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UT Biofuels Initiative

Woody Biofuels: Past, Present and Future

A short summary of the many ways that wood has been, is and could be used as a fuel: Firewood, charcoal, pellets, briquettes, hog fuel, black liquor, gasification, bio-oil and ethanol.

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Wood – and all other plant biomass – is ultimately the product of photosynthesis in living plants. The sun's energy is combined with carbon dioxide (CO_2) and water to form simple sugars. These sugars are then converted biochemically in trees to form wood. While wood is a remarkably durable and potentially long-lasting biomaterial, the sunlight energy can be released (along with the CO_2 and water) when we want to use wood as a fuel.

This fact sheet briefly describes some of the major uses of wood as a fuel.

Firewood: The original biomass fuel

Wood 'fires' can be as simple and small as a campfire, as large as a pulp-mill boiler or as sophisticated as a fast pyrolysis unit. In each case, however, the sunlight energy that was captured by photosynthesis and concentrated and stored in the wood of trees can be put to use as a biofuel.

Wood has been used as a source of heat for warmth and cooking throughout history. Despite the widespread use of wood for other purposes and the dominance of fossil fuels for energy today, fuel remains the main use of wood in the world. More than 50 percent of the trees harvested globally are used for firewood.

Wood is also the largest renewable energy source in the United States. Some of the major ways that wood is used for fuel are described below.

Charcoal: From a cleaner biofuel to a cleaner

Charcoal is formed when wood is heated in the absence of oxygen. In its simplest form, charcoal is created when a wood fire is smothered: as the wood is heated by the fire – but starved of oxygen – a dry, black, lightweight charcoal is left behind. Charcoal can be burned later in fireplaces or stoves. Charcoal produces a relatively clean and hot fire that is useful for cooking. Charcoal is a preferred cooking fuel in many regions. The main disadvantage of traditional charcoal production is that most of the wood's original energy is lost in the conversion process.

Charcoal can be generated from trees, wood chips and even sawdust. The charcoal 'briquettes' used for barbequing are made from compressed sawdust that has been converted to charcoal. Charcoal can also be refined and used in a variety of products such as filters and crayons. 'Activated charcoal' refers to charcoal with a high surface area. Activated charcoal is useful for absorbing odors, color or other impurities from air or water.

Hog fuel: Waste to power wood processing

A major use of wood in the United States is for the production of heat and electricity at industrial locations. Wood fuels are dominant energy sources for energy-intensive wood processing operations such as the kiln drying of lumber.

Wood slabs and bark can be ground up ('hogged') to make a fuel. Sawdust and planer shavings can be used directly. The quality of a hog or wood waste fuel is a function of its density, moisture (water) content and other factors, but simply put, almost any wood-processing waste can be used for fuel. In the past, it was common for sawmills to burn their wastes simply to get rid of them. Now, however, it is understood that the energy content of those residues is too valuable to waste. Mills that don't have the need for wood energy for their own operations will sell their wastes to pulp mills or lumber kiln-drying operations that can use the fuel.

Woody residues such as this hog fuel are the largest source of renewable energy used in the United States.

Cogeneration: Getting heat and electricity from wood fuel

Using wood fuels in boilers is not limited to powering wood-processing plants. Other industries or institutions that use steam or hot water for processing or heating can be fueled by burning wood processing waste. In addition to using heat from burning wood waste to generate hot water or steam, combined-heat-and-power, or 'cogen', boilers can be used to simultaneously generate electricity. This electricity may then be used on-site or sold back to the electrical grid.

Pellets: Firewood in a different form

Fluffy (low-density) wood wastes such as sawdust can also be formed into small shapes such as pellets or briquettes, providing an easy-to-handle fuel. Wood pellets are formed using machinery that compresses sawdust so much that the wood sticks together – no glue is used. These pellets are then burned in boilers or small household heating stoves. Wood pellets are clean-burning, with a low water content because they are made from dry sawdust, making the burning process more efficient. Pellets can be continuously dispensed into stoves using hoppers and automated feed screws.

Pellets and other compressed-wood-waste products, such as briquettes, are simply a convenient form of firewood – a new take on the traditional biofuel.

Black liquor: Wood fuel for making paper

Wood pulp and paper production uses low-grade trees and sawmill residues. Papermaking also requires lots of energy, especially for drying the paper sheet. Much of the energy for this processing comes from wood components removed in the pulping process.

The Kraft pulping process is the most common method of isolating pulp fibers from wood. In Kraft pulping, wood chips are mixed with chemicals under heat and pressure.

Pulp and paper making uses woody biomass as a source of both fuel and raw material.

Wood chemicals, such as lignin and hemicelluloses, are dissolved, leaving behind the cellulose fibers that will be used for making writing paper, tissues, etc. Only about 50 percent of the wood is recovered as usable pulp. However, the mixture of used pulping chemicals and dissolved wood components is not discarded. This 'black liquor' is burned in special furnaces at the mill to recover the pulping chemicals so they can be re-used. The processing of black liquor also releases heat when the wood that is dissolved in the liquor is burned. This heat is converted to steam, which is used for pulp and paper-making processing. Black liquor-derived steam is also used to generate electricity.

The burning of black liquor in the Kraft pulping process is the largest use of wood as a biofuel in the United States.

Pyrolysis, gasification and bio-oil: Liquid and gaseous fuels from solid wood

As was described above, if wood is heated in the absence of oxygen (called pyrolysis), it gets broken down and a solid charcoal fuel remains. During this process, much of the solid wood is vaporized into potentially flammable gases. In traditional charcoal making, these gases escape, wasting much of the potential wood energy. In other pyrolysis systems, these gases can be captured and used. The pyrolysis process can be adjusted to maximize the gases produced and minimize the solid char products.

In wood gasification, pyrolysis gases are captured and burned. The energy from burning these wood gases can be used to power boilers or even to operate internal-combustion engines. During World War II, wood-gas-fired cars and trucks were built in response to shortages of gasoline and diesel.

In bio-oil production, pyrolysis gases are condensed, forming a brown liquid 'oil' that can be burned in furnaces. Bio-oil has about the same fuel value of ethanol (a common gasoline additive), and it can be burned in boilers that use heating oil. Bio-oil cannot yet be used as a fuel for vehicles. Bio-oil is a complex mixture of chemicals, and current research is investigating how to purify and

make use of those components for value-added products.

Ethanol: Using wood as a raw material for fuel production

Wood is commonly used as a fuel with little or no modification. Firewood is simply cut, dried and burned. Hog fuels are waste materials from wood processing that are used like firewood. Even the pyrolysis products such as wood gas and bio-oil are in essence burning of wood – the difference is in the control over the combustion process.

The concept of making ethanol or other liquid fuels from wood is different from traditional wood fuels in that the wood structure itself is converted to new chemicals before it is used as a liquid fuel. Ethanol is an alcohol that can be used as a liquid fuel for vehicles. Wood does not contain ethanol, but ethanol can be made from the sugars that are in wood. Ethanol is created when yeast ferment free sugars, such as glucose. The starch in corn kernels is one example of a source of sugars for the production of ethanol. The cellulose in wood (about 50 percent of the wood substance) is pure glucose. However, this sugar is bonded in special ways in wood, and is protected by the lignin and other substances in the wood. In order for the glucose to be available for attack by the yeast and conversion to ethanol, the wood must first be broken down. This breakdown can be achieved in various ways, using heat and chemicals or enzymes.

The technology for the breakdown of wood to fermentable sugars and ethanol production is being continually refined, but wood may one day provide a significant source of raw material for manufacturing fuels. Wood has a number of advantages as a biomass raw material for liquid fuel production, including:

1. Trees are all around us and can be grown with very few 'inputs' of fertilizer, irrigation, etc.
2. Trees can be harvested year-round, with many years of wood production combined in one harvest. In this way, a forest can accumulate and store its potential fuel energy for decades.
3. Wood is a relatively high-density fuel that can be harvested and stored for relatively long periods of time without decomposing.
4. In addition to being a source of renewable raw materials for the production of carbon-neutral fuels[1], forests provide many other products and benefits, such as wildlife habitat and recreational opportunities.

Summary: Wood is good as a biofuel!

Wood is a concentrated form of stored sunlight (solar energy). This energy can be released and used as a fuel. Wood has always been an important source of energy for people. Today, wood is the most important source of renewable energy in the United States and a primary source of fuel for much of the world. Whether it is as simple as a campfire, or as sophisticated as producing ethanol, wood has a number of inherent advantages that ensure it will continue to be an important bio-fuel in the future.

Stored solar enery is released when wood is used as a fuel.

[1]Because trees capture and store carbon-dioxide to make wood, the burning of that wood is not considered to add to the carbon dioxide emissions that contribute to the greenhouse effect and global climate change.

Visit the UT Extension Web site at
http://www.utextension.utk.edu/

For more information about the UT Biofuels Initiative, please visit
http://www.UTbioenergy.org

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