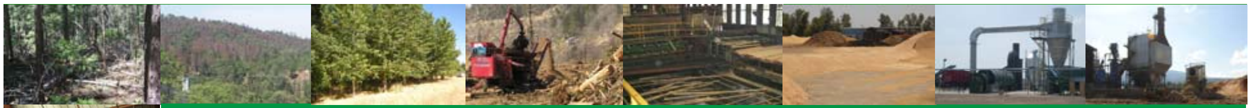

Woody Biomass Factsheet – WB1

Woody Biomass: What is it – What do we do with it?

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Woody biomass, a topic that has received much attention over the past decade, also creates much confusion...the term is not well defined and often leads to misunderstanding. It is one component of the larger biomass category that includes organic plant and animal materials, products derived from them, and the residues generated from their growth, manufacturing, and use. Major categories of biomass include:

- Agricultural plants and crop residues (e.g. straw, corn stalks and cobs),
- Agricultural animal residues (e.g. manure),
- Agricultural manufacturing residues (e.g. nut hulls, culled products),
- Trees and tree residues (e.g. tree removals, prunnings),
- Wood manufacturing residues (sawdust, bark, culled wood),
- Municipal solid waste (organic solid portion of waste and trash destined for landfills),
- Fast growing plants such as poplar and eucalyptus trees and perennial grasses including switchgrass and miscanthus that are cultivated as a specialty biomass feedstock

In industry and the research and development communities the term woody biomass is often used to refer to any non-merchantable wood materials that do not have an existing local market. This could include live trees, forest and manufacturing residues, or consumer waste materials. The USDA Forest Service (FS) defines woody biomass to "the trees and woody plants, including limbs, tops, needles, leaves, and other woody parts, grown in a forest, woodland, or rangeland environment, that are the by-products of forest management [1]." The U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) prefer the term "forest or forest-derived biomass" instead of woody biomass and define it much broader than the FS woody biomass [2]. The forest-derived biomass definition includes wood residues obtained directly from the forest or indirectly from wood manufacturing and processing factories or urban waste.

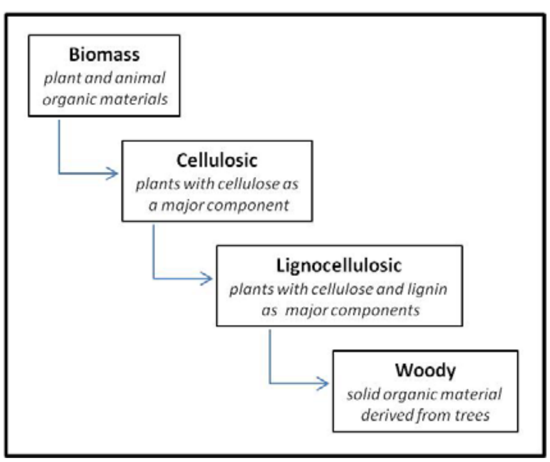

Figure 1. Biomass hierarchy

Definitions become fuzzier when the terms cellulosic and Lignocellulosic are added to the mix. Cellulosic refers to materials with cellulose being a major component of the chemical structure but in common use it is often used to refer to agricultural crops and crop residues such as corn stover (cobs and stalks) and grasses (e.g. switchgrass and miscanthus) [3]. Lignocellulosic refers to plants that contain substantial amounts of cellulose and lignin polymers – wood being a good example. Thus, wood is categorized as cellulosic, lignocellulosic, and woody biomass.

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The term woody biomass is perhaps best used to mean the material obtained from trees or the products of trees that has accumulated to a sufficient quantity that it is a hazard or disposal problem, or from trees specifically managed for biomass markets. This includes the materials listed below as sources of woody biomass, but it does not include waste paper or chemical residues from the pulp and paper industry that already have viable markets. The above definition also precludes wood and wood residues that would otherwise fit the definition except that they already are used to produce higher-value products, such as sawmill residues for particleboard and other composite panels.

Woody biomass utilization is sometimes narrowly defined to mean the use of wood as a source or feedstock solely for the production of energy (heat and electricity). This is short-sighted and often hinders the discovery of its full potential. It is important to remember that although woody biomass is low in value and quality it has potential as a feedstock for energy production as well as for higher value manufactured goods.

Sources of Woody Biomass

Woody biomass is the solid portion of stems and branches from trees or residue products made from trees. Woody biomass can come from a variety of sources, including:

dense timber stand with high fuel hazard

sawmill residues

Dedicated poplar forest

- Non-timber tree removal – removing dead and dying trees, unwanted urban trees, or trees impeding land development,
- Forest management harvesting – the removal of small diameter trees from overpopulated stands for wildfire hazard fuel reduction, pre-commercial thinning of timber stands, or forest health improvement,
- Timber harvesting and logging residues – non-merchantable wood including branches, undersized trees, and non commercial species removed during typical timber harvesting operations,
- Sawmill and other wood manufacturing residues – includes bark, undersized and defective wood pieces (e.g. lumber edging and end trimming), sawdust, and other wood waste,
- Landfill diversion – wood debris from tree removal and pruning, construction, demolition, discarded shipping materials (boxes, crates, pallets), and other trashed wood products,
- Chaparral management – removal of excess woody shrubs and plants for wildfire fuel hazard reduction or other vegetation management goals.
- Dedicated forests (plantations)—fast growing trees grown specifically for biomass markets,

Biomass Utilization

Woody biomass has the potential to be used to make any of the products that are already produced or manufactured from wood. And, just like wood it benefits from the same advantages. But because woody biomass is by definition a low quality raw material there are many challenges to using the resource effectively and efficiently. These advantages and some potential challenges are summarized below.

Advantages – Woody biomass …

- is a non-food, organic material that as a feedstock will not compete with agricultural interests for growing food crops.
- is a renewable resource.
- has positive benefits to the environment because of the lower energy requirements to manufacture products than comparable non-wood materials (e.g. wood vs. steel).
- can reduce wildfire hazard when it is removed from the forest or wildland urban interface [4].
- when burned to produce energy, emits an amount of carbon dioxide that is comparable to the amount of CO_2 released by wood during natural degradation. Since trees take in CO_2 during photosynthesis, using wood to produce energy is considered “carbon neutral.”

Challenges to using Woody Biomass are…

- Limited availability – difficult to obtain enough feedstock near large processing plants to take advantage of the “economies of scale.”
- High cost – associated with the harvest, transportation and storage of woody biomass.
- Low-energy density – woody biomass has a much lower energy density (unit of energy per unit of volume) than fossil fuels.
- Technological difficulties – the recalcitrant nature of wood and its complex chemistry make it a technologically difficult feedstock to use in chemical and energy processing.
- Competition – the growth of woody biomass markets may divert higher-quality wood away from traditional wood product markets.

Woody Biomass for Commercial Forest Products

Woody biomass in tree form cannot be used to make lumber, if it could it would be classified as timber and not woody biomass. By definition, woody biomass is unsuitable for lumber. Woody biomass in tree form comes from trees that are too small to make standard lumber sizes or trees that are too low in quality (e.g. decayed) to achieve minimum lumber quality standards. Woody biomass in non-tree form is found in a size and shape unsuitable for lumber. However, many other commercial forest products can be made from woody biomass. The range of products that could be produced from woody biomass includes:

  - Soil amendments – woody biomass roughly milled into small particles can be added directly to soil as a carbon rich, degradable buffer or to other organic materials high in nitrogen content to form a balanced compost,

- Landscape materials – bark and wood chips can be processed into uniform sizes for decorative ground cover, mulch, or playground fill,
- Firewood – woody biomass in stem form can be processed into standard firewood sizes by cutting to length and splitting,
- Posts and poles – woody biomass in stem form can be sorted to obtain stems large enough and with enough sound wood that they can be cut to length and peeled to a uniform diameter of standard post or pole size,
- Wood fiber resource – woody biomass treated to a strict preparation process can be cleaned up and sized appropriately to be the feedstock for composite panel production (particleboard, oriented-strand board, and fiberboard) , wood-plastic lumber, or pulp for paper,
- Feedstock for bio-refineries – contaminant free woody biomass could be the feedstock to produce numerous organic chemicals, including biofuels.

The above list is ordered in ascending value of the product produced and also in increasing cost of feedstock preparation. The use of woody biomass as a wood fiber resource for composite products or as a feedstock for bio-refineries is unlikely at present because of the high processing costs associated with procurement, transportation and preparation of the feedstock. But as technological improvements lower processing costs and competing raw materials increase in cost, the time may come in the not near future where these higher value products become economical [5, 6].

Woody Biomass for Bioenergy

Woody biomass and bioenergy are in some circles nearly synonymous terms. This is not surprising considering the heightened interest in alternative energy, the impacts of energy production and use on climate change, and the definite advantages related to expanding the use of woody biomass for energy. The technology exists to produce heat energy directly from woody biomass or to produce intermediate biofuels designed to be stored and transported long distances. Bioenergy categories suitable for woody biomass include the following.

Heat Energy – Through the exothermic combustion process, wood or woody biomass, is converted into the primary products of carbon dioxide, water, inorganic ash, and various gaseous and particulate emissions while giving off about 8,000 BTU's of heat for every pound of dry wood burned.

Electrical Energy – Coupling the combustion process with a steam boiler and using the produced steam to drive an electrical turbine is a well proven method of producing electricity from woody biomass.

Biofuels – Many types of woody biomass derived biofuels are possible but of the following fuels only the first three are in common usage and have proved to be economically viable. The remaining fuels listed are the subject of much research and development interests.

- Solid or milled Wood – wood in any size or shape can be directly combusted to produce heat and as such is a biofuel…firewood and wood chips are common market categories
- Densified wood – wood particles are compressed into a smaller volume of a specific size and shape (pellets, logs, bricks, etc.) to increase the fuel density (Btu's per unit volume), ease of transportation, enhance storage durability, or improve other burning characteristics.
- Charcoal – Produced by subjecting wood to a slow pyrolysis process (heating at 700 - 900°F in the absence of oxygen for many hours) that thermally degrades the wood into an aqueous liquid fraction (tar), a gaseous fraction, and a solid fraction consisting mostly of carbon (char) that is formed into charcoal [7].
- Bio-oil – Produced from the liquid fraction of wood pyrolysis. Rapid pyrolysis at high temperatures, rapid heating rates and short residence times maximizes the yield of bio-oil and minimizes the quantity of char produced [8].
- Alcohol – Produced by subjecting wood to a hydrolysis/fermentation process. In the hydrolysis step wood particles are broken down into aqueous solutions of simple sugars, usually using acids, enzymes, or both. During the fermentation step, yeast converts the simple sugars into alcohol. Ethanol is the alcohol most commonly produced but other alcohols are possible.
- Producer gas – A combustible gas of carbon dioxide, hydrogen, and various hydrocarbons that is produced by subjecting wood to a gasification process (heating at about 1400°F with a controlled, limited amount of air or oxygen) that converts the wood into a gaseous fraction (producer gas), char, tar, and ash. The producer gas can be upgraded into syngas or many higher value chemicals through catalytic conversion.
- Bio-diesel – catalytic conditioning of syngas that was derived from the gasification of woody biomass can be directed towards the production of synthetic bio-diesel with properties similar to bio-diesel produced by the transesterification of triglycerides (e.g. vegetable oils and fats) or diesel derived from fossil fuels [9].
- Drop in fuels – the next generation of bio-based fuels that are completely interchangeable and compatible with conventional fuels [10].

Biomass Availability

Estimates of the amount of biomass available for use depend on how biomass is defined and what is counted. Initial efforts to estimate the total amount of biomass from all sources in the United States that could be available for sustainable use came in as high as one billion dry tons per year – enough to replace about 30% of the US current petroleum consumption [2]. Recently, more realistic assumptions on how much is actually available – factoring in economic considerations – have reduced the estimate to about 258 - 340 million dry tons per year now, increasing to 0.767 – 1.6 billion tons by the year 2030 [11]. Global and national overviews help to understand long range goals and policies but do little to help identify potential at a local scale. The type and quantity of biomass varies greatly across the county. For example, in the Midwest about 95% of the biomass resources are agricultural residues or dedicated biomass crops [12]. However the southeastern and western part of the country woody biomass is expected to play a much larger role.

In California (Figure 2), it was estimated that about 32 million ton of biomass could be available per year (technically available) [13]. Of this 32 million, about 14 million dry tons (44%) is categorized as woody biomass, not including the woody component of municipal waste that could easily add another 5 million tons of woody biomass for a total of about 19 million dry tons of woody biomass per year in California. Although the estimates are getting better, uncertainty still exists over the actual availability in most regions of the country [14].

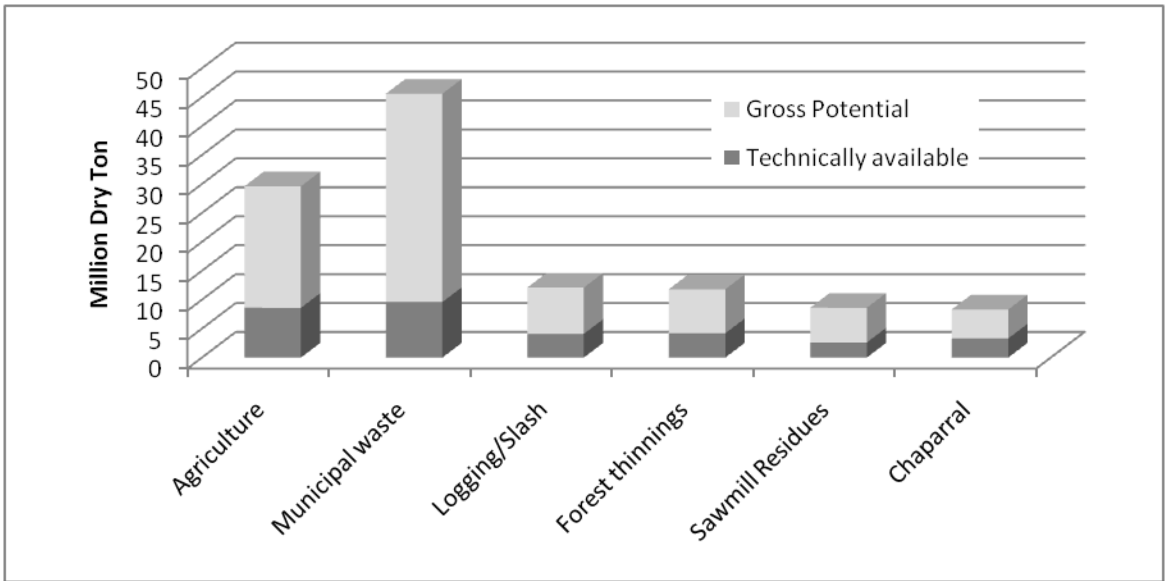

Figure 2 - Biomass estimates for California in 2007

The increasing interest in shifting energy production away from fossil fuels and toward alternative methods is refocusing attention on the use of woody biomass to help meet the world's energy needs. As a result, the past decade has seen a growing interest in understanding the role woody biomass can play in the energy market and a dramatic rise in research support into conversion technologies and availability. While technology advances are improving the opportunities for using woody biomass it remains clear that the high cost of procurement remains a major challenge and economic feasibility currently demands low cost or subsidized feedstocks [14]. In addition, researchers and policy leaders are beginning to recognize the public benefits of using woody biomass and how to assign value to the benefits [15]. However, the question remains: What is the best use for woody biomass… is it for energy or for other higher-value products such as chemicals or composite building materials? The wise use of our woody biomass resource requires a thorough understanding of the carbon life cycle, value added, and economic assessment of all the competing uses of woody biomass as well as the implementation of policies that encourage sustainable development [16].

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