COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Woody Biomass for Energy

WOODY BIOMASS STOCKPILED FOR USE AT AN ELECTRIC PLANT.

Introduction

Biomass, when used in reference to renewable energy, is any biological (plant or animal) matter that can be converted to electricity or fuel. Woody biomass refers to biomass material specifically from trees and shrubs. It is most often transformed to usable energy by direct combustion, either alone or co-fired with coal; however, efforts are underway to develop methods to cost effectively convert woody material to liquid fuels.

Renewable bioenergy sources have the potential to help extend finite supplies of fossil fuels. Woody biomass is considered to be a clean, high yielding, sustainable source of energy. Relatively minimal harvesting and processing inputs notwithstanding, woody biomass is often regarded as "carbon neutral" because carbon dioxide released during combustion is sequestered through the production of additional trees. In addition, burning wood for energy produces fewer nitrous and sulfur emissions into the atmosphere when compared to coal.

While material for woody biomass can come from many sources (e.g. forestry thinning operations, logging slash and residue, urban tree and shrub prunings, and waste from forest and wood-related industries) this profile will focus on the production of trees specifically for bioenergy. Woody plants primarily of interest for dedicated energy crops are fast-growing trees which resprout after each harvest (short rotation woody crops). Typically these planting are known as energy plantations.

Marketing

Potential woody biomass producers must be located near a viable market for their products. Efficient and economical transportation to the market outlet is critical for marketing success. Producers interested in woody biomass production should be developing a transportation and logistics plan for delivering their product to market before planting. Multiyear marketing contracts can also help guarantee a longer-term market for a perennial crop.

Relying solely on one market outlet is a weakness in marketing farm products and the same is true for woody biomass. Producers should have more than one market possibility for woody biomass products. While woody biomass production

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can represent an opportunity for diversifying the domestic energy supply, there is currently a very limited market for cellulosic bioenergy feedstocks. Pilot-scale projects involving production on marginal or reclaimed land are likely to be the main market for woody biomass products in the near future.

Market Outlook

There are currently very few large volume buyers utilizing woody biomass for energy in Kentucky. The market is developing, but it is still in its infancy. A current market is primarily selling to companies that are processing woody biomass into pelleted products for co-firing in energy production. These markets are typically well-supplied and relatively limited to new producer access. Proximity to reliable product sources, as well as economic and policy requirements, are key parts of emerging biomass markets.

An opportunity is emerging in 2012 through the Recast Project in the Louisville area, a project that would require 75,000 to 100,000 tons of woody biomass per year. Another biomass-processing project in Gallatin County could also emerge in 2013. Kentucky is also home to several existing businesses using wood by-products, including charcoal manufacturers, pulp and paper plants using woody energy sources, and hardwood floor manufacturers reclaiming wood waste into fuel pellets.

Production Considerations

Plant selection

Two of the most desirable characteristics of trees for woody biomass plantations are rapid growth rate and ability to be coppiced. Coppicing is a management tool in which a tree is cut near ground level and sprouts are allowed to develop from the stump. This enables the tree to regenerate without having to be replanted after each harvest.

In addition to growth rate and sprouting capabilities, trees for biomass should be high yielding in terms of dry tons of wood produced per acre. Other desirable characteristics include: widely adaptable, vegetatively propagated, easy to establish, hardy, and disease and insect tolerant. Lignin content and wood density are also important considerations. It is unlikely that any one species will meet all of Kentucky's biomass needs. The U.S. Forest Service is urging forest geneticists to "continue to develop new tree varieties to produce woody biomass in shorter rotations while decreasing inputs and increasing yields per acre."[1] As the biomass market develops, buyers may require specific genetically improved species that have the traits that fit their particular operation. Below are listed some of the trees and shrubs that have currently been identified as having the greatest potential for use as woody biomass in Kentucky.

Hybrid poplar (*Populus* spp.) is a general name given to the crosses and clones that have been developed from various species of poplar and cottonwood. Among the fastest growing trees in North America, hybrid poplars can grow as much as 6 to 10 feet per year. Native cottonwood has also been studied for use as a source of biomass.

Willows (*Salix* spp.), particularly genetically improved shrub types, have good potential for woody biomass. Willows are easily established from unrooted cuttings and they are vigorous sprouters.

American sycamore (*Plantanus occidentalis*) is a long-lived tree that can reach immense size. Advantages for biomass use include: medium wood density, thin bark, and adaptability to various growing sites, including disturbed areas. However, susceptibility to serious disease and insect problems may hinder its development for biomass.

Sweetgum (*Liquidambar* spp.) is not as fast growing as other biomass candidates, but it does resprout well, is very adaptable, has medium wood density, and is not bothered by many diseases.

Black locust (*Robinia pseudoacacia*) has often been successfully seeded and planted on reclaimed mine sites. It is easy to establish, grows quickly, and is a prolific sprouter.

Other trees, such as silver maple (*Acer saccharinum*) and loblolly pine (*Pinus taeda*) have also been the subject of biomass research. There are several exotic species that have been proposed for use in Kentucky. However, many have not been thoroughly tested and environmental concerns over potential invasiveness make their use suspect. Ultimately the choice of crop(s) will depend upon market demand, as well as location and local growing conditions.

Site selection, preparation, and planting

A number of woody feedstock species are native to streams and bottomlands. As such, they prefer soils that are well-drained with adequate moisture throughout the growing season. Some species can be grown on marginal or spent soils; sycamore and black locust have been successfully grown on reclaimed surface mine lands. Properly matching the species and the soils is critical for developing a successful energy plantation. This may be the single most important decision made in developing an energy plantation; selecting the wrong species for the site can easily prove fatal to the endeavor. Further, the use of marginal land, while capable of growing several common biomass species, may not be able to produce the yield necessary to make the planting economically viable.

Site preparation can include deep plowing, disking, harrowing, and fertilizer applications. Pre-plant weed control is generally managed with herbicides. Dormant cuttings (10 to 24 inches long) are planted by hand or machine so that only the buds on the top few inches are exposed. Spacing, which is based upon the growth rate of the species and time between harvests, can vary widely. In order to foster sound and sustainable woody biomass production, producers should follow the Best Management Practices identified in the Silviculture section of their farm's *Agriculture Water Quality Plan*.

Some species, such as willow shrubs, may be cut back after the first year to promote the production of multiple stems. In other cases, trees are grown as a single stem for the first harvest and then coppiced for further harvests. For most species, re-sprouting generally declines in vigor to some extent each time trees are harvested. As a result, productivity can be lost after several rotations, at which time the plantation will need to be reestablished. Biomass trees can also be grown in a single rotation and replanted after each harvest. The length of the rotation will vary depending on the plant species. For example willows could be harvested every 2 to 4 years, while poplars may be allowed to grow 6 to 15 years before being harvested.

Pest management

Disease and insect pest problems will vary depending on the host. Some biomass plants, such as sweetgum, are susceptible to very few pests. Other trees, such as sycamore and poplar, can be plagued by several debilitating disease and insect problems. For example anthracnose can cause near complete defoliation of sycamore during wet springs. While this disease does not kill sycamore outright, repeated defoliation weakens trees and makes them susceptible to other disease and insect problems; weak trees produce fewer sprouts and therefore less biomass. Pesticide applications may be necessary to manage disease and insect problems.

Weed management is important until the canopy closes and weeds are shaded out. The most common methods for controlling weeds in biomass plantations are mechanical and chemical.

Harvest and storage

Issues associated with harvesting woody biomass are based upon whether the biomass will be used for combustion or for conversion to a liquid fuel. The most likely use will be for direct combustion where fuel moisture content is an issue. The moisture comes either from natural moisture in the wood (which is generally highest during the winter and spring) or from leaves when the entire tree is chipped during the growing season. The individual biomass market will determine whether the wood can be harvested year round or whether harvesting needs to be restricted. Further, there may be price premiums for biomass harvested at specific times of the year.

HARVESTING A HYBRID POPLAR PLANTATION.

The equipment needed to harvest these short rotation plantings is significantly different than what is required for conventional logging in many parts of Kentucky. Where larger material is being harvested (for example poplars) that might be harvested on 6- to 10-year cycles, mechanized "cut-to-length" tree harvesters or mechanical feller-bunchers can be used. Both types of equipment are currently being used by loggers harvesting pulpwood in western Kentucky. Very few of these machines are in use in central and eastern Kentucky. When biomass plantings with small material are harvested (for example, 2- to 4-year-old willow), specialized equipment is needed. This technology exists; willows grown for biomass in New York are being harvested using a cut-and-chip harvesting system based on the New Holland forage harvester. The harvester has been equipped with a specially designed cutting head that can cut stems up to 6 inches in diameter. However, none of these harvesters are currently operational in Kentucky.

Regardless of the equipment used to harvest, refer to the Kentucky Division of Forestry's publication, *Recommendations for Harvesting Woody Biomass,* for sustainable harvest strategies. While this publication is mainly geared towards harvesting biomass in natural forests, it also contains information applicable to dedicated energy plantations.

Typically, harvesting energy plantations will result in the woody material being chipped on-site and the biomass trucked immediately to market. Storage is a huge issue if the producer needs to hold over the product for any length of time. Woody biomass is bulky and requires considerable storage space. Because it must be kept dry, the storage space needs to be covered. Harvested wood (chips) may be further processed into pellets, briquettes, or torrefied wood to improve burning efficiency. While some of this processing could potentially be completed on-site, it will generally occur at market.

Labor requirements

Woody biomass production is labor- and management-intensive. In this regard it is similar to the production of agricultural row crops. As dedicated energy markets develop for woody biomass, specialized equipment, intensive forest management, and a trained labor force will be essential for profitability.

Economic Considerations

Initial investments include land preparation and purchase of cuttings. An additional start-up cost can include the installation of an irrigation system. The purchase of specialized harvesting equipment, which tends to be quite expensive, is another economic consideration. Wildlife and pest control can also present significant costs in the production of some woody crops.

Because markets are so thinly established, and because of the wide range of potential woody biomass crops, per acre profitability estimates should be determined on a case-by-case basis.

Production of woody crops could have non-financial economic benefits when used as part of a whole farm plan. When grown on marginal or spent soils, woody crops can help replenish the land and increase productivity. Planting woody biomass trees on reclaimed forest sites could help restore woodlands. In addition, growing bioenergy feedstock on otherwise agriculturally idle land would not compete with food crop production. Woody biomass can also be grown as windbreaks and riparian forest buffers.

Selected Resources

- Current Research: Biofuels (CDBREC)
http://www.uky.edu/Ag/CDBREC/biofuels.html
- Demonstrating Techniques for Establishing Woody Biomass Plantations on Surface Mine Lands as Feedstocks for Energy Production (University of Kentucky, 2010) *1.63 MB, 45 pp.*
http://energy.ky.gov/biofuels/Documents/Barton%20bioenergy%20final%20KOEP.pdf
- Kentucky Agriculture Water Quality Plan (Kentucky Division of Conservation, 2008)
http://conservation.ky.gov/Pages/AgricultureWaterQuality.aspx
- Kentucky Division of Biofuels (Energy and Environment Cabinet)
http://energy.ky.gov/biofuels/Pages/default.aspx
- Kentucky Forest Practice Guidelines for Water Quality Management (University of Kentucky, 2001)
http://www.ca.uky.edu/agc/pubs/for/for67/intro.pdf
- Recommendations for the Harvesting of Woody Biomass (KY Division of Forestry, 2011)
http://forestry.ky.gov/Documents/Biomass%20Harvsting%20Recommendations%20Oct%202011.pdf
- Bioenergy Feedstock Information Network (Oak Ridge National Laboratory)
https://bioenergy.ornl.gov/main.aspx
- Biofuels from Trees: Renewable Energy Research Branches Out (Oak Ridge National Laboratory, 1998)
http://www.afdc.energy.gov/afdc/pdfs/8515.pdf
- Biomass Energy Data Book, ed. 4 (Oak Ridge National Laboratory, 2011)
http://cta.ornl.gov/bedb/download.shtml
- Introduction to Bioenergy: Feedstocks, Process and Products (National Sustainable Agriculture Information Service-ATTRA, 2010)
https://attra.ncat.org/attra-pub/summaries/summary.php?pub=342
- Short Rotation Woody Crops (Mississippi State University, 2010)
http://msucares.com/pubs/publications/p2611.pdf
- Short Rotation Woody Crops for Biofuel (University of Tennessee, 2008)
https://utextension.tennessee.edu/publications/Documents/SP702-C.pdf
- Wood 2 Energy – A State of the Science and Technology Report (University of Tennessee, 2010) *2.2 MB file*
http://www.usendowment.org/images/Wood2Energy_Publication_Final_S.pdf
- Wood to Energy: Woody Biomass Basics (University of Florida, 2009)
http://edis.ifas.ufl.edu/fr283
- Woody Biomass for Bioenergy and Biofuels in the United States — A Briefing Paper (USDA Forest Service, 2010)
http://www.fsl.orst.edu/lulcd/Publicationsalpha_files/White_pnw_gtr825.pdf

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[1]Improving Trees for the Bioenergy Market: Highlights from the 31st Southern Forest Tree Improvement Conference (June 13-16, 2011)
http://www.srs.fs.usda.gov/news/improving_trees.html

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