wood chips

A short list of examples of abundant biomass in different parts of the country

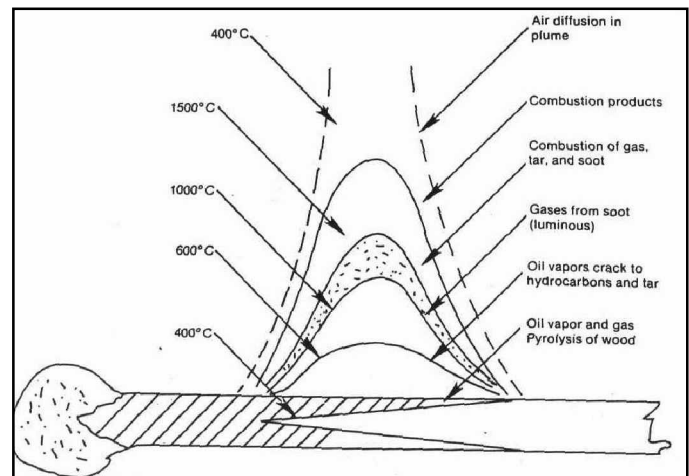
- Illinois – corn stover; industrial waste woody biomass
- Michigan – cherry pits
- Texas – mesquite
- Wisconsin – forest slash
- Arkansas – rice husks
- California – nut shells

Part 2: What is Gasification?

The way that Chip Energy's Biomass Furnace turns biomass into heat is through pyrolysis, gasification, and combustion.

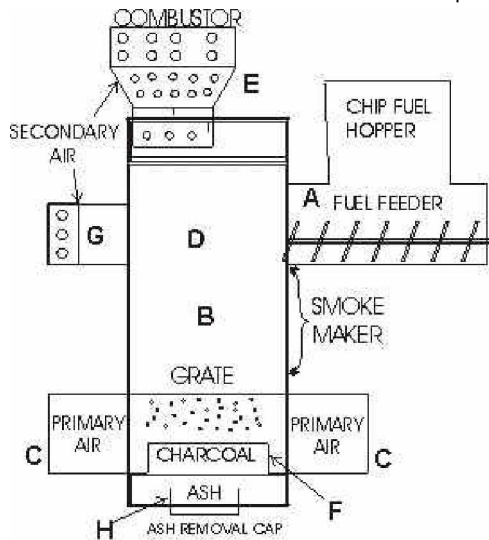
- Pyrolysis – using heat for the separation of biomass into combustible gases (“smoke”) and charcoal (**Pyro** = heat; **lysis** = breaking apart)
- Gasification – conversion of a solid to a gas
- Combustion – burning of the gas to make heat

You can see the whole process in its simplest form by burning a matchstick.



It is the same concept when throwing a log onto a wood burning fire. The log doesn't just light up right when it is placed into the flame. That is because the potential for combustion lies in the smoke. The fuel must first be heated to approximately 450° Celsius in order to separate the combustible gases. Then when there is enough of it concentrated and mixed with oxygen, it can be combusted into flame.

- A. Fuel is added from hopper onto fuel pile above grate
- B. Fuel is top lit with lighter fluid
- C. Air enters upward through fuel
- D. Hot smoke fills the "smoke maker" above the fuel
- E. Air enters the "Combustor" for clean combustion of the smoke rising from the smoke maker
- F. Used fuel becomes hot char and keeps the in-coming raw fuel heated to release smoke (pyrolysis gases)
- G. Openings for lower secondary air help control draft
- H. Ash and excess char are released after build up



Gasification related to your Biomass Furnace

This is a diagram of a Chip Energy micro-gasifier. Micro-gasification is the same process described above, but modified for intensity and efficiency. The making of gases from the dry biomass takes place separate from where the gases are combusted. This control allows for a complete and clean burn at a much lower cost than other options.

This process is considered to be “carbon neutral.” It does not produce greenhouse gases. Any carbons released after combustion were taken from the atmosphere previously when the biomass was a living plant. In fact, it releases virtually no visible particulate matter at all.

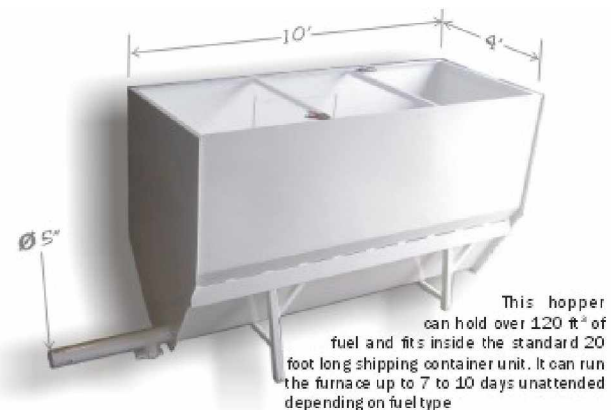
The Biomass Furnace’s standard hopper is ten feet long and can hold up to 120 ft³ of fuel and can run the furnace completely unattended for up to 10 days depending on fuel type. At a fuel rating of 8,500 BTU/lb, a preliminary furnace

rating is 184,50 BTU/hr. That is a furnace with only one gasifier unit. Larger buildings may be interested in a furnace with two or more gasifiers and an even larger fuel hopper.

The entire process depends completely on draft: the passage of air through the system. Without airflow, the pyrolysis, char gasification and combustion cannot take place.

Part 3: Understanding the Biomass Furnace

The Chip Energy Biomass Furnace is an Outdoor Biomass Gasifier Hydronic Heater. Hydronic means that the heat produced is transferred and stored in water until it is re-released via a heat exchanger. Chip Energy uses a flash boiler to extract the heat directly from the gasifier. As water passes through the coils, it is instantly heated and pumped to the



The gasifier and flash boiler



heat exchanger that sends hot air through the building’s existing central air system.

An insulated water tank will store the hot water for improved efficiency. Once the water reaches the appropriate temperature, the PLC (Programmable Logic Controller) will turn down the gasifier, but water will continue to pump to the heat exchanger. The amount of time this can continue depends on the size of the tank and the size of the area being heated. Running for 24 hours, the furnace can go through approximately 520 lbs of fuel. That amount can be significantly reduced using the optional water storage.

Your Biomass Furnace services from Chip Energy

The PLC takes readings from weight sensors to monitor when to deliver fuel to the hopper, and when to empty the ash and char storage. It is the company’s goal to have a recycling and delivery center in every region of the country where there are biomass furnace owners.

Currently, Chip Energy has one location in Goodfield, Illinois with a recycling system for used construction pallets collected from local businesses. There is over 3 million lbs (1,500 tons) of wood on the lot with more being collected everyday. That is enough to fuel 50

furnaces running 24/7 straight through an entire heating season in this cold winter climate.

The ash and char remnants must be occasionally removed. Both components are in high demand in the agriculture industry. The ash contains nutrient value for plants. The char created from biomass is appropriately called biochar and represents CO₂ removed from the atmosphere. Studies show that sequestering biochar enhances plants’ overall growth and crop yield by up to 200%.

The Furnace can be set to automatically remove the byproduct from the gasifier at any stage and store it in the drum. Like fuel delivery, Chip Energy will one day be prepared to provide biochar and ash collection. It is capable of converting 15% to 20% of the fuel used daily (up to 80 lbs of biochar a day). If used agriculturally, the biochar will generate a “carbon negative” effect. The carbon negative phenomenon actually reverses the greenhouse effect, meaning it removes CO₂ from the atmosphere and returns it to the earth.



A sample of wood pellet fuel and a sample of biochar removed after combustion