Chapter 4 Implications of Producing and Using Woody Biomass

4.0 Introduction

When considering whether or not to produce and use woody biomass, a number of factors have to be considered including availability and cost of existing feedstocks, existing processing facilities, new facilities; facility permits, feedstock transportation costs and logistics, available wood supply, environmental impacts of production and utilization, and individual- and community-level economics and social concerns. In an effort to help individuals and communities in the decision-making process, this chapter explores the advantages and disadvantages of producing and utilizing woody biomass as an industrial feedstock for heat, power, and other bioproducts. While there are several types of biomass, this chapter focuses only on woody biomass. All sources of energy have costs and benefits: positive and negative environmental, economic, and social impacts. Communities and industries will want to carefully examine all reasonable options and determine which will best meet their needs.

4.1 Environmental Implications

Using woody biomass for energy production and as a feedstock for industrial materials affects air quality, land use, forest health, and other natural resources in different ways and at different intensity levels. There are both environmental costs and benefits to implementing a woody biomass production and utilization plan. These costs and benefits should be compared to those of other feedstock options, such as fossil fuels for industrial products.

Maintaining Forests

There are some concerns that the growing demand for wood, especially for energy production, will lead to rampant harvesting and removal of forests around a bioenergy facility. Certainly, competition for wood and long-term supply within a region are important factors to consider when thinking about using woody biomass.

Wood is a renewable resource and with proper management, forests can produce wood relatively quickly and sustainably. As discussed in chapter 2, there are many different sources of woody biomass. In some communities, waste wood from utility line maintenance or from forest harvesting operations can be used to supply facilities to reduce the pressure to use standing trees. Wood supply in a particular area based on current forest harvesting practices and urban waste resources can be calculated by using the supply curve tools found in chapter 6, "Do It Yourself Supply Curve: Tools to Help You Get Involved in an Entrepreneurial Woody Biomass Project."

Figure 1: *A biomass removal operation in Minnesota.*
Photo courtesy of Diomy Zamora, University of MInnesota.

When trees are harvested, the branches, leaves, and stumps that are unsuitable for pulp or lumber are typically left behind as waste. In some parts of the United States they are burned in large piles. In other areas they become a fire hazard. While leaves and stumps are generally not removed during harvest, the wood from branches and other residue can be collected and used as fuel.

Moreover, harvesting woody biomass can help reduce the risk of wildfire and improve overall forest health. Many forests throughout the U.S. are in great need of fuel load reduction. Brush and small diameter, low quality and damaged trees can be harvested, collected, and used as feedstock in a wood using facility. In addition, using wood for energy and in new, emerging markets may allow landowners to maintain their forests rather than sell their land for development. Working forests provide environmental benefits such as soil protection, clean air and ground water, carbon sequestration, and wildlife habitat.

Air Quality

When any substance is burned, emissions are produced. Conventional wood-fired power plants typically produce some of the same emissions as coal-fired power plants including carbon dioxide (CO_2) and carbon monoxide (CO). The same is true when burning ethanol, a biofuel derived from wood and agricultural feedstocks, in place of gasoline. Wood-fired power plants and ethanol fuel, however, produce very little mercury and much lower levels of sulfur and nitrogen oxides than fossil fuels do (U.S. EPA, 2006b).

On the other hand, both wood-fired power plants and ethanol produce higher levels of particulate matter than coal and gasoline, and some studies suggest that ethanol may produce higher levels of ground-level ozone. The American Lung Association has identified particulate matter and ground level ozone as contributors to respiratory illness (American Lung Association, 2007). Particulate matter, however, is the easiest emission to control and can be managed by using pollution-control devices such as scrubbers, filters, and catalytic converters (Power Scorecard, 2007). The type of wood fuel, power plant, and emissions control technology used determines both the emissions produced and the overall impacts on air quality. Using woody biomass or co-firing (wood used in combination with coal or other fuels) has less of an impact on air quality than using coal alone.

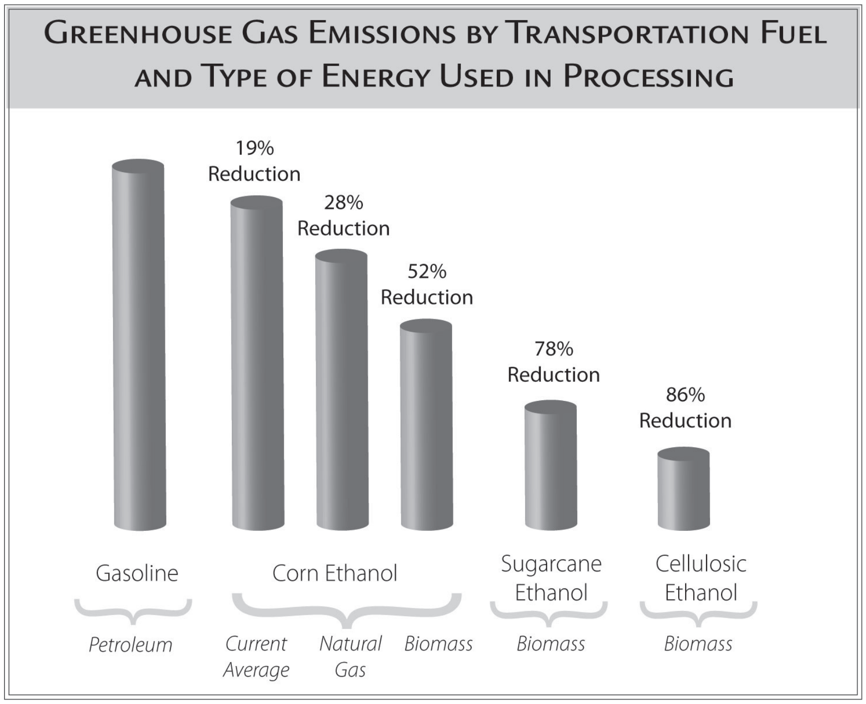
Some sources of woody biomass, such as yard trimmings and debris from land clearing for development, are often burned in open fields without emission controls. Burning these wood resources in the controlled environment of a power plant can significantly reduce the air quality impacts created by these materials when they are burned in open areas.

Greenhouse Gases

Wood, coal, oil, and natural gas are all made of carbon-based compounds. Burning these feedstocks releases carbon, which then becomes carbon dioxide, a major greenhouse gas. The big difference between wood and fossil fuels is that the carbon released by burning wood has been recently circulating through the atmosphere. Growing plants and animals absorb and release carbon every day and cycling this carbon is a benefit that our ecosystems provide to us. In addition, the newly planted trees, if grown to the same size as the trees being replaced, will absorb about the same amount of carbon during their lifetime as they release when converted into energy. Burning coal, natural gas, or oil, on the other hand, releases fossilized carbon that has been out of circulation for millions of years. This fossilized carbon, when added to the atmosphere, is thought to contribute to global warming. Notably, woody biomass that is produced, harvested, transported, and processed using fossil fuels is not completely carbon neutral. However, if biofuels were used for all of the steps of harvesting and using woody biomass, it could be a nearly carbon-neutral energy source.

The amount of greenhouse gases associated with a particular feedstock depends on what is emitted, when it is burned and on the energy used in growing, harvesting, and processing. Diagram 1 shows the promise of bio-feedstocks with respect to greenhouse gas emissions on a full life-cycle basis for various transportation fuels.

Diagram 1: *Greenhouse gas emissions by transportation fuel and type of energy used in processing.* Adapted from Life-Cycle Energy Use and GHG Implications of Brazilian Sugarcane Ethanol Simulated with GREET Model. 2007.



Water Quality and Quantity

Methods used to obtain different types of energy feedstocks can impact water quality and quantity. For instance, coal mining typically alters the shape of the land and changes the patterns of water flow in the area mined. Surface mining, deep mining, and even coal stored in piles can produce acid mine drainage, a flow of liquid that tends to be highly acidic and can contain high levels of potentially toxic metals (U.S. EPA, 2006a).

Harvesting wood for energy and other products can lead to soil erosion and runoff if proper management practices are not used. Growing trees require less water and fewer chemical fertilizers and pesticides than growing annual energy crops, such as corn. In addition, the root systems in forests help filter pollutants in surface waters.

Healthy, well-managed forests, especially forested areas with steep slopes, are esential to maintaining clean, rivers, streams, lakes, marshes, and groundwater,. The health of our watersheds, those sloped areas, which channel precipitation to lower elevations, is directly related to the quality of water in our waterways. Watersheds serve to absorb rainfall, filter pollutants from the air and water, recharge aquifers, and sustain stream flows. What pollutants that are not captured in watersheds often end up in our drinking water. Proper forestry practices help maintain this relationship and offer low cost, long-term solutions to the nation's energy and pollution problems.

Figure 2: *Improper forest management can be detrimental to water quality, especially in areas with steep slopes.* Photo courtesy of Steve Norman, U.S. Forest Service.

Regardless of their fuel source, most power plants require water for stream production and cooling. Water can be conserved if power plants elect to reuse it, although for various reasons there is a limit to how many times it can be reused. For example, the water used for cooling is much warmer after circulating through the system and has often been treated with chemicals to prevent equipment corrosion. If water is released untreated into lakes or rivers, it can negatively affect water quality. Power plants are usually required to obtain a permit to release water used in this way and water quality is monitored (Sustainable Northwest, 2005).

Both thermal and chemical water pollution can harm aquatic animals and plants and potentially pollute drinking water. It is important for communities to consider the condition of local aquatic resources and how energy decisions will influence those resources.

In terms of growing wood for energy, different species and practices will have different impacts on water quality. For example, some short rotation woody species may need larger quantities of water than slower-growing tree species. People and communities exploring the possibilities of growing wood for energy production should carefully consider the potential impacts of various alternatives.

Soil

Growing trees for energy can also enhance soil quality. In comparison with agricultural feedstocks, trees are typically grown from 20 to 90 years before they are harvested. During this time, their roots and leaf litter help stabilize and enrich the soil. Some tree species can even sprout back from the stump after they are harvested. Using trees that can regenerate naturally may reduce the need for tilling and planting thereby reducing soil erosion.

Typically, harvesting woody biomass involves removing tree trunks and large branches and leaving stumps, roots, and leaves. Ensuring that leaf litter remains in the forest helps maintain soil quality because about one-third of a tree's nutrients are contained in its leaves or needles (Moller, 2000). Wood production generally places less intense demands on soil nutrients than agricultural production. For instance, growing and harvesting corn (either grain or stalks) removes over 89.27 lbs of nitrogen per acre annually, while growing and harvesting loblolly pines removes about 4.46 lbs of nitrogen per acre. Furthermore, although the cost of trucking and spreading it might be a deterrent, ash from wood-fired power plants, when put back into the forest, may provide sufficient nutrients to alleviate nutrient loss from harvest, depending on the soil type.

Soil quality can also be affected by physical disturbance and compaction. Roads and heavy machinery used during harvesting may lead to increased soil compaction, erosion, and water runoff. Runoff can contaminate nearby water bodies with soil, silt, and chemicals. Minimizing the area disturbed by heavy machinery and scheduling a harvest when soils are dry or frozen can reduce these impacts. There are a number of well-established best management practices for harvesting that help protect soil. Again, proper management practices can help maintain soil quality and sustain forest productivity.

Invasive Exotic Tree Species

One way to produce large volumes of woody biomass in a short period of time is to plant short rotation woody crops (SRWC). While not all of these crops are invasive species, some of them, such as giant reed (*Arundo donax*), African oil palm (*Elaeis guineensis*), and castor oil bush (*Ricinus communis*) are, and this is a concern for some people. Invasive species can overwhelm native ecosystems, outcompeting native plant life and crowding out food sources for native wildlife. Proponents of using SRWC, including invasives, for biomass production believe they can be managed and contained, while opponents fear that widespread cultivation of invasives could spell environmental and economic disaster. For more information regarding exotic invasive species being recommended for biofuel feedstock in the United States, go to www.nature.org/initiatives/invasivespecies/.

4.2 Economic Implications

Biomass utilization facilities are costly investments that may represent a substantial financial burden to an industry or community. Furthermore, bioenergy, biofuels, and bioproducts can be costly for suppliers to harvest and transport and individuals to purchase and use. At the same time, these facilities, along with the products they produce, can bring significant benefits to the local economy, benefits such as new opportunities for landowners to sell wood and pay for forest management activities, new strategies for reducing waste, new local jobs, and local economic stimulation. This section will explore some general information about the overall economic implications of woody biomass facilities and products.

Implications for Landowners

Private forest landowners represent part of the first steps in the forest bioenergy and bioproducts supply chain. Their production of woody biomass feedstock is critical to the emerging bioproducts industries and is equally important for their own forest-based revenue streams. The potential economic benefits for landowners include revenue from the sale of biomass, savings on-site preparation costs in forest stand regeneration, revenue from the sale of carbon credits, and low- to no-cost stand improvement.

Revenue from Biomass Sales

Globalization has led to a decline in some of the more traditional forest product markets because it has become cheaper to grow, harvest, transport, and process forest products elsewhere. Because of this, some of the historically more reliable forest-based revenue streams, such as those that come from pulp markets, have become less reliable. As heat, power, and transportation fuel plants that utilize woody biomass as a feedstock are constructed throughout the United States, new revenue streams could emerge. As the bioenergy and bioproducts industries develop nearby, the demand for cellulosic material will increase, and more opportunities will be available for local private landowners to sell their woody biomass.

Savings on Site Preparation Costs

Site preparation costs are a major component of forest stand regeneration costs. Landowners can save as much as $80 to $100 per acre in site preparation costs when logging residues are recovered for bioenergy and bioproducts markets. Technical and terrain constraints, however, limit the amount of logging residues that can be collected from harvesting sites to about two-thirds of the actual material left on-site.

Revenue from the Sale of Carbon Credits

Managed forests, both afforestation and reforestation projects, and forest land set aside for conservation purposes, are all eligible for carbon credit programs. Forests, in general, are eligible because the growing trees that make up a forest sequester carbon emissions. By growing trees and managing forests, landowners can earn credits that can either be "banked" or sold on the open market to net carbon emitters. Another way landowners may be able to benefit from the sale of carbon credits is by providing carbon neutral fuel to power producers. The Chicago Climate Exchange (CCX) has established credits not only for sequestering carbon but also for burning carbon neutral fuels in place of fossil fuels. If a power plant earns credits that can be banked or sold for burning carbon neutral fuels, they may be able to transfer this cost savings or revenue to forest landowners by paying a higher price for the raw feedstock. For more information on carbon credits and an example of calculating credits, please visit http://www.forestbioenergy.net/training-materials/fact-sheets/module-6-fact-sheets/.

Figure 3: *A forest stand after it has been thinned.* Photo courtesy of Kenneth E. Gibson, U.S. Forest Service.

Low to No-cost Timber Stand Improvement

In many areas, particularly hardwood dominant areas, high-grading and diameter-limit cutting (i.e., taking only the more desirable species or dominant trees in a stand) have resulted in low stocking, low value, and undesirable or non-merchantable species. These timber-harvesting practices have undermined the long-run productivity of many forests. The impacted forests are not likely to recover without stand rehabilitation and improvement. The development of bioenergy and biobased product industries is a potential solution, as this industry will create markets for low value, low quality wood while simultaneously stimulating timber stand improvement efforts. Additionally, the development of biomass markets will enable more landowners to carry out precommercial and commercial thinnings (Figure 3).

Implications for Consumers

Cost is an important factor to consider when biomass users are selecting a feedstock. Depending on the type and proximity of the source and local supply and demand, wood prices can be competitive with most fossil fuels. See the Cost and Supply Profiles in chapter 6 for more information.

Bioenergy

The cost of using wood to generate energy can vary significantly depending on the technology used; the size of the facility; the haul distance; and the size, quality, and cost of wood itself (Power Scorecard, 2007). Feedstock prices directly impact consumer electricity bills and fuel costs. Table 1 shows a comparison of the price of fuels measured in British thermal units (Btu). For instance, if a wood-fueled facility is situated near the source of wood, fuel transportation costs will be lower, making the final fuel cost lower. Currently, the most inexpensive method of using woody biomass is co-firing, which involves burning two or more types of fuel together, such as coal and wood. Modifying an existing coal power plant to use wood is much less expensive than building a new, exclusively wood-fueled facility. The addition of wood and reduction of coal reduces overall air emissions and cuts down on emission control costs (Power Scorecard, 2007).

One of the biggest challenges associated with using woody biomass as a feedstock for energy and industrial materials is transportation from the forest to the processing facility. Woody biomass in its raw form (slash, small trees, and tree sections) has a low bulk density. In addition approximately 50 percent of raw woody biomass transported mass is water. Both air and water increase the cost of transportation because they reduce the energy efficiency of the load. Reducing the size of the material via chipping, grinding, or shredding may increase bulk density; transpiration drying on-site decreases the amount of water in the biomass. Still, in some cases, road conditions and haul distance may prevent the use of woody biomass from being a feasible feedstock. Low bulk density increases the cost of transportation because air is a major component of transported volume. One way to get around the challenge of transporting forest biomass may be to convert the feedstock to a higher energy value product on site, before transporting it to an end-use facility. For a more detailed explanation of how this is carried out, please refer back to chapter 2: "What is Woody Biomass?"

Table 1: *Approximate price of residential heating fuels in 2008.* (Energy Information Administration 2008a).

Fuel Type	Dollars per million Btu
Oil (residential)	$22.42
Wood*	$9.09
Natural Gas	$12.40
Coal	$8.03

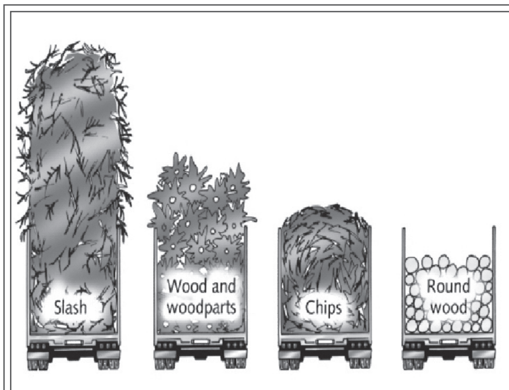
*The price of wood for fuel can vary depending on several factors, including the type of tree species. Energy Information Administration 2008a.

Bulk density is the mass of a material per unit volume.

Biofuels

According to the Renewable Fuels Association, the U.S. produced 5.4 billion gallons of ethanol in 2007 (RFA, 2008). As of March 2008, U.S. ethanol production capacity was at 7.2 billion gallons, with an additional 6.2 billion gallons of capacity under construction. Cellulosic ethanol, produced from wood, is still a fairly new innovation. Its current production cost is about $2.25 per gallon (Bull, 2006). As technologies are improved and production moves from pilot- to commercial-scale, this cost is expected to lower to about $1.07 per gallon, similar to the current production cost of corn ethanol (Bull, 2006).

Figure 4: *Volume differences of the same weight material by different product types.* Photo courtesy of U.S. Forest Service Forest Product Laboratory.



Implications for Communities

Although woody biomass facilities can be costly investments, they can also bring significant benefits to a community or region. Heat, power, electricity, and transportation fuels are important aspects of modern society. If woody biomass can be used to meet these needs instead of fossil fuels, local resources can be used with profits being kept within that community or bioregion.

What is transpiration drying?

This occurs after a tree has been cut down. The foliage continues to pull water out of the trunk of a tree until it dies and completely falls off the tree.

In general, businesses in the bioenergy and bioproducts sector (such as landowners, loggers, foresters, power companies) sell their products and services to final consumers through wholesale and retail distributors, and to other businesses, locally, nationally, and internationally. Firms that purchase wood and other materials from local suppliers generate economic activity through recirculation of money in the local economy. Households of employees spend their earnings for personal consumption of items such as food, clothing, housing, and entertainment, which further contributes to the local economy. Sooner or later, money leaves the local economy for purchase of goods and services not available locally, outside investments, and federal taxes; this phenomenon is known as leakage. The more raw materials (such as wood) that are obtained locally, the greater the positive impact on the local economy because less leakage occurs. If fossil fuels are imported from another state, comparatively little local economic activity is created by a power plant that uses them.

The regional and national economic impacts of woody biomass utilization are significant and continue to grow. According to the United States Department of Energy in 1998, 66,000 jobs, $10 billion in capital investment, $460 million in taxes, and $1.8 billion in income have been generated from the nation's 6,500 MW of wood-fired power plants. In the Northeast, for every 1,000 tons of wood energy consumed, 1.96 jobs and about $46,600 of income have been produced (Gan, 2006). In the Southeast, for every 1,000 tons of wood energy consumed, 1.39 jobs and about $24,000 in income have been produced (Gan, 2006). Additionally, every 1,000 tons of black liquor, a processing residue from the paper-making process, has led to 0.77 jobs and $11,000 in income (Gan, 2006).

4.3 Social Implications

Competition for the Resource

Certainly, competition for wood within a region is an important factor when considering a wood-using facility. This is particularly an issue for existing small-diameter wood-using industries such as pulp and paper companies. From an economic perspective, however, an increase in competition should drive the price of wood higher, which could encourage more forest landowners to plant trees for future feedstock needs. And while woody biomass is a new and potentially revolutionary forestry product, there are many additional uses and benefits of forests, including recreation, timber, paper production, and wildlife habitat. Communities must prioritize local economic, ecological, and social needs and values regarding forest use and decide how to allocate forest resources.

Potential for Community Engagement

Since wood bioenergy is typically grown in proximity to where it is used, community members may be more aware of their energy source and thus, more cognizant of how they use it. With more communities working toward self-sufficiency through diverse economies, locally grown food, and thriving infrastructure, locally produced energy can provide yet another way for communities to be self-reliant.

Using wood for energy also provides opportunities for public engagement in the energy decision-making and planning processes. Citizens can share important concerns, ideas, and expectations, and if local policymakers consider their input, bioenergy plans can be more innovative and publically supported, and often more successful. See the "Power to the People" case study in chapter 8.

National Security

While coal and natural gas are plentiful in the U.S., the fact that fossil fuel energy sources are nonrenewable may compromise national energy security. Despite these domestic resources, the U.S. currently imports more than half of our daily needs of oil and petroleum products each day. Additionally, though consumption of petroleum and coal have slowed with the economic downturn, the general trend during the past decade has shown increasing consumption. The U.S. used 34 million additional short tons of coal in 2007 than it did in 2003 (EIA, 2009). Oil consumption increased by 646,000 barrels during the same time span (EIA, 2008b). This increasing demand and dependency on foreign energy sources could affect the nation's economy by contributing substantially to the trade deficit. Furthermore, national security could be affected because much of the oil imported to the U.S. comes from politically unstable regions such as the Middle East. Whether instability is the result of internal conflicts or a turbulent relationship with the U.S., imports from these regions may not be as reliable as from other, more stable parts of the world.

Facilities that produce or use renewable sources of energy are typically small and geographically dispersed. Multiple, small, wood-to-energy facilities spread around community borders can help further increase security and energy reliability. They promote energy independence and provide an infrastructure that is not easily disrupted. Biomass resources can be derived from any location that can support agricultural or silvicultural production. Thus, biomass resources and facilities can be located almost anywhere in the country, broadening our resource availability and increasing energy security (National Renewable Energy Laboratory, 2000).

Aesthetic and Health Issues

The use of woody biomass for energy production and other products also creates concerns about aesthetics and health. Some bioenergy facilities have dealt with odor problems from manure piles or fermenting woodchips and dust that can be hard to contain, both of which aggravate nearby residents. And since wood typically is transported by trucks, large wood-powered facilities may require increased truck traffic. This can create concerns about noise, safety, and road and traffic issues.

There is also public concern about the visual impacts that forest thinning or harvesting can leave. While these issues may seem less important to some people than those that directly affect health and economics, they can dramatically influence public opinion about a woody biomass project and thus should be addressed.

4.4 Summary and Conclusion

Many of the concerns about using wood for energy and other products are reasonable and warrant thoughtful consideration. Utilizing wood for energy requires a change in energy production infrastructure, and as is the nature of change, there is and will continue to be some resistance. Additionally, across the nation, variations in forest type, topography, energy availability and cost, harvesting practices, road networks, and economic conditions affect the feasibility and desirability of using woody biomass as a feedstock in place of coal or other fossil fuels. It is important to investigate costs, benefits, assumptions, and other factors in order to create a strategy that best suit your community.

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