



# How Wood Properties Influence Utilization

## FACT SHEET 5.2

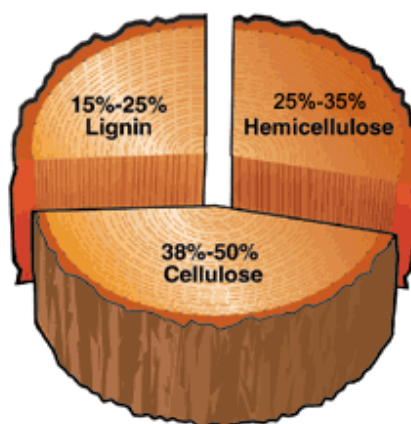
### INTRODUCTION

Wood is one of the most abundant resources in the bio-based industry. Yet it is also one of the most complex materials. Woody plant species are so diverse that they grow in virtually every part of the world and can be harvested to produce solid, liquid or gaseous energy feedstocks. Wood is composed of polymers, which are large organic molecules of lignin and carbohydrates that are physically and chemically bound together. This fact sheet provides a brief description of some of the more important properties of wood and how they play a role in the use of woody biomass for energy, fuel, and industrial products. All of these components affect the energy value and utilization potential of biomass.

### WOOD COMPOSITION

The four major components of woody biomass are cellulose, hemicellulose, lignin, and mineral components.

**CELLULOSE.** Cellulose is a polymer composed of glucose (sugar) chains. It makes up nearly 50 percent of woody plant mass. Cellulose consists of carbon, hydrogen, and oxygen in the form of starches, proteins, and sugars. It is the most abundant organic material on Earth. It can be isolated during the pulping procedure and later processed to yield ethanol, cellophane, and cellulose ethers such as acetate, rayon, and nitrates. Due to the relatively high



*Figure 1. Percentage Breakdown of the Various Components of Woody Biomass*

manufacturing cost, many of these derivatives have only specialty applications. The primary source of wood cellulose in the South is softwood species such as pine. But over the last 20 years, hardwood utilization has increased. (*Figure 1*)

**HEMICELLULOSE.** Hemicellulose consists of pentose sugar carbohydrates, mainly xylose. This carbohydrate comprises 25 to 35 percent of the dry weight of wood residues, second only to cellulose in abundance. The use of hemicellulose is currently limited due to manufacturing related costs. However, quantities of hemicellulosic pectins and various other plant polymers are abundant and have great potential in the production of chemicals and materials.



**LIGNIN.** Lignin is a phenylpropane polymer that holds together the cellulose and hemicellulose components of woody biomass. Lignin constitutes about 15 to 25 percent of the weight of woody biomass. Lignin has not yet been used as a raw material for industrial purposes in large quantities. This reflects the chemical complexity of lignin. In addition, attempts by pulp and paper research laboratories to develop by-product markets for lignins have met with only limited success<sup>1</sup>.

**MINERAL COMPONENTS.** Woody biomass is composed of many mineral elements. The principal elements include carbon, oxygen, and hydrogen. While these elements do not produce energy during combustion, they do affect the energy content of woody biomass. On average, hardwoods have a higher concentration of these mineral elements than softwoods. However, the presence of these minerals is more affected by the site where they are grown rather than their age, species, or size.

Other elements include nitrogen, sulfur, chlorine, and heavy metals. All potentially can have negative impacts when combustion is the technological process being employed.

- Nitrogen is a component of all fuel systems. During the combustion process, it is oxidized into nitrogen oxide (NO<sub>x</sub>). When emitted from combustion facilities at relatively low levels, NO<sub>x</sub> may have a useful fertilizing effect on forests. However, as emission levels increase, NO<sub>x</sub> produces adverse health effects and increases the acidification of water and soils.
- Sulfur emissions from combustion of fuels cause extensive damage to ecosystems and buildings, so fossil fuels are often graded by the amount of sulfur present. As

with nitrogen, sulfur is oxidized during combustion to form sulfur oxide (SO<sub>x</sub>). This compound can have serious environmental effects and causes the acidification of soils and water.

- Most chlorine in trees is found in the foliage as an essential component in chlorophyll. Although only present in trace amounts, its ability to form alkali compounds with potassium and sodium, resulting in oxidation and corrosion, can create serious problems for boiler equipment during combustion<sup>2</sup>. Eliminating foliage from woody biomass feedstocks can reduce corrosion problems, as can co-firing biomass resources with higher sulfur content fuels such as peat or coal<sup>3</sup>.
- Heavy metals tend to vaporize during combustion. The remainder contributes to ash formation. Should levels of heavy metals be high, recycling of ash as fertilizer is restricted by environmental legislation, since the metals may leach into groundwater or be absorbed by crops.

## MOISTURE CONTENT

The moisture content of biomass material varies greatly and plays a large role in determining the most suitable energy conversion process. Wet conversion processes such as fermentation are often more suited to biomass with a higher moisture content (e.g. corn, sugarcane, barley straw). Dry conversion processes such as pyrolysis, gasification, and combustion are more suited to biomass with a lower moisture content (e.g. wheat straw, pine, switchgrass, etc). Generally, wet conversion processes are used when the moisture content of the biomass requires excessive energy for drying, compared to the energy content of the end product<sup>4</sup>.





Energy yields are often expressed as net caloric values. These values increase as wood moisture content is reduced. The percent moisture content of the biomass used has a large impact upon the design and selection of technologies ideal for energy production.

The moisture content in wood depends on a combination of climatic conditions, time of year when harvesting takes place, and the duration and method of storage. These simple formulas can calculate the moisture content of biomass:

$$\text{moisture content (wet basis)} = \frac{(\text{total weight of wet wood} - \text{oven dry weight})}{\text{total weight of wet wood}} \times 100$$

$$\text{moisture content (dry basis)} = \frac{(\text{total weight of wet wood} - \text{oven dry weight})}{\text{oven dry weight}} \times 100$$

## SUMMARY AND CONCLUSIONS

Wood composition and moisture content are two of the more important properties of woody biomass in terms of utilization potential and energy yield. Moisture plays a significant role in the type of conversion process used and, at high levels, reduces energy yield.

For more information, please refer to the Encyclopedia of Southern Bioenergy at <http://www.forestencyclopedia.com/Encyclopedia/bioenergy>.

## ENDNOTES

- 1 Bozell, J.J.; Landucci, R. 1993. Alternative Feedstocks Program: Technical and Economic Assessment, Thermal/Chemical and Bioprocessing Components. Washington DC: Department of Energy, Office of Industrial Technologies.
- 2 Riedl, R.; Obernberger, I. 1996. Corrosion and fouling in boilers of biomass combustion plants. In: ETA-Renewable Energies and WIP-Renewable Energies, ed. Proceedings of the 9<sup>th</sup> European Bioenergy Conference, Copenhagen.
- 3 Orjala, M.; Ingalsuo, R.; Patrikainen, T.; Mäkipää, M.; Hämäläinen, J. 2000. Combustion of wood chips, produced by different harvesting methods, in fluidized bed boilers. 1st World Conference and Exhibition on Biomass for Energy and Industry. Sevilla, SP, 5–9 June 2000. OPET Finland. 6 p.
- 4 McKendry, P. 2002. Energy production from biomass (part 1): Overview of biomass. *Bioresource Technology*. 83(1), 37–46.

