

W  
B  
I  
P  
paper



## **Biomass and Biomass-fueled energy production**

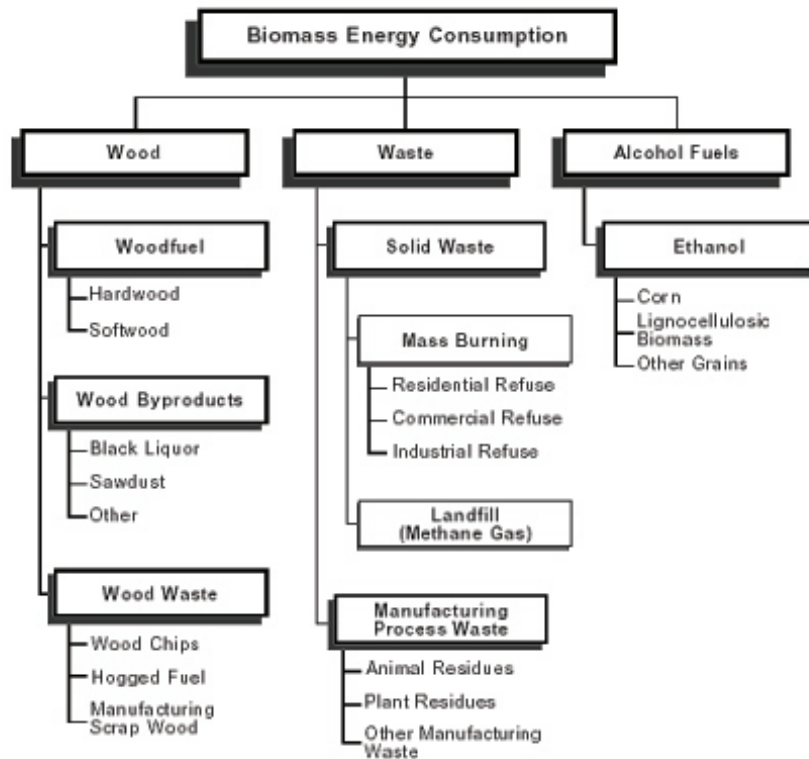
**Specifically with  
woody biomass**



## **What is biomass?**

In a simple definition, biomass, a renewable energy source, is biological material derived from living, or recently living organisms, such as wood, waste, and alcohol fuels. For example, forest residues (such as dead trees, branches and tree stumps), yard clippings and wood chips may be used as biomass. However, biomass also includes plant or animal matter used for production of fibers or chemicals. Biomass may also include biodegradable wastes that can be burned as fuel.

## **Types of biomass**



Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternative Fuels.

## **Woody biomass**

While technically a biomass renewable energy source, solid waste (municipal, commercial, industrial) is often considered to be in a different category. For our purposes here, we will be referring to what is known as woody biomass. Woody biomass is plant material from trees and shrubs that can include roots, bark, leaves, branches, limbs, trunks, and vines. Woody biomass can come from many sources, including forestry operation residues, wood product residues, urban waste wood, and trees grown specifically for energy, fuel wood, and forest thinnings.

The use of terms and units of measure related to wood energy differs among the consuming sectors. The industrial and electric utility sectors use the term wood fuel for all types of wood, wood-derived fuels, and wood byproducts burned as fuel, including cord wood, limb wood, and black liquor (described later).



Forests and woody crops are a source of energy through the conversion of woody biomass into convenient solid, liquid, or gaseous fuels to provide fuel for industrial, commercial, or domestic use. According to IEA Bioenergy, biomass provides about 11% of the world's primary energy supplies. About 55% of the wood used annually by the world's population is used directly as fuel wood or charcoal to meet daily energy needs for heating and cooking, mainly in developing countries. In addition, large quantities of industrial wood waste are used to generate heat, steam and electric power in developed countries. Bioenergy systems often use biomass that would otherwise be considered to be non-merchantable. Typical conversion methods of biomass may involve combustion, chemical (biochemical), or thermochemical processes.

### ***History of biomass***

Using biomass to produce energy has been around for thousands of years, when we first started to burn wood to cook our food or get heat. What we refer to today as biomass energy, or bioenergy, really began in the late



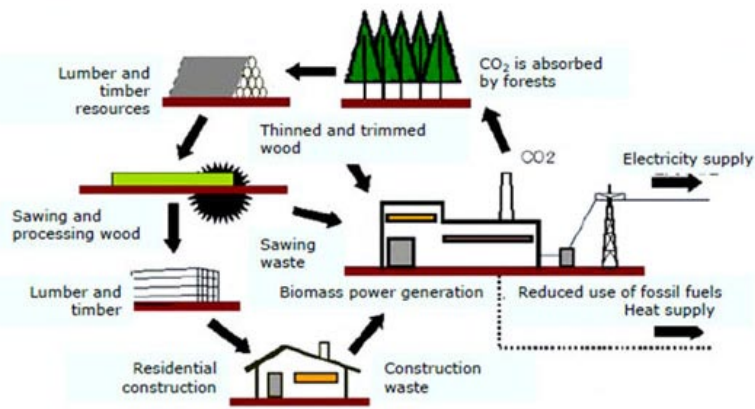
1970's, and emerged fully in 1982, using wood chips and sawmill waste. The processed material is known as feedstock.

Biomass-fueled energy production became a very expensive process, and in the 1990's, we saw most of the woody biomass processing plants shutting down. Those that remained turned to other sources, such as forest thinning, orchard removal, agricultural byproducts, and urban wood waste.

Forest thinning has become one of the most viable resources for woody biomass. Programs known as sustainable forest management and woody biomass utilization have emerged to protect this very valuable natural resource. This practice offers benefits in addition to supplying fuel for energy production, such as reducing what is known as the understory, or the lower level growth, which acts as a fuel source and a "ladder" that allows flames to jump up to the canopy and the taller, older trees.

Current forest management programs consider this thinned material to be non-merchantable timber, and therefore typically disposed of through open burning known as controlled or prescribed burns. While this is the most economical method, and poses no significant emissions threat, these prescribed burns often cause wildfires to erupt due to sparks and fly ash traveling to nearby forests. Many communities have accepted these burn methods, due to the increasing costs of transportation and disposal of this timber that has no marketable value.

## Biomass-fueled-power generation



The important aspect of biomass power is that this technology actually reduces GHG emissions when compared to alternative disposal methods. This is because landfilling, open combustion, or decomposition of biomass all release a fraction of the carbon, in a reduced form, methane (CH<sub>4</sub>), which is recognized as 25 times more damaging as a GHG on an instantaneous basis than the almost pure CO<sub>2</sub> emitted by biomass power facilities. The fraction released as methane varies from 5-50% of

the total carbon depending on disposal method. Therefore, through combustion of pure methane to carbon dioxide, as occurs in a biomass power plant, there is a substantial reduction of GHG potential in the atmosphere compared to not using the biomass wastes as fuel.

The first regulatory body to recognize the benefit found in biomass-fueled power production is the California Public Utility Commission (CPUC) which ruled in decision D.07-01-039, implementing SB1368, the California GHG emissions performance standard:

*“In particular, the record shows that electric generation using biomass (e.g., agricultural and wood waste, landfill gas) that would otherwise be disposed of under a variety of conventional methods (such as open burning, forest accumulation, landfills, composting) results in a substantial net reduction in GHG emissions. This is because the usual disposal options for biomass wastes emit large quantities of methane gas, whereas the energy alternatives either burn the wastes that would become methane or burn the methane itself, generating CO<sub>2</sub>. Since methane gas is on the order of twenty to twenty-five times more potent as a GHG than CO<sub>2</sub>, and since methane has an atmospheric residence time of twelve years, after which it is converted to atmospheric CO<sub>2</sub>, trading off methane for CO<sub>2</sub> emissions from energy recovery operations leads to a net reduction of the greenhouse effect.”*

## Current technologies

There are a number of technological options available that make use of a wide variety of biomass types as a renewable energy source. Conversion technologies may release the energy directly, as in the form of heat or electricity, or may convert it to another form, such as liquid biofuel or combustible biogas. These methods can easily be categorized into either combustion or non-combustion.



### Combustion:

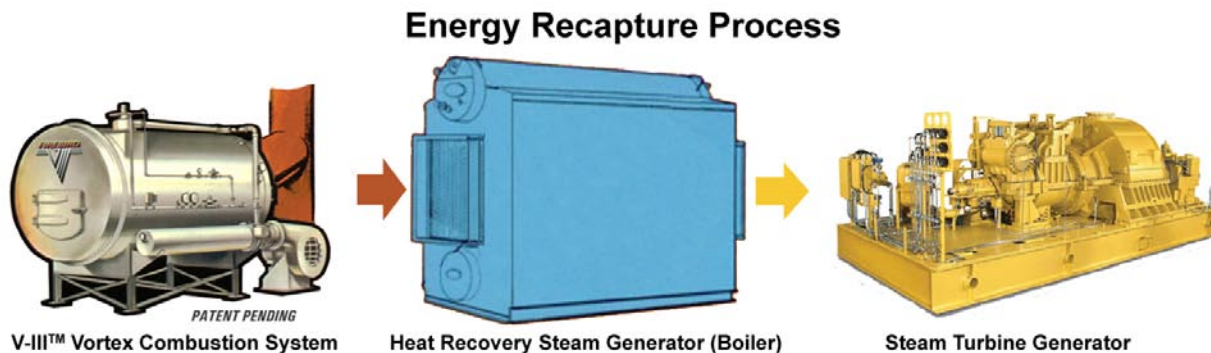
The old way of converting biomass to energy, practiced for thousands of years, is simply to burn the material to produce heat. This is still how most biomass is put to use, in the United States and elsewhere. The heat can be used directly, for heating, cooking, and industrial processes, or indirectly, to produce electricity by combining with heat recovery systems (boilers) and steam turbine generators.

Additional thermal conversion technologies that fall under this category include:

- Pyrolysis - chemical decomposition at high temperatures
- Torrefaction - a milder form of pyrolysis
- Gasification - a process that converts carbonaceous materials, such as biomass, into carbon monoxide and hydrogen at high temperatures with a controlled amount of oxygen to produce a gas mixture called synthesis gas, or syngas. Syngas acts as a fuel for energy production. Gasification is a method for extracting energy from a variety of organic materials.

An approach that may increase the use of biomass energy in the short term is to burn it mixed with coal in power plants—a process known as "co-firing." Biomass feedstock can substitute up to 20 percent of the coal used in a boiler. The benefits associated with biomass co-firing include lower operating costs, reductions of harmful emissions, and greater energy security. Co-firing is also one of the more economically viable ways to increase biomass power generation today.

The image below shows the energy recapture process using our Firebird V-III™ Vortex Combustion System along with a commercially available boiler and steam turbine generator.



#### **Non-combustion:**

A number of non-combustion methods are available for converting biomass to energy. These processes convert raw biomass into a variety of gaseous, liquid, or solid fuels that can then be used directly in a power plant for energy generation. This conversion can be done in three ways:

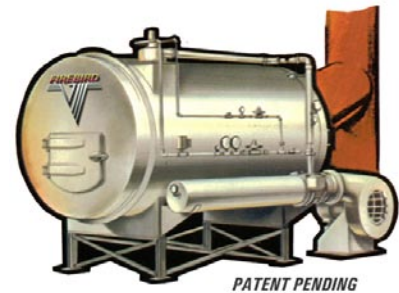
- Thermochemical - When plant matter is heated but not burned, it breaks down into various gases, liquids, and solids. These products can then be further processed and refined into useful fuels such as methane and alcohol. Biomass gasifiers capture methane released from the plants and burn it in a gas turbine to produce electricity. Another approach is to take these fuels and run them through fuel cells, converting the hydrogen-rich fuels into electricity and water, with few or no emissions.
- Biochemical - Bacteria, yeasts, and enzymes also break down carbohydrates. Fermentation, the process used to make wine, changes biomass liquids into alcohol, a combustible fuel. A similar process is used to turn corn into grain alcohol or ethanol, which is mixed with gasoline to make gasohol. Also, when bacteria break down biomass, methane and carbon dioxide are produced. This methane can be captured, in sewage treatment plants and landfills, for example, and burned for heat and power.
- Chemical - Biomass oils, like soybean and canola oil, can be chemically converted into a liquid fuel similar to diesel fuel, and into gasoline additives. Cooking oil from restaurants, for example, has been used as a source to make "biodiesel" for trucks. (A better way to produce biodiesel is to use algae as a source of oils.)

## ***Environmental impact***

Biomass reduces air pollution by being a part of the carbon cycle, reducing carbon dioxide emissions by 90 percent compared with fossil fuels. Sulfur dioxide and other pollutants are also reduced substantially. All renewable power generation technologies are widely acknowledged to produce no net greenhouse gas (GHG) emissions, and to offset those of fossil fuel combustion. Biomass-fueled power generation is unique among renewable technologies in that it produces carbon dioxide (CO<sub>2</sub>) emissions during normal operation, in fact, more than the fossil fuel emissions it is displacing. The difference is that its emissions result from combusting the current residues of agricultural, forestry and solid waste management activities, and are absorbed by the next crop of forestry and agricultural activities. Fossil fuel combustion, on the other hand, emits carbon into the atmosphere that would otherwise remain locked away in geologic storage where it has been sequestered for millions of years.

## ***Our technology***

Our product, the Firebird V-III™ Biomass Combustion System, is a vortex combustion technology that offers the same process of high speed combined with high temperatures used by our other versions, in applications such as hazardous and infectious waste, and other solid waste disposal programs.



While combustion is the oldest form of converting biomass to energy, it has only been used for full-scale energy recovery programs for the past 25 to 30 years. We have adapted our vortex systems to work efficiently and safely in programs such as forest thinning, as well as biomass-fueled energy production.

What makes our system unique is the achievement of complete and perfect combustion, meaning that the only byproducts are CO<sub>2</sub> and H<sub>2</sub>O. Because of the 90 mph vortex (tornado on its side) and the fact that the chipped wood material is fed into the chamber along with a primary air flow to blend into the 2,000° F temperatures, our system can easily handle high moisture content. For woody biomass processing, this means that there is no need to dry (season) the cut timber. Our system does not produce any harmful emissions, or even smoke as typical combustion systems, and does not require complicated and expensive exhaust scrubbers.

## ***Conclusion***

There is an ever-growing recognition of the local and global environmental advantages of biomass-fueled energy production, or bioenergy. Bioenergy is the most widely used renewable energy source, representing nearly one billion tons of oil equivalent, which reflects consumption levels comparable to that of natural gas, coal, and electricity. There is a trend towards cleaner, greener, and even smaller, more decentralized energy production facilities.