# Electric Power Generation with Torrefied Biomass

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## ABSTRACT

A new breakthrough has been made in converting biomass into a usable fuel. This new process uses liquid immersion heat treatment to make torrefied wood. Prior testing has shown that this system should prove to be faster, less expensive and safer than prior torrefaction methods, primarily due to the heat transfer advantages of immersing the feedstock in a high temperature heat transfer fluid, thereby creating direct contact between the hot liquid and the biomass surface. This new Carbon Neutral Fuel is called CNFbiofuel™ or CNF torrefied wood™.

***Keywords:*** torrefaction, biomass, electric power, wood pellets, feedstock

## BACKGROUND

We receive far more energy from the sun than we could ever use if we could only capture and use it.

Biomass is nature's solar battery. It slowly converts solar energy into carbon compounds that can be extracted and used for energy production. The problem is that biomass also contains lots of moisture and VOC's (Volatile Organic Compounds).

When biomass with moisture and VOC's is burned, incomplete combustion results and tremendous amounts of air pollution result.

The key is Torrefaction! This is a process that exposes biomass to high temperatures in an oxygen free environment where all the moisture and VOC's are driven out of the wood. During this heat treatment the wood undergoes an endothermic process that alters the cellular structure and changes the chemical composition during Torrefication.

Torrefication was developed by the French over 60 years ago but very little has been used to date. The reason little has been used is due to the prior art methods of "Convection" processing used with hot inert gas and or steam. High operating costs and non-uniform product are among the primary reasons for the lack of use of Torrefied Wood.

The solution is CNFbiofuel™ or Enhanced Torrefied Wood Pellets.

This is a new breakthrough in Torrefication Processing that overcomes all the problems of prior art. The result is a clean burning, carbon neutral, renewable energy fuel that is friable, hydrophobic, uniform, low in cost and practical as a useful fuel to replace fossil fuels.

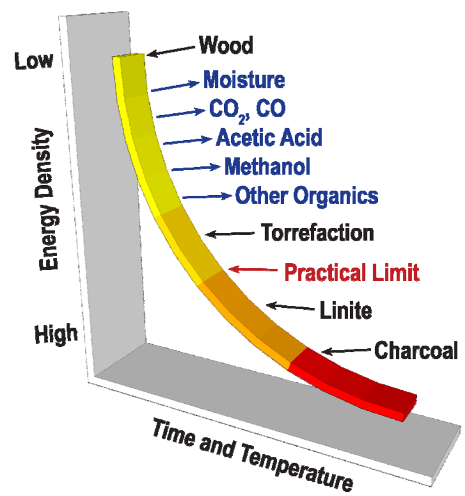


Figure 1: Graph of energy density verses processing time and temperature.

## BIOMASS

Biomass is the most promising renewable resource fuel. However, less than 1% of available biomass is currently used for electric power generation. Biomass burners with wood chips have been met with limited success, mainly because raw biomass is not friable and cannot be pulverized for atomization. Some of the other problems include transportation costs, a low bulk biomass density of 10 to 15 pounds per cubic foot, high moisture content, non-uniform moisture content and unreliable supply. Power plants need dependability in the fuel they use.

One improvement in recent years has been pelletizing the biomass. This has reduced transportation costs due to the dense, 50 pound per cubic foot, pellets. Even with this improvement, the pellets have been shown to break down when they absorb moisture, and non-uniform moisture content results in incomplete combustion with undesirable pollution being generated.


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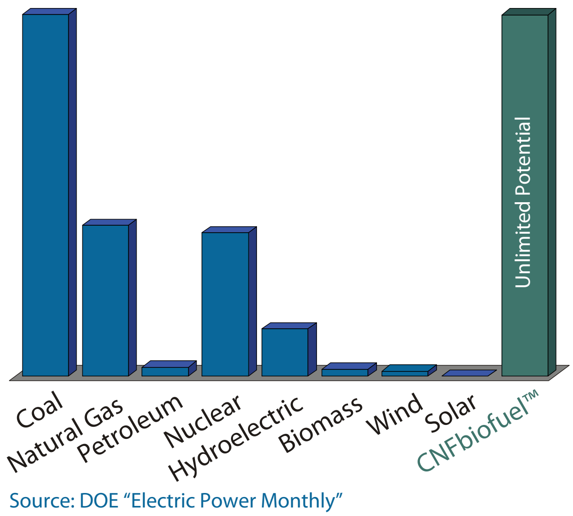

Figure 2: Electric power generation by energy source.

Biomass may be in the form of chips, sawdust, pellets and other shapes. In the field it is bulky and difficult to transfer. Wood and other forms of biomass have been used for thousands of years as a main fuel source. The products of complete combustion of cellulose in plants are water and carbon dioxide. However, incomplete combustion normally occurs when biomass is burned because of the contained water, VOC's and carbon compounds. No practical solution has been developed to convert wood into a clean burning, practical fuel until now.

## TORREFACTION

Prior use has clearly shown that torrefied wood is very clean burning and can effectively reduce fossil fuel use, mainly coal. However, all prior torrefied wood processing systems have used hot gas or steam convection-dominated heat treatment processing.

Based on the lack of use of torrefied wood to date, this prior technology has not been practical as very little is used. The primary reasons include a non-uniform product, high costs, high energy usage, and polluting emissions.

Current research in biomass torrefaction has been toward indirect, convection, heating with an inert gas or superheated steam [1]. Torrefaction requires an oxygen free environment to prevent combustion. Our process is the first to produce torrefied biomass by direct submersion, conduction heating, in a high temperature heat transfer fluid. This should prove to be a safer, quicker and lower cost method of torrefaction.

The benefits of using torrefied biomass in gasification have recently been discovered [2]. Biomass fuels have a relatively low energy density and high moisture content. This leads to high transportation and handling costs. The fibrous and tough qualities of biomass make it difficult to process in gasification plants. Torrefaction greatly increases the energy density, up to 30%, while removing large amounts of moisture and VOC's. The final product is friable and uniform, making it an ideal fuel for gasification. Previous torrefaction methods, with convection heating, have used large amounts of energy in production. While this torrefied biomass has been shown to be an ideal fuel for gasification plants, its high input processing energy from inefficient convection heating has made it uneconomic for electric power generation.

## CNFbiofuel™

Our new processing technology turns wood pellets into enhanced torrefied wood pellets, that burn clean with high heat content, and do not reabsorb moisture. This allows for long range storage without degradation or moisture absorption. Virtually all forms of biomass could be utilized with this technology. Systems of any size can be constructed and producing over 60 tons per hour are envisioned.

Figure 3: Wood pellets (Left) next to Enhanced Torrefied Wood Pellets (Right).

This new torrefaction system is being developed by CNFbiofuel, Inc. Several small prototypes have been built and testing has shown positive results with increased heat content and friability. The produced fuel is ideal for solid fuel, atomization or a uniform feedstock for gasification. The author has several patents pending on this torrefaction technology and is now looking for interested partners in building a demonstration facility.

## PROCESS

This process uses biomass in the form of wood pellets as the intended input feedstock. These are dense, small, uniform pellets and ideal for conduction heat treatment. Later testing will be conducted on other forms of biomass.

Biomass is first pre-heated with heat transfer fluid at close to 300ºF. This drives out the majority of the moisture in the biomass. This moisture in the form of steam exits a pressure relief valve and is condensed and collected. The pre-heated and dried biomass then enters the heat treatment phase.

Heat treatment is done with heat transfer fluid at 480ºF. This is where the VOC's and any remaining moisture are driven out. These gases are condensed and collected for later use or disposal. During the heat treatment phase the biomass composition continues to take in heat without a change in temperature. This is the endothermic reaction phase where torrefaction occurs. The cellular structure and chemical composition of the pellets changes during torrefaction.

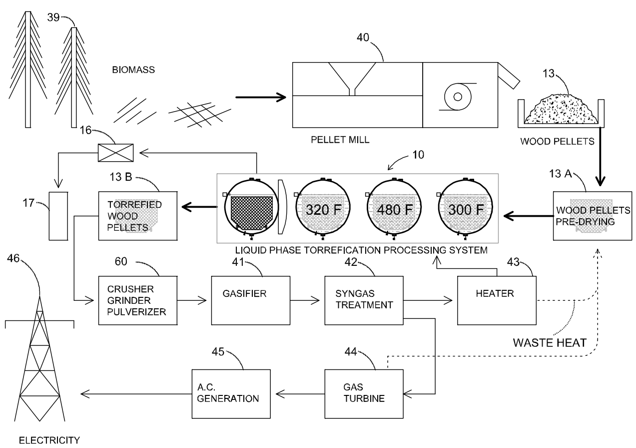


Figure 4: CNFbiofuel flow chart shows a gasification system for electric power generation. At step "13B" torrefied wood pellets are ready for use as a solid fuel.

The torrefied biomass is then cooled with 320ºF heat transfer fluid. This cools the torrefied biomass to a safe temperature where combustion cannot occur. (Note: Wood heated to torrefaction temperatures can oxidize and combust when exposed to air or in the presence of oxygen. This has been one of the problems with convection systems.) The torrefied biomass is air cooled and further draining of the heat transfer fluid occurs. The drained heat transfer fluid is captured and re-used in the process.

The heat transfer fluid is a paraffinic base material that has a very low vapor pressure at 480ºF. The vapor pressure at this condition is less than a two inch water column. The entire processing operation occurs below 5psi pressure. The heat content of the heat transfer fluid is over 18,000 Btu per pound. The torrefied biomass does contain a small amount of heat transfer fluid and this enhances the heat content by the amount of heat transfer fluid on and within the treated biomass.

## COMMERCIALIZATION

This new torrefication process has a great commercialization potential. Biomass energy has not been greatly utilized because it has never been processed into a practical and useful energy form. Unprocessed biomass has cost, emission, and transportation issues. By solving all these issues biomass should become a fuel competitive with coal and natural gas. This technology could satisfy the near-term and long-term need to replace fossil fuels.

We have already been approached by several companies that would like to purchase this technology once it has been developed. These include electric power companies, coal burning electric power plants and wood pellet mills. Other companies have requested that torrefied biomass be shipped to them in thousands of tons for use in co-firing with coal.

Torrefaction works on waste biomass as well as, non-food, energy crops such as switchgrass. American agriculture will benefit by being able to produce energy crops for electric power generation.

Production plants can be built wherever there is a source of biomass. On site pellet mills can densify biomass to over 50 pounds per bulk cubic foot. This allows for greater use of forest residue, agricultural pruning and other waste biomass from rural and agricultural areas. Wood pellets can then be processed on site or more economically transported to a central processing plant. The reduced volume and high energy content of torrefied wood allows for lower transportation costs to power plants. This will allow for greater use of waste and produced biomass from rural and agricultural areas.

## ADDITIONAL BENIFITS

Biomass torrefaction benefits the environment in several ways. By offsetting the use of fossil fuels there is an immediate reduction in carbon dioxide and other greenhouse gasses will be seen, along with reductions in heavy metals and other harmful contaminates from coal burning power plants.

Waste biomass left to decay produces methane and other airborne contaminants. Open burning releases ash and other air pollutants. Converting these waste products into a clean burning fuel will reduce a considerable amount of pollution that is entering our air. This is a great way to capture the suns energy for practical use.

When coal and other fossil fuels are burned a large amount of carbon dioxide and other greenhouse gasses are released into the atmosphere. This is considered 100% added carbon to our air environment. However, when a renewable energy such as torrefied biomass is burned, the carbon dioxide is reabsorbed into the plants used to make it.

This results in no net increase in carbon dioxide. Therefore, renewable energy adds "zero" net carbon dioxide to the air.

## REFERENCES


[1] "New process for Torrefied Wood Manufacturing", Bioenergy Update, April 2000, Vol. 2 No. 4

[2] "Torrefaction for Entrained-flow gasification of biomass", P.C.A. Bergman, 2005