Woody Biomass for Energy in Missouri

In the Midwest, when people think of using woody biomass for energy, the first thought that usually comes to mind is burning wood in a fireplace or wood stove. But the passage of the Energy Independence and Security Act of 2007 combined with the fact that one-third of Missouri is forested has tremendously increased interest in using this natural resource on a much larger scale. This guide defines woody biomass and describes how it can be used for energy, its various sources, and how it is harvested from the forest. This guide also highlights voluntary environmental safeguards to ensure woody biomass is sustainably harvested and provides insight gained from surveys seeking to understand landowner interest in harvesting it.

Figure 1. A typical acre of Missouri forest contains about 73 green tons of aboveground woody biomass.

Woody biomass defined

By strict definition, woody biomass consists of the roots, wood, bark and leaves of living and dead woody shrubs and trees. When harvesting woody biomass for producing energy, however, it is practical to consider only the aboveground portion (Figure 1).

Woody biomass is measured in tons, and a typical acre of Missouri forest contains just over 70 tons. But not all of this biomass is harvested at any one time. Good forest managers remove only about 25 percent, or 18 tons, at one time for traditional forest products, such as lumber and flooring. Half of the biomass is left standing as an intact forest to provide habitat for wildlife and to grow more wood for future harvests. The remaining 25 percent lies in the tops of the harvested trees and in small-diameter trees of poor form or health left in the forest because they have no commercial value. Before the increased interest in woody biomass, the only use for this last 25 percent has been firewood, if it was harvested at all.

How woody biomass is used for energy

Today, combustion is the most common way woody biomass is used to produce energy. In fireplaces and wood stoves, the energy produced is thermal energy. In utility companies, the energy produced is also thermal, but that thermal energy is used to produce steam that then drives a generator to produce electricity. Burning wood to produce steam to turn a generator uses less than one-third of the energy released in the combustion process; the rest goes up the smoke stack. Some energy facilities, such as that of the University of Missouri's Columbia campus, are what are called combined heat and power (CHP) plants. After the steam turns a generator to produce electricity, the waste steam is then distributed via pipes to heat and cool campus buildings. Recently, MU installed a biomass boiler that supplies 25 percent of the total electrical and thermal energy required by the campus. (See *MU energy plant* sidebar.) The Missouri University of Science and Technology in Rolla and Northwest Missouri State University in Maryville also have used wood chips in their energy facilities to supply thermal energy to their campus buildings.

Other thermochemical processes include *gasification*, in which biomass is turned directly into what is called syngas, short for synthesis gas; and *pyrolysis*, in which biomass is converted into bio-oil, which is similar to home heating oil. *Fermentation* is the biological process of using microorganisms and enzymes to convert biomass into liquid transportation fuels, such as ethanol. This conversion is a relatively easy process if the source of biomass is corn; not so easy if the biomass is wood. Although promising, these more advanced wood-to-energy processes have yet to reach commercial scale.

Written by
Hank Stelzer, Forestry State Specialist, Department of Forestry
Mihaela Cernusca, formerly Department of Forestry
John Dwyer, Associate Professor Emeritus, Department of Forestry
Francisco Aguilar, Associate Professor, Department of Forestry
Marissa "Jo" Daniel, Forester, U.S. Forest Service, Mark Twain National Forest

MU energy plant reduces greenhouse gas emissions by 35 percent using woody biomass

The University of Missouri has made great strides toward reaching carbon neutrality since signing the American College and University Presidents' Climate Commitment in 2009. Named a "sustainability rock star" by the Princeton Review's Guide to Green Colleges, MU has decreased emissions by 35 percent from its 2008 baseline and is projecting an additional 10 percent decrease by 2017.

Key to the dramatic reduction in greenhouse gas emissions has been the installation of a 100 percent biomass boiler at the university's combined heat and power (CHP) plant. In total, this energy facility supplies all of the university's electrical power, and heats and cools more than 13 million square feet in 340 buildings across campus. With a thermal efficiency of over 70 percent, the CHP plant has won several awards, most notably one from the Environmental Protection Agency (EPA) for producing reliable energy and preserving the environment.

The boiler began operating in the fall of 2012 and became fully operational in the following year. Currently, the source of the biomass is wood chips produced from sawmills in the region and from sustainably harvested woodlands. Whereas the university previously spent over $5 million annually buying coal from southern Illinois, those dollars now stay in Missouri purchasing woody biomass and supporting local communities.

In addition to meeting campus energy needs, MU's Energy Management Department, which manages the CHP plant, has developed partnerships with university researchers in agriculture, agricultural engineering, engineering and forestry to develop new ways to grow, harvest, transport and process biomass feedstocks from a variety of sources. The department is also working closely with MU Extension in sharing these new technologies with farmers, woodland owners and interested citizens.

The University of Missouri's combined heat and power (CHP) plant is among the nation's leaders at producing green energy.

Sources of woody biomass

Woody biomass can come from many sources, some of which are more readily and consistently available than others. Woody biomass in a standing forest is just one of several sources available to an energy facility. The more common sources and their relative availability are described below. The actual supply breakdown to a specific facility will depend on local conditions, such as the distance between the biomass source and the mill, and the cost to produce one biomass source versus another biomass source.

Mill waste

Sawmill residues (Figure 2) can be used to create electrical and thermal energy. However, in Missouri, about 93 percent of this material goes into other value-added products, such as charcoal, landscape mulch and wood pellets for home heating stoves. In the free market system, price will determine where this material goes.

Figure 2. Bark and other sawmill residues have ready use as landscape mulch and as an energy source.

Debris from natural disasters

Woody biomass can also be generated from trees damaged or destroyed by natural disasters. The most common natural disasters in Missouri are ice and wind storms (Figure 3). Such disasters can generate large amounts of woody biomass, but this supply is unpredictable. So although energy facilities will use this material when available, they do not base business decisions on this source.

Short-rotation plantations

Fast-growing species such as cottonwood or willow can be grown in what are called short-rotation plantations (Figure 4). Woody biomass can be harvested every three to five years, after which the stumps generate new shoots. This cycle can be repeated several times before the site needs to be replanted. But these plantations will not be grown on land more suitable for higher-value agronomic crops like corn or soybeans. Short-rotation wood energy crops will be limited to marginal fields and pastures. In addition, experts estimate it will take 10 to 15 years to develop supply chains capable of delivering this form of woody biomass to an energy facility on a reliable basis.

Logging residues and small-diameter trees

Branches, tops, stumps and other woody debris from commercial harvesting operations are often left at the harvest site (Figure 5). In addition, trees of small-diameter, poor form or ill health are left in the woods because no markets currently exist for them. Those trees, like weeds in a garden, compete with more desirable plants for sunlight, water and nutrients. This overcrowding results in trees of lower vigor that are more susceptible to attack from insects and disease. The excess wood also places the entire forest at risk of catastrophic fire.

Of all the sources, logging residues and small-diameter trees are the most readily available forms of woody biomass.

Figure 3. A natural disaster may create a one-time source of woody biomass. The January 2006 ice storm in southwest Missouri generated enough woody biomass in Springfield alone to reach from Springfield to Denver, Co., stacked 3 feet high by 3 feet wide.

Figure 4. Experimental 1-year-old cottonwood trees growing at the MU Horticulture and Agroforestry Research Center in New Franklin, Mo.

Figure 5. Tree trunks too crooked to make lumber (left) and small-diameter trees that compete with better trees for water and nutrients (right) could be chipped and used to make energy.

Harvesting systems

Traditionally, trees to be harvested are felled by a person with a chain saw and cut by the sawyer into logs. The logs are then skidded, or transported, to the edge of the forest (Figure 6) where they are loaded onto a log truck for delivery to the sawmill.

When woody biomass is harvested, the entire tree is brought to the forest edge where the trees of commercial value and size are placed in one pile and processed, and nonsalable trees are placed in another pile to be chipped and placed in semitrailers for transport to the energy facility (Figure 7). The simultaneous removal of woody biomass and solid hardwood products is known as a *one-pass* or *integrated* harvest.

Most logging businesses favor one-pass harvesting because, other than adding a chipper, they have to make few, if any, modifications to the way they currently harvest trees. Moreover, landowners and foresters prefer this method because it is lighter on the land and thus reduces the potential for soil compaction and erosion.

Highly mechanized pieces of harvesting equipment are now being used in Missouri's forests (Figure 8). They are safer and more efficient for removing large amounts of wood when harvesting biomass along with more valuable timber. Cost-effectiveness of using this equipment remains a challenge, though, because of high capital and operating costs as well as the higher transportation costs of moving bigger machinery from forest to forest; the limited amount of material per operation for biomass markets specifically; and the relatively low value of biomass. These costs make the size of the forest tract being harvested and the amount of biomass available per acre important factors in determining the economic feasibility of harvesting woody biomass.

Figure 6. In a conventional harvest, only the salable logs are removed from the woods.

Figure 8. Highly mechanized harvesters, such as the one pictured here, are becoming an increasingly familiar site in Missouri's forests.

Figure 7. An integrated, one-pass harvest sorts and processes low-value woody biomass at the landing.

Figure 9. A healthy, vigorous forest in mid-Missouri after a commercial timber harvest and woody biomass removal.

Figure 10. As demand for woody biomass grows, so will the demand for processing facilities such as this one in Scott City, Mo., providing jobs for local communities.

Benefits of using woody biomass

In addition to being a sustainable, renewable source for energy and biofuels, properly managed forests are healthier and grow more wood than unattended forests. Like plants in a weeded garden, the trees remaining after a properly executed harvest grow faster and bigger, removing more carbon dioxide from the atmosphere and placing it into long-lived carbon pools. Vigorous, healthy trees are also better able to resist attack from insects and disease. With less wood in the forest, the risk of a catastrophic wildfire is reduced. Improving the vigor and health of the remaining trees also means more food for wildlife in the form of both hard mast (acorns and nuts) and soft mast (berries). Finally, removing the small-diameter trees allows for more light to reach the forest floor to help regenerate the forest.

Forest landowners and rural communities can benefit, too — economically. A properly executed harvest in which woody biomass is removed not only generates modest revenue, but it actually saves the landowner money. MU researchers have shown an average of 15 green tons of woody biomass can be sustainably harvested from a typical acre of Missouri forest (Figure 9). Revenue generated from the sale of this material can range from $1 to $3 per ton, or $15 to $45 per acre. Currently, biomass can only be sold in conjunction with commercial sawtimber, and if this material is not removed, the landowner must pay $100 to $150 per acre to have the unwanted trees killed on the stump to give future crop trees room to grow. The results of harvesting biomass along with salable trees are more money in the landowner's pocket, healthy and vigorous trees better suited to resist attack from insects and disease, and a forest with a higher value for future generations.

Many of Missouri's rural communities need additional markets for their timber to help offset downturns in commercial sawtimber prices. Using logging residues and small-diameter trees, building processing facilities, and marketing the resulting products can bolster local economies (Figure 10). In addition, dollars that once left the region to buy energy outside Missouri have the potential to stay in the region by purchasing locally produced bioenergy.

Addressing environmental concerns

Harvesting woody biomass removes more woody material from a forest than a common timber harvest does. Removal of this additional woody biomass could result in soil compaction and adverse effects on future forest productivity, water quality, wildlife habitat and other environmental influences tied to forest sustainability. To ensure future forest sustainability, the Missouri Department of Conservation, in conjunction with natural resource professionals and stakeholder groups from across the state, developed a manual of best management practices (BMPs) to guide forest owners and loggers on harvesting biomass using sustainable management and harvesting techniques. (See *Highlights* sidebar.)

Highlights of Missouri's woody biomass harvesting best management practices

To protect future forests

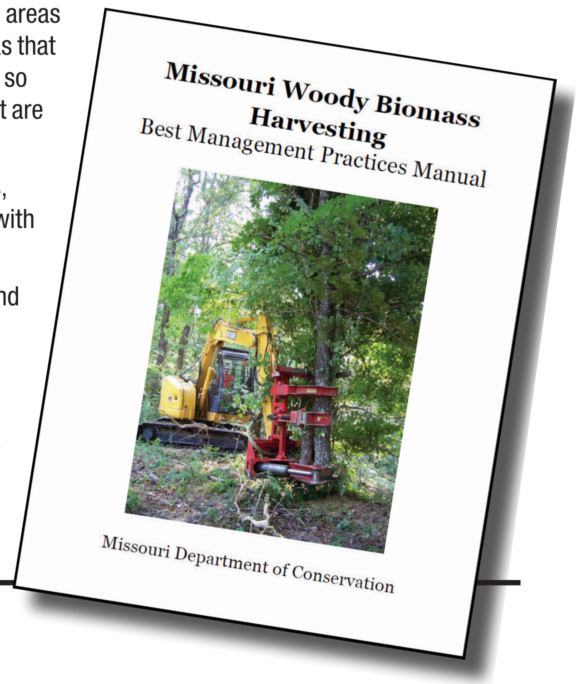
- An up-to-date forest management plan prepared by a professional forester should be in place.
- Harvesting should be done at a time when the soil is firm to minimize soil compaction and erosion.
- Woody biomass should be harvested at the same time as sawlog timber to minimize potential damage to remaining trees and the site.
- Damage to remaining crop trees should not exceed 10 percent by number.
- Avoid skidding on shallow soils (less than 20 inches to bedrock) or steep slopes (greater than 35 percent) that may be subject to erosion.

To protect wildlife

- Before harvesting, conduct an on-site survey to identify natural features or special wildlife and plants that may need special care during the harvest.
- Retain at least one-third of the harvest residue (tops, branches, coarse woody debris, etc.) on site, distributed throughout the harvested area.
- Leave trees of various sizes and species for mast production, especially oaks.
- Loggers should use directional felling to avoid damaging soft mast trees such as dogwood, cherry, mulberry and persimmon.
- Create a gradual transition from areas that are to be heavily cut to areas that are to be lightly cut and in doing so avoid creating "hard edges" that are detrimental to wildlife.
- Smooth and seed logging decks, main skid trails and haul roads with green browse food plot crops.
- Leave at least three den trees and three dead snag trees per acre.
- Maintain a 200-foot buffer from the mouth of any cave.

To protect water quality

- Streamside management zones (SMZs), where harvesting is closely monitored, should be at least 50 feet wide, 25 feet on each side of the stream.
- Leave trees on stream banks to protect stream channel and keep fish habitat cool.
- Remove any treetops from the stream channel.
- Maintain a 100-foot buffer around all sinkholes.
- Do not restrict natural surface or subsurface flow of water under haul roads in wetlands.



Missouri Department of Conservation (MDC). Missouri Woody Biomass Harvesting: Best Management Practices Manual. ***http://mdc.mo.gov/sites/default/files/resources/2010/09/woody_biomass_harvesting_bmp_book.pdf.***

Landowner interest

In 2011, MU Department of Forestry researchers conducted surveys to better understand Missouri landowners' motivations for owning woodlands and to gauge their potential interest in harvesting woody materials from their woodlands for energy production (Table 1). The survey results suggest that although Missouri's woodland owners are interested in harvesting woody biomass for renewable energy, current market prices may not provide sufficient incentive. While higher woody biomass prices may increase a landowner's willingness to harvest woody biomass, sawtimber prices were the predominant drivers for harvesting. The surveys also indicated that public incentives do not increase landowners' willingness to harvest.

Table 1. Summary of results of the "Woodland Management and Bioenergy" study conducted among private woodland owners in Missouri.

Topic	Responses	Percentage
Woodland ownership	20 to 49 acres of woodlands	32%
	50 to 99 acres of woodlands	22%
	100 to 499 acres of woodlands	26%
Missouri family woodland owners can be categorized into four main groups	*Woodland enthusiasts* Main priority for owning woodlands was for privacy, protection of aesthetics and leaving behind a legacy. They were also in agreement with positive bioenergy statements.	31%
	Woodland retreat landowners Main priority for owning woodlands was for privacy. They were also in agreement with positive bioenergy statements.	27%
	Woodland preservationists Main priority for owning woodlands was for protection of aesthetics and privacy. They neither agreed nor disagreed with positive bioenergy statements nor how woody biomass harvests affects the environment.	24%
	Apathetic woodland owners Overall these landowners had no main priority for owning their woodlands. They found protection of aesthetics and leaving behind a legacy moderately important, and were in agreement with the positive bioenergy statements.	20%
Top three reasons for owning woodland in Missouri	• Land has been in the family for generations • Enjoyment of beauty or scenery • Privacy	
Forest management	Landowners who have a forest management plan	8%
	Landowners who have harvested timber since acquiring their woodlands	91%
Average price landowners are willing to consider for timber harvest	Would harvest for $100 to $300 per acre	28%
	Would harvest for a higher price	22%
	Would not harvest, regardless of price	37%
Views toward woody biomass as a renewable energy	• Overall support for bioenergy • Sees potential of woody biomass harvests to impact the environment	
Top five statements landowners agreed with about the use of woody biomass to produce bioenergy:	• Waste wood from forest harvests should be used for energy/fuel generation. • Harvesting woody biomass for energy/fuel is likely to benefit local economies. • I support harvesting woody biomass for energy. • Forest health is likely to be improved by harvesting woody biomass. • Woody biomass is a viable alternative to fossil energy (e.g., coal, oil, gasoline, diesel).	
Average price landowners are willing to consider for harvesting woody biomass	Landowners indicated between $25 to $75 per acre	32%
	Would harvest for a higher price	20%
	Would not harvest, regardless of price	33%

Note: This results summary is from the University of Missouri master's thesis of Marissa "Jo" Daniel, "Social Availability of Woody Biomass for Renewable Energy: Missouri Non-Industrial Private Forest Landowners' Perspective," University of Missouri, 2012.

For more information

If you are interested in learning more about wood energy, visit eXtension's Wood Energy website, ***http://extension.org/wood_energy***. To find out if harvesting woody biomass from your forest is a possibility, contact your local professional forester.

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