FY 2013 PGFireBox

A Biomass Waste Solution

Table of Contents

1.0 Introduction

This technical brochure presents a new machine called the PGFireBox, that combines two known technologies to create the first portable machine for power generation from large scale biomass . Air Curtain pollution control technology and Waste Heat to Power (WHP) technology are combined to produce a portable self contained unit which generates significant amounts of electricity from vegetative waste and is the fastest, most environmentally friendly method for reducing vegetative waste. With this machine you can recover green energy and reduce your carbon footprint.

Air Curtain Burners deployed to the forests and landfills have proven to be one of the most cost effective and environmentally friendly ways to deal with large amounts of wood and vegetative waste. Our technology is well proven and our machines have been subjected to extensive testing by numerous environmental agencies worldwide. We are a CRADA partner with the US EPA, we work closely with the US Forest Service (USFS Tech Tip 0251-1317), the Department of the Interior, the Department of Energy and the US Military. Our machines are currently used by numerous communities, state agencies and national parks.

An Air Burners PGFireBox is the most economical and lowest environmental impact method to deal with vegetative waste. The Power Generating FireBox accomplishes three important tasks;
1) It reduces the wood waste by 98%, ten tons of logs in, gives you a couple hundred pounds of ash out. A clean, natural ash which is a highly desirable recycled product for agriculture, growers, nurseries and is also a good landfill cover.
2) It captures energy from the wood waste and converts it to electricity providing an additional income from the use or sale of that electricity.
3) It significantly reduces the greenhouse gas emissions from the current methods of disposal, grinding and landfilling.

The primary difference of this machine compared to current designs of biomass power generating facilities is the ability to convert whole logs, branches, limbs, pallets and other wood waste into energy without the costly processing that hamper the economics of the current biomass energy facilities and create large amounts of greenhouse gas emissions. To accept whole logs, branches and other whole wood products, current biomass energy systems require multiple stages of grinding and pelletizing to precondition the waste. Then, most of these type of biomass facilities require a supplemental fuel like natural gas (as high as 20%) to support combustion. The PGFireBox does not require any waste preconditioning or supplemental fuels.

In addition the Air Burners, PGFireBox can be relocated very easily if supply of waste material changes over time. One of the other important differences of the Air Burners machine is that it can be resold if you decide on a larger machine in later years or if your business model changes over the years. Unlike the current biomass to energy designs, you are not stuck with a permanent structure.

This type of machine would be useful in almost every landfill, transfer station or forestry operation. The PGFireBox allows the operators of these facilities to move away from costly diesel powered machinery and convert to electrically powered equipment and vehicles “fueled” by the waste they are collecting.

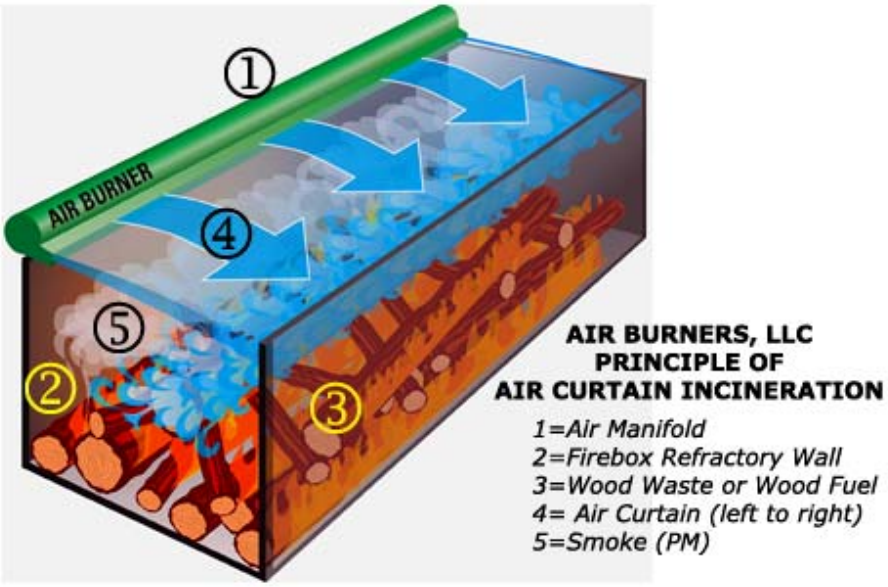
On the following pages we present an overview of our technology, an outline of the new PGFireBox and the expected performance.

2.0 Air Curtain Technology

Air Curtain Burners were designed principally as a pollution control device. The primary objective of an air curtain machine is to reduce the particulate matter (PM) or smoke, that results from burning clean wood waste. It is sometimes hard to visualize without seeing a machine in operation (see video at: www.AirBurners.com), but the machines do not burn anything, rather they control the results of something burning. You could look at it as a pollution control device for open burning. Clean wood waste is loaded into the FireBox, an accelerant is added to the wood and the pile is ignited. Once the fire is ignited the vegetative waste burns naturally; no additional fuels are used. Similar to starting a campfire. The air curtain is not engaged until the fire has grown in strength or the air curtain may blow the fire out. Once the fire has reached suitable strength, usually in 15 to 20 minutes, the air curtain is engaged. The air curtain then runs at steady-state throughout the burning operations and the waste wood is loaded at a rate consistent with the rate of burn.

Principle

The purpose of the air curtain is to stall or slow down the smoke particles on their way out of the FireBox. In doing this the particles are subjected to the highest temperatures in the FireBox. Stalling the smoke particles in this region just under the air curtain causes them to re-burn, further reducing their size to an acceptable limit. The result is a very clean burn with opacities well under 10% using the EPA Method 9 testing (as compared to open burning which typically can run at 80% to 100%).



Operation

You can see in the picture to the right a standard Air Burners FireBox completely full and burning while in the background a pile of wood is open burned. This is a photograph taken by BC Hydro in Canada at one of their hydro-electric dams during the first test of the Air Burners machines. The wood is regularly removed from the water intakes.

The wood pile that is open burning continued to burn for several days. That open burning pile could have been eliminated with the FireBox in less than 2 hours with significantly less impact on the environment.

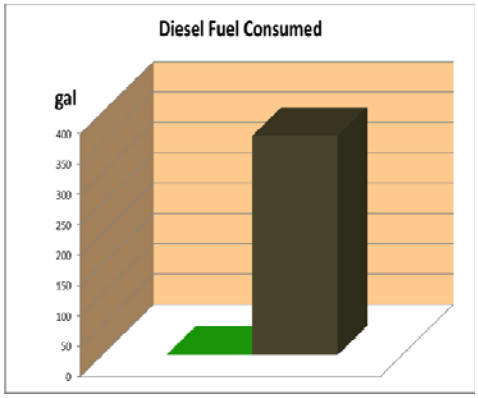
3.0 Reducing our Carbon Footprint

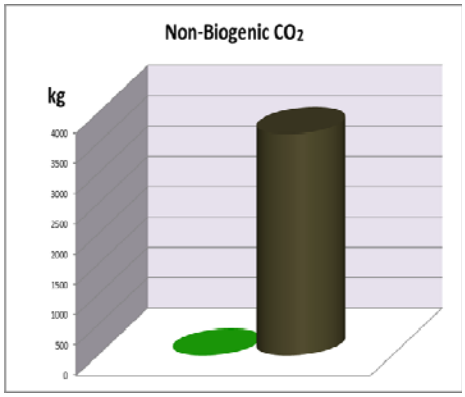
"Alternatives to open burning – such as land filling, composting, or chipping and hauling may generate more greenhouse gases than open burning (due to secondary life-cycle emissions)"
Canadian Ministry of the Environment.

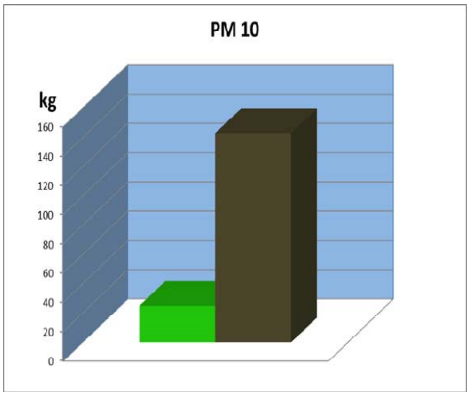
While burning of clean wood and vegetative waste is a natural process that has been occurring since Earth's beginnings and is part of the green life cycle to deliver "good" carbon dioxide to grow our plants that produce the oxygen we breathe; it also delivers particulate matter into our air. It is the particulate matter (Black Carbon) that we are most concerned with as it hinders our breathing and it has been proven to be a significant contributor to global warming. Therefore, many environmentally conscious people advocate for alternative methods to handle our wood waste like landfilling, grinding, composting, etc. But they don't seem to be aware of the environmental "cost" of these other processes, like the diesel fuel burned to grind and haul or the particulate matter dispersed from grinding and composting, or the outgassing of non-naturally occurring gases like methane as the piles decay or the impact of leachate to our ground water. The best environmental solution is to burn naturally without the particulate matter release. (visit www.AirBurners.com for more detailed information)

The PGFireBox allows the wood waste to burn naturally with no supplemental fuels, it cuts the particulate release by at least 90% and it produces electricity from the waste. (see emissions test data in appendix A).

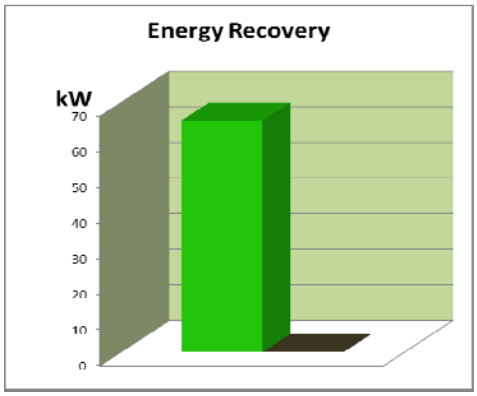
The charts below compare grinding with the Air Burners machine. This is the same process necessary to support all the Biomass to power schemes today…. except the PGFireBox. See the comparison of processes on the following two pages. All of this processing and the resulting pollution and cost is eliminated with the PGFireBox. The charts below compare the costs and emissions for processing 100 tons of wood and vegetative waste (approx. 1 day worth of material).

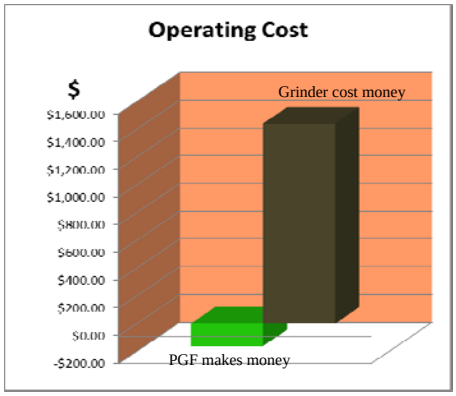


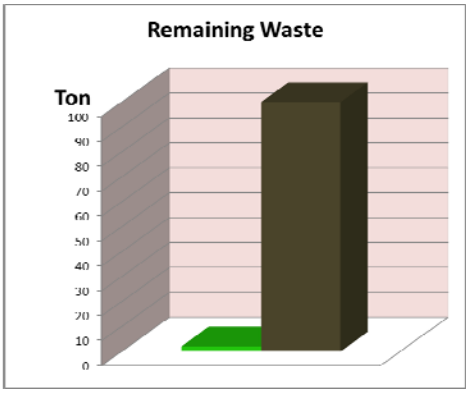




PGFireBox **Grinder**





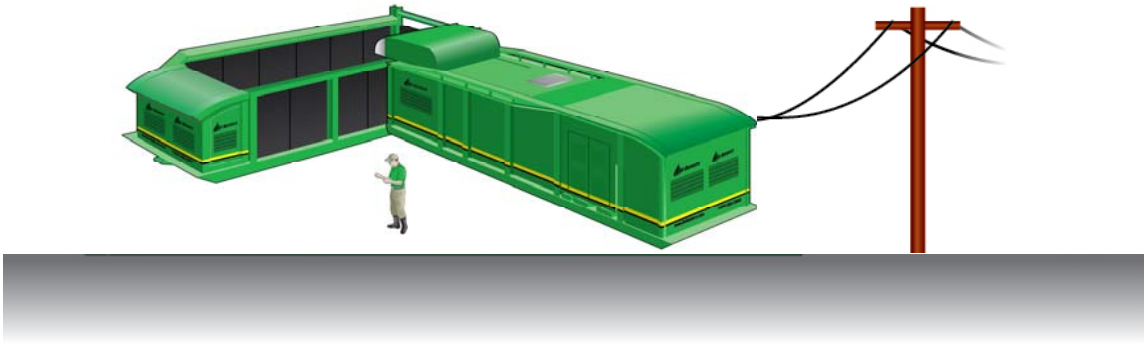


Air Burners, Inc.
4390 Cargo Way, Palm City FL 34990, Phone: 772-220-7303

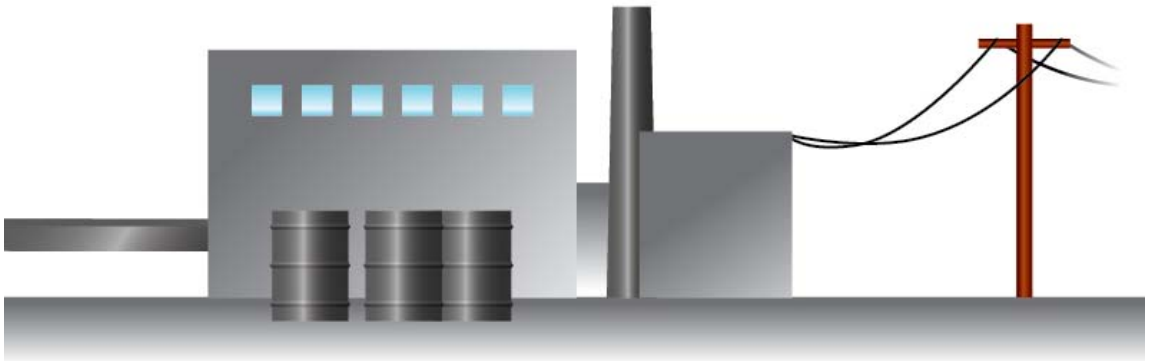
3.0 Reducing our Carbon Footprint, *cont.*

When comparing the PGFireBox with the typical biomass incinerator, the most significant difference is the reduction in processing. Biomass incinerators require the grinding and chipping of the wood waste into very small chips so they work on the conveyers supplying the incinerator. This process is the most expensive and highest emissions producing component of biomass power today. More importantly, it is a "recurring cost" of daily operations. The PGFireBox does not require any processing. Whole logs and branches go directly into the machine to produce significantly cheaper and cleaner power. The diagram on the next page provides a comparison of the two processes.

PGFireBox

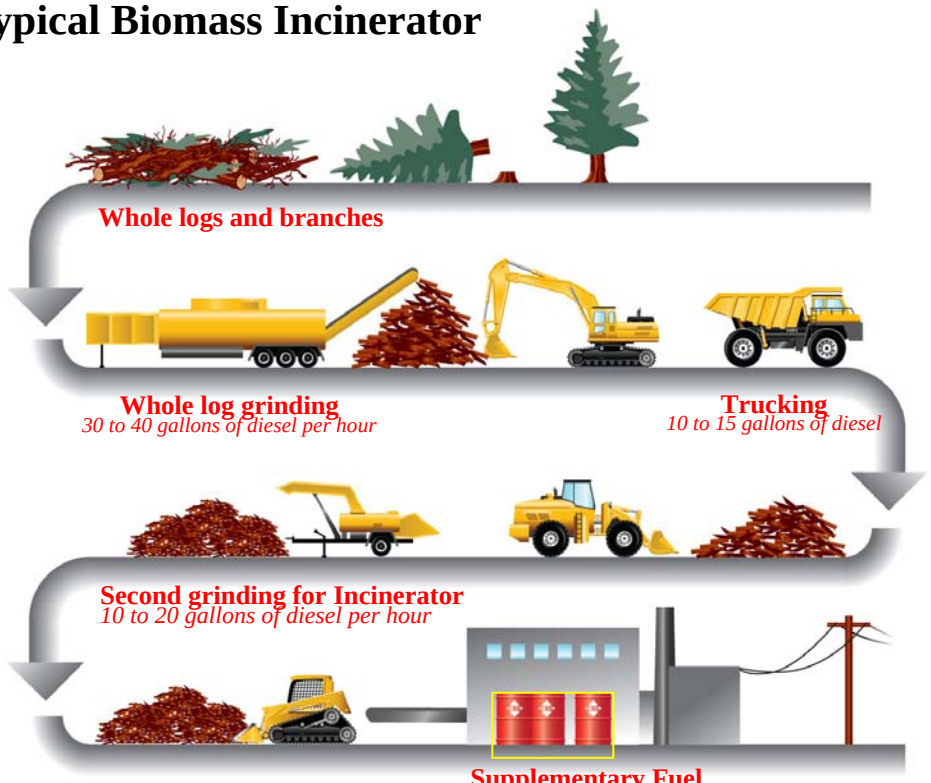


Biomass Incinerator



Comparing The Two Processes

Typical Biomass Incinerator



Rev2

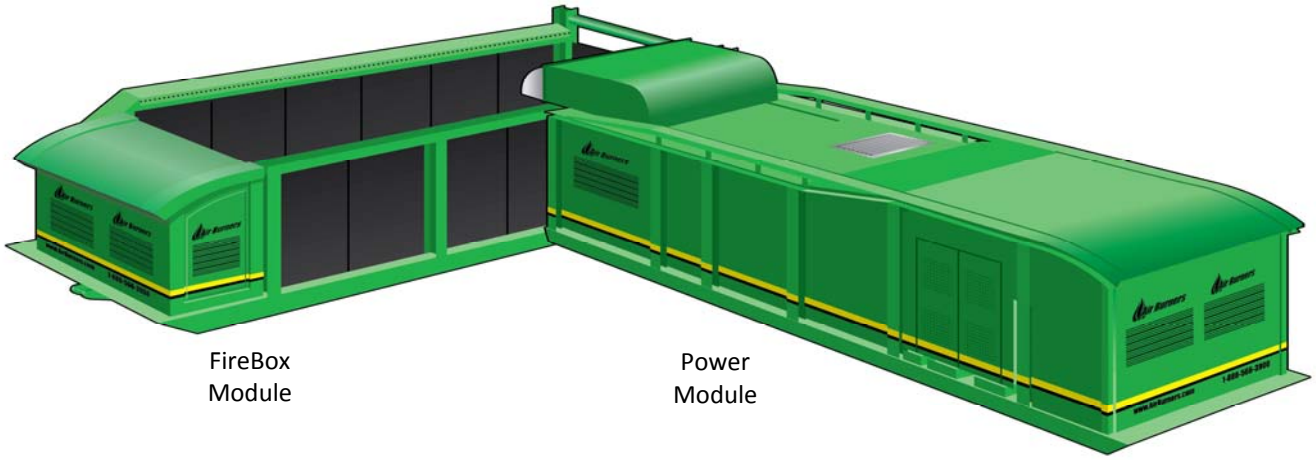
Air Burners, Inc.
4390 Cargo Way, Palm City FL 34990, Phone: 772-220-7303

4.0 PowerGen FireBox

Design

The new PGFireBox is a significant step forward in alternative energy, we have designed and patented a new high efficiency heat recovery system that allows for the simple capture and transfer of heat produced by the burning wood waste to the Organic Rankine Cycle Waste Heat Generator (WHG). Currently we are using the ElectraTherm system as it is the most sophisticated and efficient system on the market. The WHG transforms the waste heat to electricity. All of this is processed and controlled within the Air Burners Power Module. The PGFireBox is fully self-contained in two components as depicted below.

The FireBox Module is where the burning operations occur. Wood waste is loaded over the manifold into the FireBox which is 20 feet long by 7 feet high and 7 feet deep. At the rear are two doors which allow for the daily removal of ash which is removed using the Air Burners ash rake. Ash removal takes about 10 minutes.



The FireBox module includes the; thermo ceramic lined FireBox, the air curtain pollution control system and the air curtain fan and drive. The air curtain fan is driven and controlled electrically by the Power Module.

The Power Module is where the electricity is generated. This includes; the heat capture system, the waste heat generator (WHG), the operator interface and the expansion system. The machine is fully self-contained and easily transportable, making its use possible between multiple sites or communities.

Operation

The two units arrive by standard truck and are placed on level ground. The Power Module is "pushed" into place in a "T" pattern as depicted above. The grid connection and cooling connection are completed and the unit is ready to operate. Wood waste is loaded into the FireBox Module and ignited. After approximately 15 minutes the heat recovery hood is extended and the unit begins generating electricity. When burning operations are complete the operator stops loading the FireBox. The hood can remain in place as long as heat remains to power the WHG (estimated additional 2 to 3 hours). Once the heat is insufficient to power the WHG the hood is retracted and operations stop.

4.0 PowerGen FireBox

Systems

There are four major systems in the PowerGen FireBox; 1) Waste heat recovery loop, 2) Benign refrigerant loop, 3) Electrical power processing and 4) Condensing loop.

1) Waste Heat Recovery Loop

The waste heat recovery hood extends into the path of the FireBox heat plume. This area produces heat in excess of 800 degrees Fahrenheit. The heat is directed into the Power Module where it is transferred through heat exchangers to the refrigerant that powers the ORC. This is an internal system that functions automatically.

2) Benign Refrigerant

The eco friendly benign refrigerant is contained in a closed system and is not expelled or replenished. The refrigerant starts as a liquid when it is cycled through the waste heat recovery loop. As the heat is transferred to the refrigerant, the refrigerant boils causing it to change from liquid to vapor. This rapidly expanding vapor travels through the "expander" in the ORCWHG causing it to spin the generator which produces electricity (AC Power). The vapor then travels in its closed loop system to the condensing loop and is condensed back to a liquid and the cycle repeats. This is an internal system that functions automatically

3) Electrical Power Processing

The generator outputs alternating current into a power conditioning unit located in the Power Control Module at a rate of approximately 65kW. The power conditioning unit controls, distributes and conditions the power coming from the generator. First the power is distributed within the system itself to charge the batteries and to run all the pumps, valves, fans and electronics of the system. This consumes approximately 10% -15% of the power. (If an air blast cooler is used for condensing, it will consume an additional 5% to 7%). The FireBox Module will consume approximately 10KW. The remaining power, approx. 30 to 50kW, is then outputted to the local grid or for local use. Power can be provided at almost any voltage and frequency required (50Hz or 60Hz) but the most common is 480volts 3 phase 60Hz AC power.

4) Condensing Loop (for the benign refrigerant)

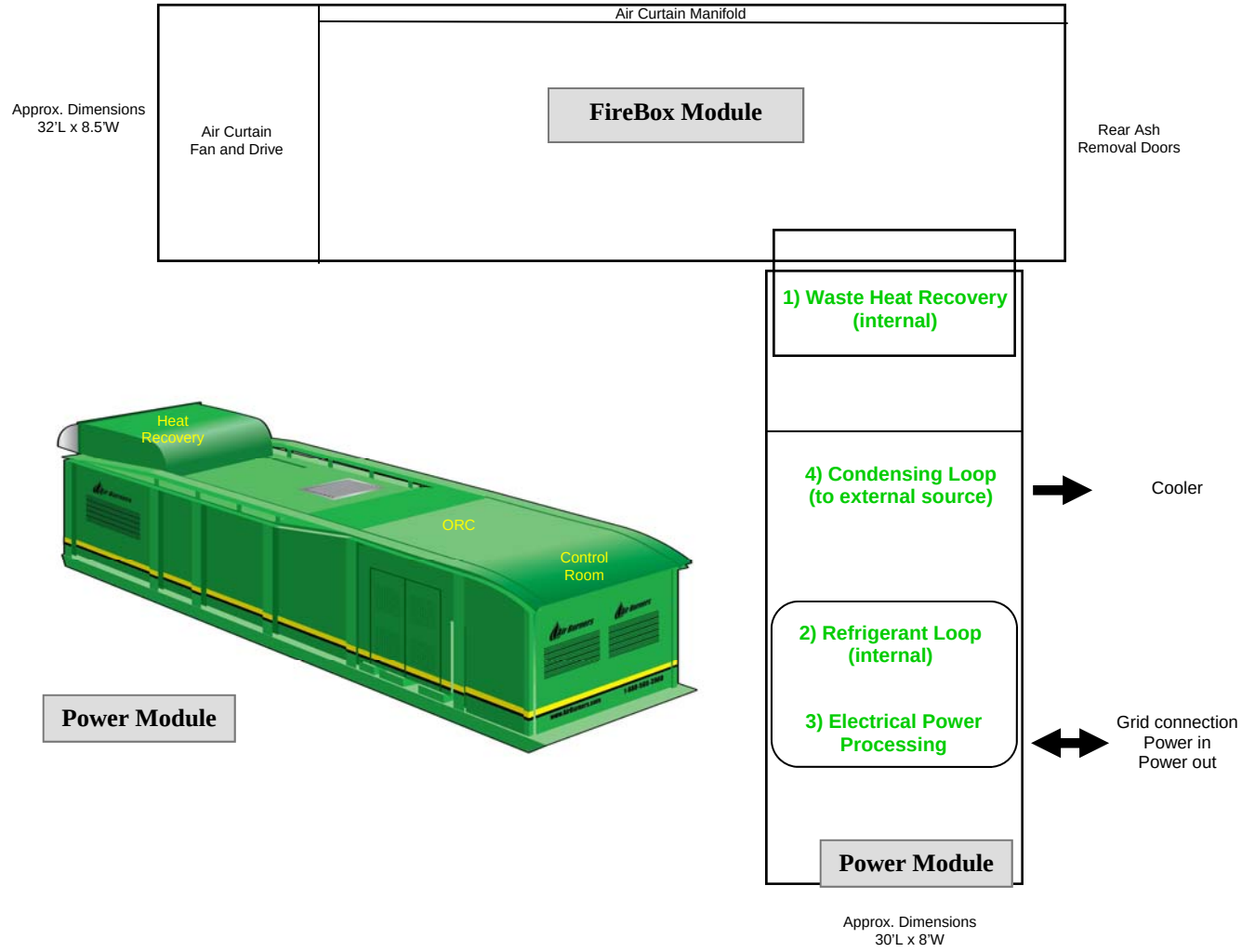
Once the refrigerant exits the waste heat generator it must be condensed (or cooled) back to a liquid. This can be accomplished by three different methods that depend on the location and use of the machine. (See page 10 for additional cooling information). This cooling method is not part of the PGFireBox package and is locally installed based on the best method for a particular site. (Once the best method is decided, we will help specify or purchase the cooler for you).

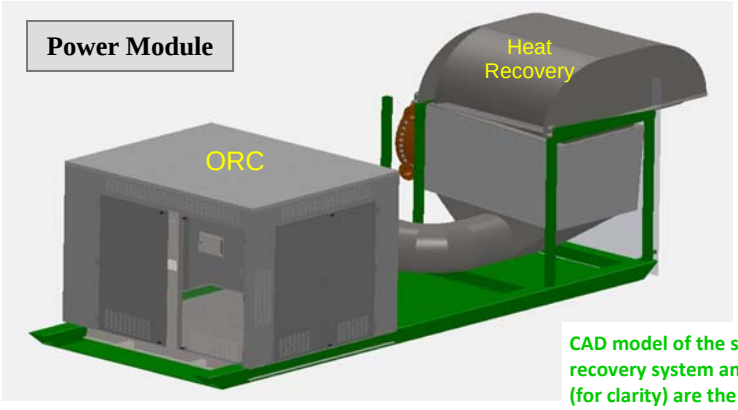
A) Cold Water Condensing - The simplest and lowest cost system is a cold water (78 degrees F) loop where cooling water is drawn from a local pond, stream, lake or well. In this system no cooling water is consumed, lost or contaminated in the process, but the returning water will see about a 10 degree Fahrenheit increase in temperature.
B) Air Blast Cooler - The second option is a cooler which typically uses an ethylene glycol and water mix that flows to and from the machine's internal heat exchanger. This type of cooler is readily available in most regions and it does not require the internal refrigerant to be circulated outside of the PGFireBox.
C) Air Blast Condenser - The third option is an air blast condenser which uses air fans to blow cooling air across a radiator and condenses the refrigerant. This system allows the refrigerant of the PGFireBox to circulate into the condenser. In some regions this will be a more efficient system.

Heat rejected from both options B and C could be further utilized to heat buildings or greenhouses.

4.0 PowerGen FireBox

Power Module

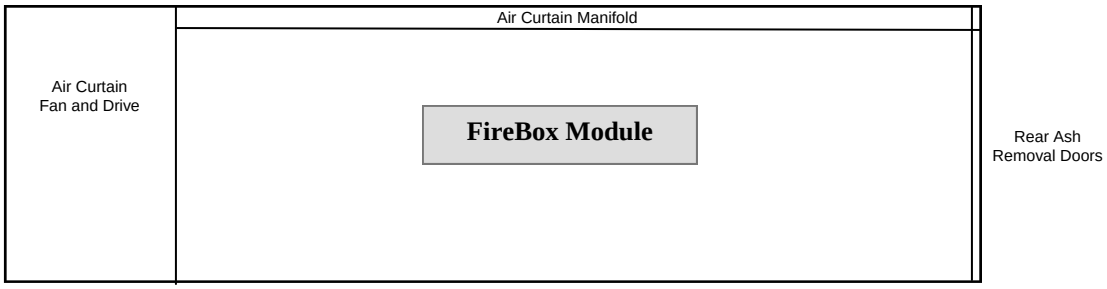


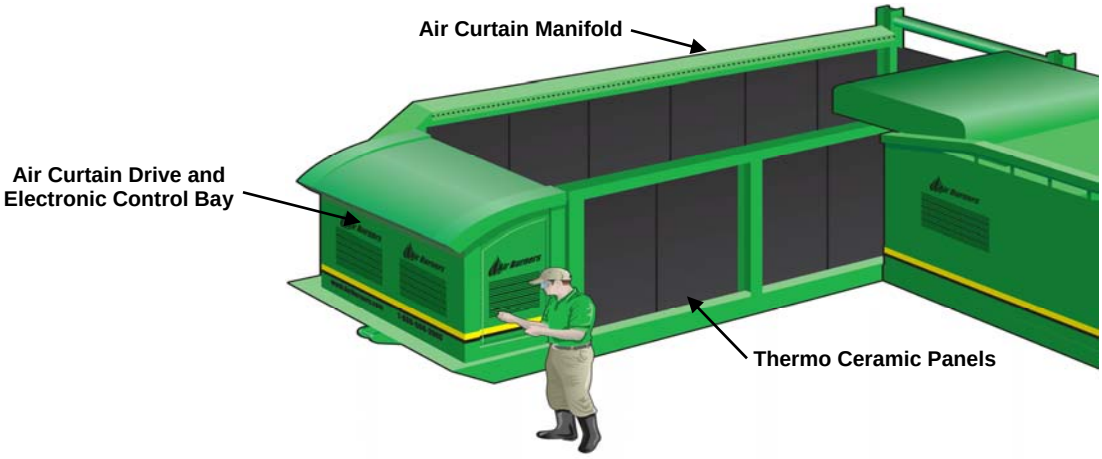


CAD model of the skid base showing the waste heat recovery system and the ORC placement. Not shown (for clarity) are the detail components including pumps, valves, and controls. Also not shown is the front control room.

4.0 PowerGen FireBox

FireBox Module





4.0 PowerGen FireBox

1) System Specifications

The system consists of two components the FireBox Module and Power Module. Each unit is sized for legal load (no permits) transport over North American roads. The only additional component required is the cooling, which can be purchased locally with our help our can be supplied (additional cost) by Air Burners.

Power Module

Power module outputs voltages and frequencies as required by the customer. The most common is 460V, 3 phase 60 Hz. But other frequencies and voltages are available. The machine is designed around the 65kW generator. After the internal parasitic loads the approximate net output will be 50kWh, but will vary some from site to site depending on local conditions including cooling.

Working Fluid

Eco friendly Benign Refrigerant in a closed loop system.

FireBox Module

The waste heat generated in the FireBox Module is captured in the Power Module, converted from heat energy to an expanding gas. The increasing pressure for the gas spins the turbo machinery to generate AC current.

Vegetative Waste Throughput

This system is designed to consume approximately 6 to 8 tons per hour (approximately 30 cubic yards)

Site Delivery and Setup

The units do not require any site preparation other than level ground and an electrical grid connection. Most of the operations for the PGFireBox are automatic so operating training is simple. Complete manuals and maintenance guides are provided with the machine. Onsite setup and training is provided by Air Burners. The training and set up is included in the price of the machine but due to the widely varied locations these machine are going we will bill for travel expenses (air, hotel, food, car etc) at cost. We will work with you at time of purchase to quote those costs.

PGFireBox Specifications		
Cost (FY 2013)	Power Module and FireBox Module	See your local representative or contact the factory at; AirBurners@PGFireBox.com
Vegetative Waste Throughput	Wood, branches, stumps, boards, pallets, saw mill cuttings. (machine will not burn chips, sawdust or mulch)	6 to 8 tons per hour (approximately 30 cubic yards per hour)
Power Output	Gross power 65kW– estimated internal loads 15kW, may vary per site, cooling parasitic load is additional.	Estimated Net power 30 to 50kWh
Dimensions	Power Module is designed to fit in an ocean container, 40 feet long. FireBox module can ship on a flat rack Both units fit on standard trucks	L x W x H 34' x 7.6' x 8.2' Power Module 30' x 8.6' x 8.6' FireBox Module
Weight	Power Module (estimated) FireBox Module (estimated)	12 tons 15 tons
Training and setup	Onsite Air Burners personnel to help with set up and training.	Labor is included in the unit price. Travel expenses are billed at cost.
Not included	Cooling option and electrical connection to grid	Price quote available from Air Burners
Options	Ash Rake, cooling, ember screen	Price quote available from Air Burners

4.0 PowerGen FireBox

Condensing Loop Cooling Considerations

The benign refrigerant needs to return to a liquid after the vapor has performed the job of spinning the turbine and generating electricity. Consideration should be given to the most advantageous method of cooling as there may be additional heat energy to utilize in particular applications.

Water Cooling Method - The water cooling method is the lowest cost option, consumes the least amount of power and does not consume or contaminate the water. The water system is a closed loop system. Any water entering the system will return exactly the same with the only exception being temperature. The return water will see a 10F to 15F degree rise in temperature over the inlet temperature. Generally the most efficient method is to return the water to its source as the small temperature rise is not very useful in any other heat extraction schemes. The most common method is a ground water well as the Earth is a very efficient heat sink and the returning delta in water temperature will not have any effect on the underground aquifer. If a river or lake is used as the water source then you must ensure the delta temperature of the water will not have any effect on the source. With this cooling option Air Burners will integrate the plate heat exchanger and controls in the Power Control Module. The cooling water pump can be located anywhere convenient onsite. The water source and connection to the water source would be provided locally. The water flow would be approximately 300gpm with a 10F to 15F degree delta outlet temperature.

Air Blast Cooling or Condensing Method - The air blast cooler is a system that incorporates a series of radiators and electrically driven fans to remove the heat. Shown below are typical examples of air blast coolers. This would be the simplest package if the system ever needed to be moved. The Air Blast cooling option can be purchased as part of the package from Air Burners or it can be purchased locally by the customer. If the cooler is purchased from Air Burners then we will include and test all the components necessary to operate the system. If the Air Blast cooler is to be purchased locally, Air Burners engineering will provide the specification and work with the local supplier to integrate the unit. The Air Blast system has the potential to provide waste heat for additional use including; building warmth, greenhouse heat or drying heat.

Evaporative Cooling - The evaporative cooler is very similar to the air blast cooler except a small amount of water is run over the radiators to provide extra cooling efficiency. Depending on the location this can reduce the cooler size by 25% to 50%. Typically the evaporative cooler consumes a small amount of water (varies greatly depending on location temperature and humidity). Depending on the ambient conditions some portion of the cooling water is reused and some portion evaporates. The waste heat from evaporative coolers can be reused, but it tends to be higher humidity than the air blast cooler.

Example of locally installed cooler

Example of integrated Air Blast cooler

Example of locally installed

5.0 ElectraTherm Waste Heat to Power Generator

ElectraTherm's Heat to Power Generation System

ElectraTherm's Green Machine converts low temperature water flows (between 190°F/88°C and 240°F/116°C) into fuel-free, emission free power. The Green Machine output range is from 30-65kWe, based on temperatures and flows.

Visit: **www.ElectraTherm.com** for more information

The machine has low input requirements for its hot water supply relative to other ORC systems. The Green Machine's ability to utilize these low temperature water flows allows its implementation in a rapidly expanding number of distributed heat to power applications. The small footprint, skid-mounted design facilitates ease of installation often where current methodologies for heat to power solutions are not feasible.

The Green Machine is scalable to each heat source, allowing connection of multiple Green Machines to a single heat source if enough energy is provided. The Green Machine employs a robust design and the majority of machine components are readily available. Routine maintenance is easy, and with basic ElectraTherm training, technicians with an HVAC and mechanical background can handle required maintenance.

Additionally, The Green Machine's control system is fully automated, allowing remote control, remote monitoring and off site maintenance.

The Power Block

ElectraTherm's Green Machine uses a twin screw expander for its power block. The twin screw design is simple and robust. The operating speed of the Green Machine is low, and does not require a gearbox. The twin screw can also run in a "wet" condition meaning the refrigerant does not have to be 100% superheated vapor. This is an advantage over traditional turbine-based expansion devices.

Attractive Payback

In locations with electricity rates greater than $US .10, a Green Machine can present an attractive return on investment to an end user. In certain geographies and applications, federal, state or even utility incentives may apply. These incentives further accelerate the return on investment.

ORC Waste Heat Generator

6.0 Summary

The Air Burners PGFireBox is a revolutionary technology that allows you to change a common waste process, reduce emissions and create green energy. This machine generates income from eliminating waste and by creating electricity from that waste. The power from this machine is enough to support 30 typical American homes (USEIA data) or to power a community landfill, or provide electricity to run the facilities at a state park. But beyond just providing power as an alternative to the local power company, the PGFireBox allows you to consider other options like increasing your electric vehicle fleet or changing from diesel and gas powered machinery to electric or battery powered equipment, all charged from a new fuel...your waste.

This technology will allow people to rethink how they treat their waste. If you have an orchard, for example, you might consider storing your trimmings and dead trees to use as fuel to power the fruit sorting plant. If you are a national park you might consider saving some of the debris removed during wildfire prevention clean up to power the maintenance buildings. In areas that experience forest fires the community can provide cleanup collection sites that include a PGFireBox. The power savings is passed back to the tax payers, or that site could provide free green energy to power electric vehicles.

One day land clearing sites and forestry sites will be run with electric machines instead of diesel and they will be powered by the very waste they are creating. Instead of putting diesel in your tractor you will swap out the batteries that have been charging all day on the PGFireBox. No longer would trucks have to haul the waste off site, filling up our landfills, increasing emissions and damaging our roads. The machines would be quieter, the air would be cleaner and we would make a small dent in reducing our dependency on oil.

We hope you will be interested in the PGFireBox. You can visit our website for more information about our Company and our products. And when you are ready to join the Green Energy revolution call us or email us. We look forward to working with you on your next project.

PGFireBox
Powered by ElectraTherm

Appendix (A) AIR BURNERS, INC. EMISSIONS DATA

Charted below is test data from an Air Burners, Inc. machine (this data is only applicable to an Air Burners designed machine). Air Burners air curtain burners have been tested on a number of occasions over a decade's span. Tests were either commissioned by Air Burners (Fountainhead), our customers (Air-Tec BC-Hydro) or a Government Agency (Missoula, US EPA/ Lockheed). The US EPA carried out extensive tests in Louisiana for the purpose of studying the use of our machines for the destruction of vegetative waste recovery from Hurricane Katrina (videos are accessible on our website at www.airburners.com/videos.html).

The standard test to judge the proper performance of an air curtain burner for Air Source Permit Title V acceptance is a visual emissions (VE) test based on a certified smoke reader's observation or by comparing his observation to the Ringelmann Scale, a simple tool for judging the density of a smoke plume. The density is expressed in percent (%) opacity. The US EPA sets limits for opacity for various emissions sources, including air curtain burners. The limit for steady-state operation is 10% opacity. This is determined by recording the opacity four times a minute and then averaging the 24 readings every six minutes pursuant to EPA Method 9. None of the averages should exceed 10%, except during the initial 30 minutes of start-up during which time the average opacity may reach 35% for air curtain burners as the machine increases its operating temperatures in the combustion chamber (FireBox).

Air Burners, Inc. FireBox Emissions Factors for Combustion of Vegetative Waste
Emissions Factors are shown in lbs. of emissions per 1 ton of vegetative waste combusted (except opacity & ratios)

PM 2.5	PM 10	SO_2	Nox	CO	VOC/NMHC	CH4	CO_2	Opacity	CO_2/CO	CE	Notes
Air Tec - BC Hydro											
na	0.13	0.00313	0.03	0.611	0.11	na	3,607	5.00%	5,900	na	CO_2 Calc.
Missoula - USDA Forest Service											
1.1	na	na	na	2.6	1.1	1.4	3,616	na	1,400	99%	
Fountainhead Engineering											
na	0.10	0.005	0.05	1.050	na	na	3,607	5.40%	3,400	99%	CO_2 Calc.
Lockheed/EPA Region 1											
na	na	ND	na	1.17 (Note 1)	0.005 (Note 2)	na	3,607	na	3,000	na	CO_2 Calc.

ND = Not detected; na = Not tested
Note 1 = 50 ft downwind (Puerto Rico)
Note 2 = 100 ft downwind (Puerto Rico); 50 ft = ND
CO_2/CO ratio is a good indicator of combustion efficiency.
A high number signifies a clean burn. Anything above 1,000 is acceptable per DEFRA/UK
Complete Test Reports can be made available upon request

Appendix (B) AIR BURNERS, INC. Power Module

Power Module
(shown without panels)

Heat Capture Hood

Heat Exchanger

ORC
(generator)

Control Room
(without enclosure)