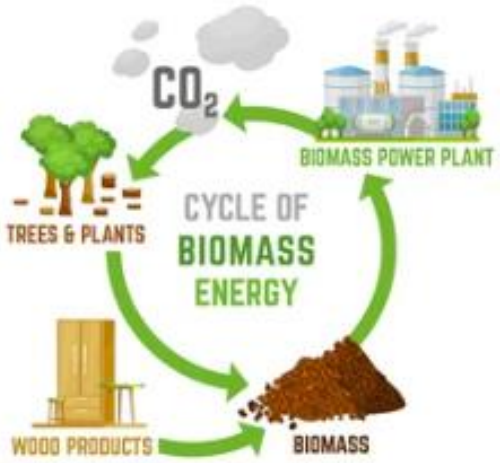


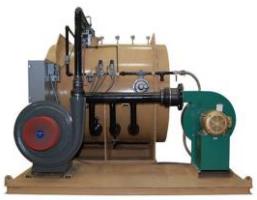
Woody Biomass & Agricultural Biomass

Vortex Energy Group LLC
www.VortexEnergyGroup.com

A Guide to Woody Biomass-to-Energy Vortex Combustion Technology

Our *"Did You Know?"* Series

As part of our "Did You Know" series, we are offering this detailed description of our latest ***Thermo*MAX™** technology, for specific applications. To learn more about vortex combustion, you can read our Guide to Thermal Vortex Technology, or other documents in this series, available online at www.VortexEnergyGroup.com.



Pat. 11,835,231

General Description

The ***Thermo*MAX™** is a grateless combustor that uses high temperatures (2,000^{o} F and above) with high speeds (a 90 mph tornado on its side) to more efficiently burn shredded waste material, in this case, woody biomass. This material then moves through the chamber towards the back wall, where (through a patented and proprietary method) it is re-introduced back into the vortex for continuous burning.

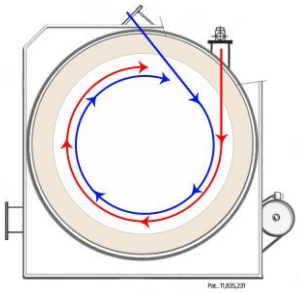
This overall process is known as "synergistic iteration." As the waste material burns in suspension, it becomes its own fuel, mixing with controlled amounts of air (oxygen) to achieve ***complete and perfect combustion***. Current technology systems allow the waste to sit or rest on a grate while burning, which produces the harmful emissions, gases, fly ash, and smoke, because of incomplete combustion. These require expensive and complex air scrubbers to remove the contaminants prior to entering the atmosphere. The ***Thermo*MAX™** does not produce these same harmful outputs, and therefore does not require exhaust cleaning or scrubbing.

Background

Biomass is biological material derived from living, or recently living organisms. Woody biomass, for our purposes, is the material from trees, but specifically the non-marketable wood normally found in forest undergrowth, also known as the understory. This material does not have a marketable usage, and is therefore disposed of in most areas through the process of open-field burns, known as prescription burns. To prevent massive amounts of smoke choking the surrounding environment, this forest residue must dry out, or season for several months before being burned. One issue that raises concerns about the open burning is the potential for sparks and fly ash to travel through the airstream and ignite wildfires in nearby forests. Our technology will allow processing 24 hour per day, 7 days a week, and can accept very high moisture content.

Details

The trees are fed into a standard chipper either onsite or at a nearby facility. The chipped wood is then inserted into a material handling manifold with the help of a fan supplying the primary air for the combustion chamber. This mixture of air and chipped wood is introduced into the chamber tangentially,



which follows the contour of the chamber, and is blended with the motion and direction of the vortex flame, as shown with the blue curved line in the image to the left. This process now creates a super-heated vortex which burns the chipped wood material while fully in suspension. To achieve complete and perfect combustion, it is necessary to control the mixture of the waste, fuel, and oxygen. Turbulence is also a critical factor, which in this case comes about with the high-speed vortex rather than a shaker-grate as some combustors use. Additionally, as the waste material is moving through the chamber, it is not only reducing in size, but becomes fuel for the process, which allows for a higher level of combustion and efficiency.

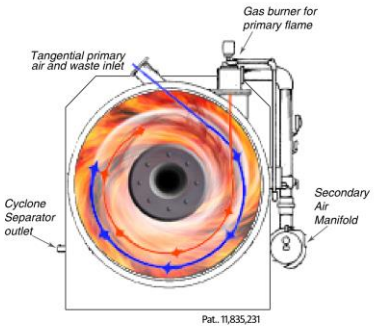
Did You Know…?
… that combustion has been used as a means of waste management since the 1800's?

The ***Thermo*MAX™** has been designed with state-of-the-art programmable logic controllers (PLCs) for automation processing. It is also equipped with an array of sensors which allows complete and accurate control and monitoring of numerous factors, such as vortex temperature, vortex speed, secondary air dampers, and the air quality contained in the exhaust stack. The system is equipped with EPA-approved monitoring software, with remote access capability to provide continuous transmission of the data collected and reports directly to the state environmental protection agency, and to local public works managers and supervisors.

Did You Know…?
… that in addition to being part of our breathing process, CO_2 is used for adding carbonation to sodas, and in the making of wine?

With complete and perfect combustion, the only by-products are CO_2 and H_2O. No harmful emissions, gases, fly ash, odors, or even smoke, are produced through the process of this vortex combustion, therefore no scrubber systems are needed. The exhaust that is released into the atmosphere is clean and harmless, far exceeding EPA air quality specifications and standards. Because this process doesn't allow for waste to sit or to collect, as well as not having soot or other messy residue build-up, there is very little maintenance required as opposed to current technology systems.

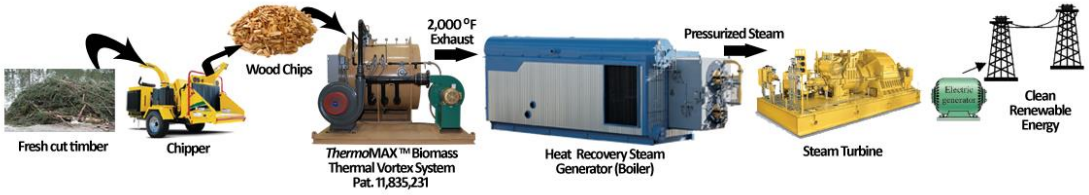
One of the most unique features of this technology is the high speed vortex. No other combustion system takes advantage of the efficiency that this offers, compared to standard combustors that use fixed or even shaker grates, or multiple chambers. With the use of a "free vortex" in combination with the high temperatures, and no need for the exhaust scrubber systems, the output temperature in the exhaust stack stays consistently around 2,000 º F.



This system can be used as part of a waste-to-energy (WtE) system, where the super-heated exhaust can be directed to a heat recovery steam generator, or boiler, and then to a steam turbine for the production of electricity. By processing woody biomass material, which burns

at 3 times the BTU rating of standard municipal solid waste, energy is produced more efficiently than other technologies that create oils and fuels from biomass. Current methods require several steps, such as the creation of feedstock (pellets), used as fuel for various biomass-to-energy processes. The ***Thermo*MAX™** can easily handle chipped wood at a rate of 8 to 10 tons per hour, which will obviously generate an impressive capacity of electricity.

Woody Biomass to Energy Process



This energy recapture process has been used for decades in this country, as well as all around the world. In each case, there is always a boiler and a steam turbine, but the combustion source can vary based on specific needs. Other combustion sources include jet engines, natural gas / coal fired / wood burning furnaces. Combustors are used, but because of the need with current technologies to have exhaust scrubbers that reduce output temperatures, they aren't as efficient as other sources.

Without getting into technical electricity distribution and transmission concepts, the process, once the electricity is generated from the steam turbine, is handled by the electric utilities. The electrical output is purchased by the utilities, and distributed into the grid as necessary. The power that is generated at one site may not be used in the same geographic region, but could be transmitted several states away. Having a lower cost of energy production also gives the owner/operator a significant return on investment, much sooner than is currently available with other renewable and biomass-to-energy resources.

Did You Know…?
… that just one 4 ton/hr T*hermo*MAX™ system with energy recapture can generate more electricity than 4 large wind turbines?

Summary

The ***Thermo*MAX™** offers a high level of efficiency through the unique blending of extreme temperatures and high speeds, along with a patented process of reintroduction of particulate matter for continuous burning to achieve complete and perfect combustion. Because of this process, the system does not produce harmful emissions and gases, odors, fly ash, or smoke. With a small footprint, this system can be installed closer to populated areas, and offers a unique, modular design for rapid replacement or modification. The ***Thermo*MAX™** can also be used as an eco-friendly solution for mobile needs, and can also be configured with smaller boiler/steam turbine combinations to produce electricity on a temporary basis.

Although the ***Thermo*MAX™** Vortex Combustion System can be used on its own to increase productivity for forest thinning in sustainable forest management plans, it is most beneficial when combined with energy recovery systems to produce incredible capacities of clean, renewable energy. Since current technologies for biomass-to-energy are typically very large and expensive processes, our low cost, smaller footprint, and fully scalable system offers electricity generation at a fraction of the cost of available methods. But most importantly, our solution means higher productivity in forest thinning, as well as preventing commonplace wildfires, all while protecting our precious environment.

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"Our flame is igniting the world"

Show Me The Money!!

According to a recent feasibility study by the US Bureau of Land Management, forest thinning operations for small diameter materials, or understory, would yield between 6 to 7 tons per acre. Using statistics from the US Forest Service regarding the thinning of this understory, there are 3.3 trees per ton.

- More than 28 million acres of Ponderosa Pine are found in the 12 Western states. If we took only 1 tree from every acre, we would get 28 million trees – with 3.3 trees per ton - that equals 8.5 million tons. It would take 162 of our ***Thermo*MAX6™** systems to process this material.

Stand-alone units	*Complete energy recovery*
162 X $2,682,250 = **$434,525,000**	162 X $11,157,200 = **$1,808,000,000**

- There are over 50 million acres of Pinyon-Juniper woodlands in that same area. If we took only 1 tree from every acre, we would get 50 million trees – with 3.3 trees per ton – that equals 15.1 million tons. It would take 289 of our ***Thermo*MAX6™** systems to process this material.

Stand-alone units	*Complete energy recovery*
289 X $2,682,250 = **$775,170,000**	289 X $11,157,200 = **$3,225,000**

- 8.5 million tons combined with 15.1 million, equals 23.6 million tons of the two species of trees
- Using the statistics from both the Bureau of Land Management and the US Forest Service, the 6 to 7 tons per acre and 3.3 trees per ton, would yield between 20 and 23 trees per acre average.
- According to a joint report by the USDA and the US Dept. of Energy regarding biomass materials available each year in the United States, there are more than 368 million tons of woody biomass resources, including forest thinning, residential and commercial yard waste, storm damage cleanup and other sources.
- The same report shows that there are more than 998 million tons of agricultural biomass resources, including crops such as corn stover/stalks, corn cob material, sugar cane, and others.
- The two sources offer a combined total of 1.366 billion tons of biomass material available.
- 23.6 million tons for just the two species of trees mentioned, represents only 6.4% of the woody biomass, and only 1.73% of the total biomass material available.
- To process the 1.366 billion tons of biomass material, using 6 tons per hour, 24 hours a day, for 365 days would require 25, 989 systems, or a total investment of nearly $290 billion.

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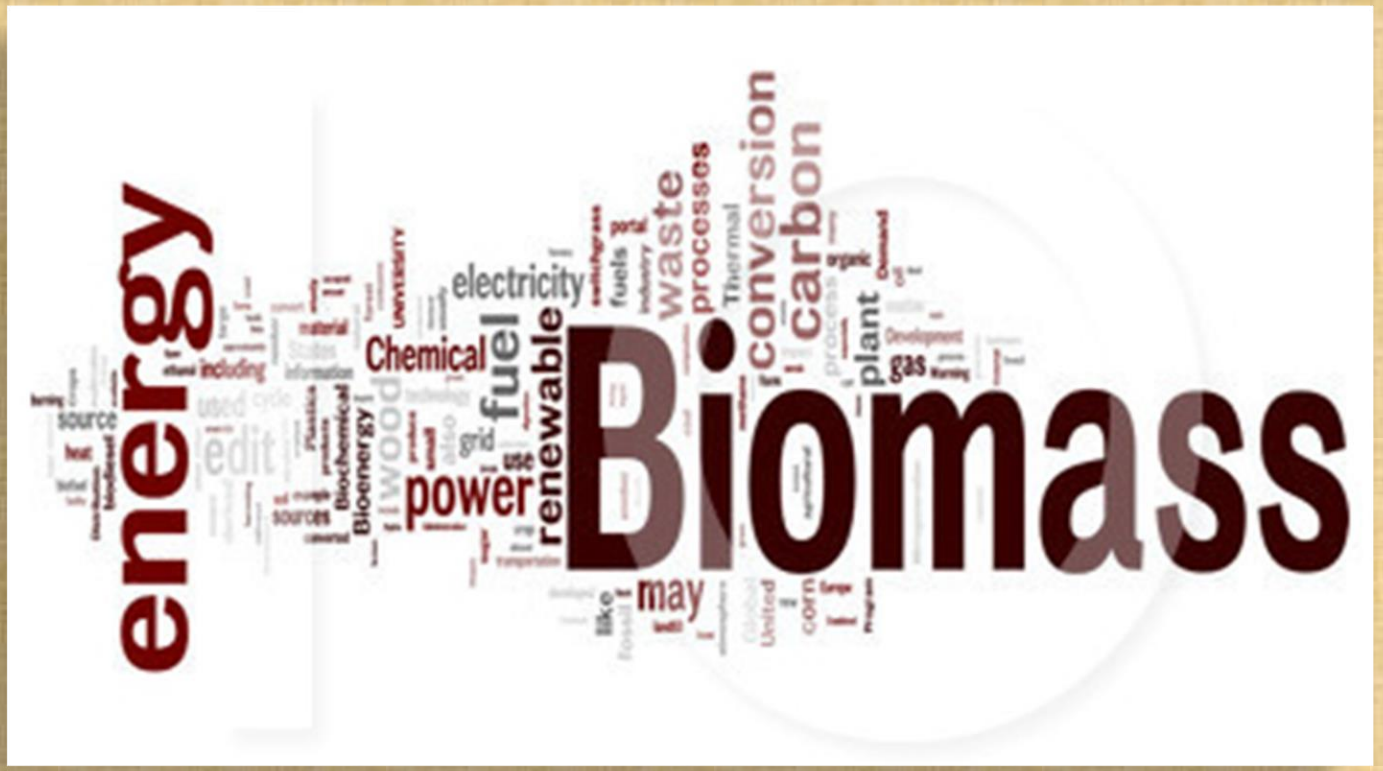

Presented by:

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demand and focus

- Our current worldwide demand for energy using fossil fuels is projected to continue to increase over the next 20 years and beyond. The U.S. gets most of its energy from other countries, some that don't like us very much.
- It is imperative for us to find new, sustainable renewable and alternative sources of energy. For this discussion, we are going to focus on biomass, specifically woody biomass and agricultural biomass.

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what is biomass?

bi·o·mass - biological material from living, or recently living organisms, most often referring to plants or plant-derived materials. As a renewable energy source, biomass can either be used directly, or indirectly by conversion into another type of energy product such as biofuel. Biomass can be converted to energy in three ways: *thermal conversion*, *chemical conversion*, and *biochemical conversion*.

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Other types of biomass

- Municipal Solid Waste (MSW) –
- Wood mill residues –
- Urban wood waste –
- Methane capture from landfills –
- Domestic wastewater treatment –
- Animal manure –

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thermal value of biomass

• MSW	4,000 BTUs/lb
• Forest residue	8,500 BTUs/lb
• Corn (cob)	7,911 BTUs/lb
• Corn (stover/stalks)	7,768 BTUs/lb
• Sugarcane (bagasse)	8,188 BTUs/lb
• Wood pellets	8,246 BTUs/lb

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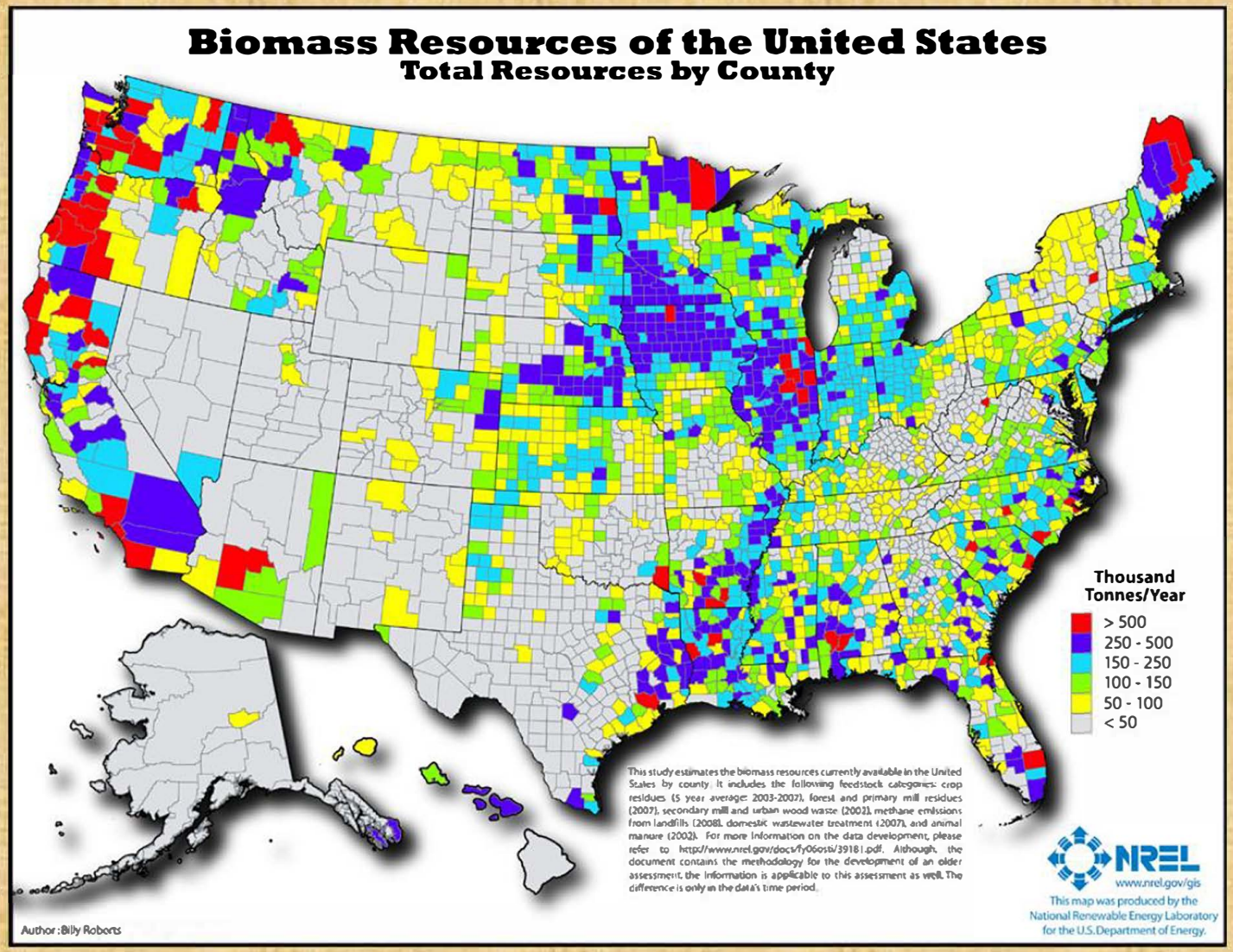

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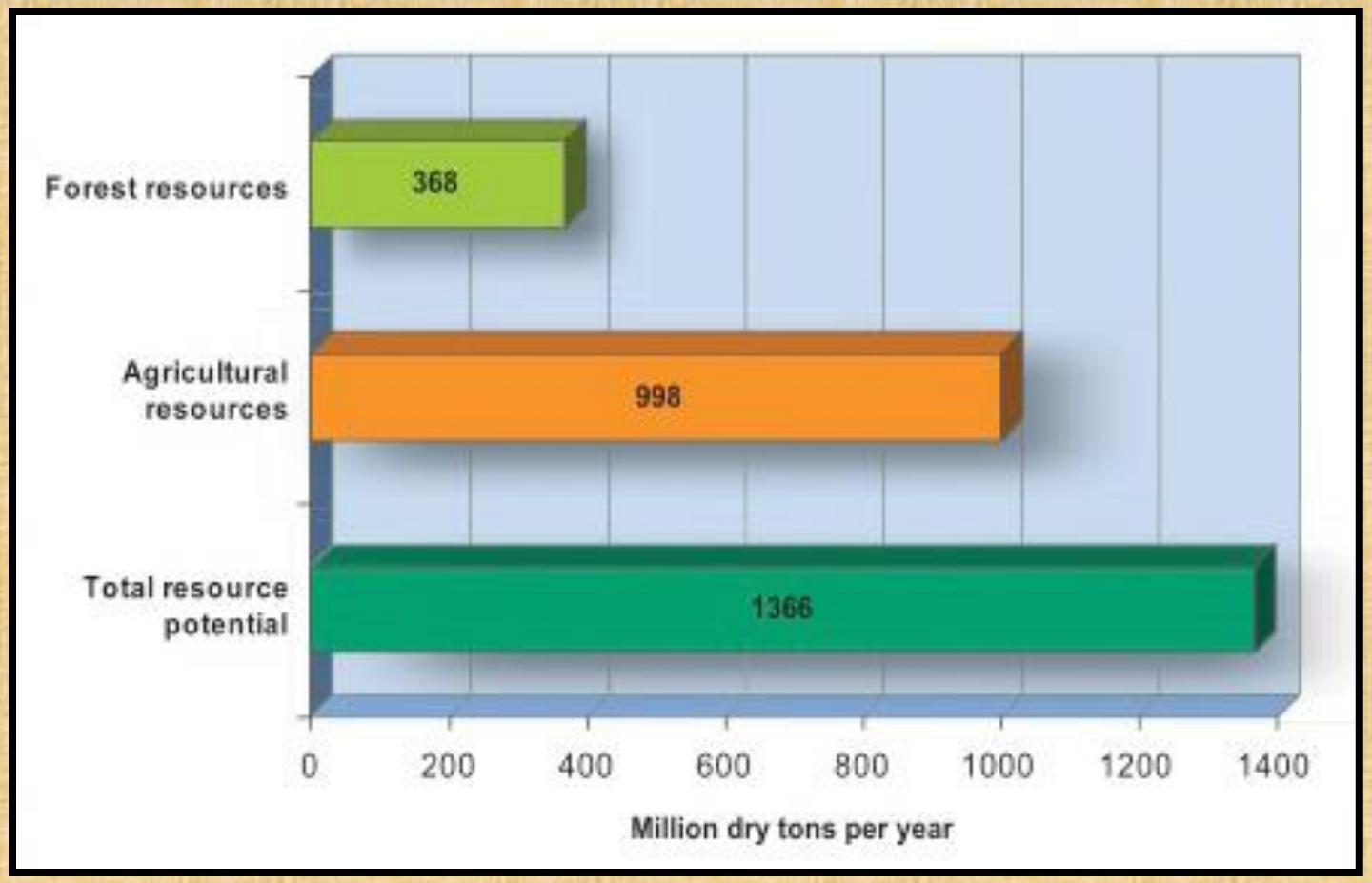
resource potential



Annual Biomass Resource Potential - USDA/DOE

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woody biomass

Benefits of using wood waste:

- As a fuel load reduction that decreases the potential fuel that can be used in a wildfire
- As a means of enhancing forest health (provides a sustainable forest management)
- Improves wildlife habitats
- An abundant fuel supply that doesn't require importing from unfriendly countries
- Inexpensive renewable energy source

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wildfires

Years of fire suppression have left forests throughout the U.S. overstocked and in need of fuel load reduction.

Current methods of forest thinning often result in wildfires caused by errant sparks and fly ash.

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thermal conversion

Thermal conversion is the most widely used method for processing wood waste and turning it into energy. The three primary methods are:

- ***Combustion*** – the oldest known and most widely used controllable energy source on earth, combustion is a chemical reaction where biomass and oxygen are combined in a high temperature environment *(our process is between 1,800°F and 2,200°F)* to form carbon dioxide, water vapor, and heat
- ***Gasification*** – a special combustion process occurring between 1,112°F, and 1,832°F where biomass solids are turned into biogas
- ***Pyrolysis*** – the process of rapid thermal decomposition of biomass in the absence of oxygen. Produces energy, liquids, gases, and char, typically at around 930°F

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our process

Our process for producing significant volumes of clean renewable energy from woody biomass is unique for many reasons:

- *No need to create a feedstock such as wood pellets, reducing cost and operational complexity*
- *Capable of processing high moisture content without decreasing the efficiency of the energy output*
- *Unlike gasification or pyrolysis, wood waste is combusted in full suspension in the vortex, and never rests on a grate*
- *Wood waste can be processed minutes after forest thinning*
- *No fly ash or errant sparks released that could cause wildfire*

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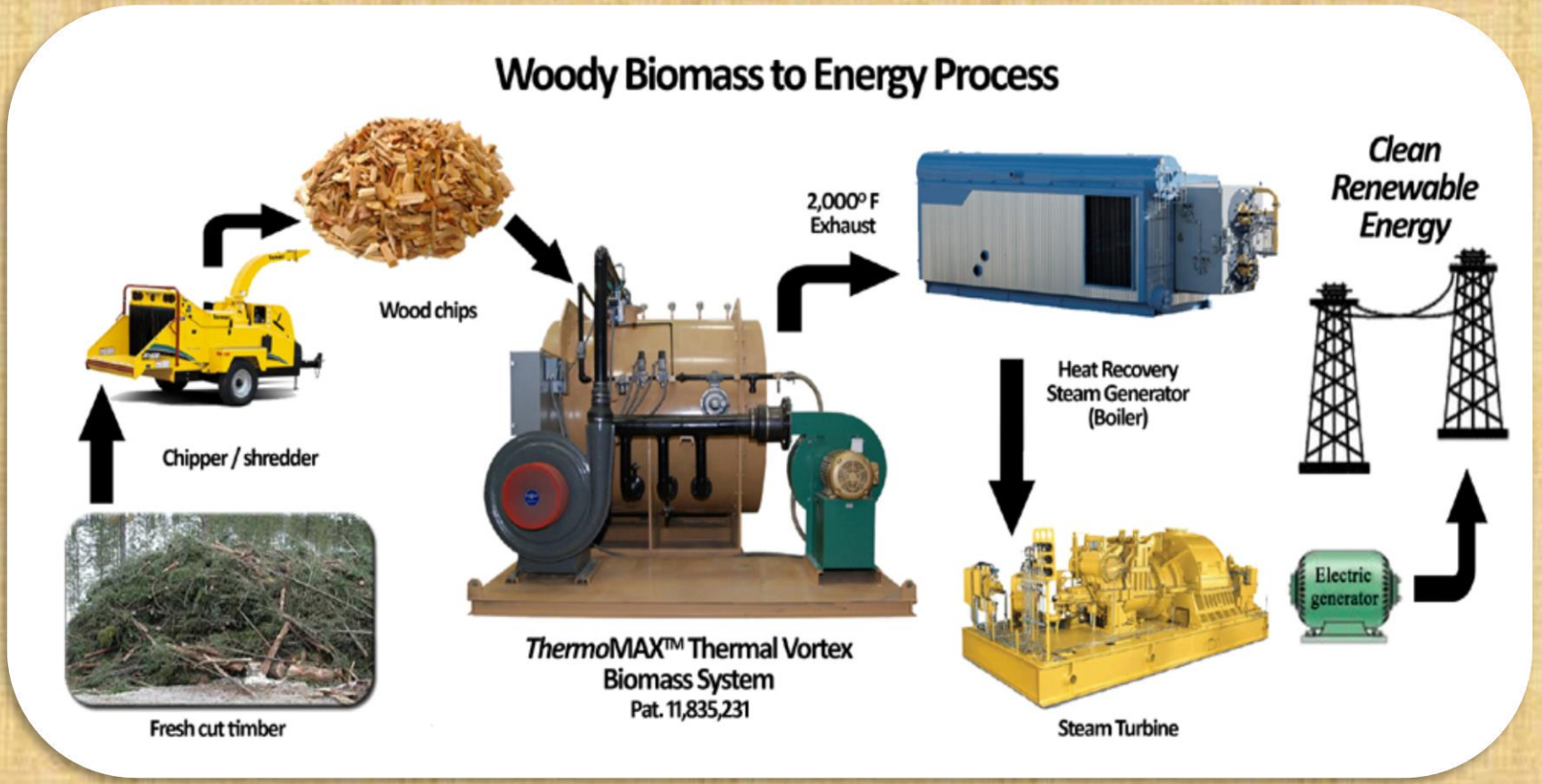
woody biomass to energy



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agricultural biomass

- Agricultural biomass used in energy production offers several benefits, both for transportation with biofuels, and as a source for cogeneration, also known as combined heat & power (CHP)
- Crops include sugarcane (bagasse), corn (cobs and stalks), and a variety of hulls and husk waste products

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sugarcane residual - bagasse

- Bagasse is often used as a primary fuel source for sugar mills; when burned in quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill, with energy to spare. To this end, a secondary use for this waste product is in cogeneration, the use of a fuel source to provide both heat energy, used in the mill, and electricity, which is typically sold on to the consumer electricity grid.
- The resulting CO_2 emissions are equal to the amount of CO_2 that the sugarcane plant absorbed from the atmosphere during its growing phase, which makes the process of cogeneration greenhouse gas-neutral.

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corn – cob and stover

- Corn cobs have long been used as a fuel source for heating. With the advent of the modern combine, cobs are typically left in the field and not harvested. Recently, the value of using corn cobs as a renewable energy source has made a resurgence.
- Corn stover or the leaves and stalks of the corn plant, are also a valuable source of fuel if combusted. Stover has nearly the same BTU value of the cob, or many other biomass materials.

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summary

Used for centuries, biomass is the most abundant and lowest cost source of renewable, non-fossil fuel energy available.

Our proposed micro power generation facilities offer low cost, rapid deployment, as well as a sustainable method for processing wood waste material and conversion into energy.

Compared to other methods, our technology can often be up to one fifth of the cost, and can be installed in months, not years.

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Contact Us

If you would like more information about our biomass to energy process, please contact us:

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